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EFECTOS DEL EJERCICIO FÍSICO EN LA DIABETES GESTACIONAL EN MUJERES EMBARAZADAS

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Resumen

Objetivo: Justificar los efectos del ejercicio físico como método de prevención y tratamiento de la diabetes gestacional en mujeres embarazadas, concretar el tipo de más recomendado e identificar los resultados maternos y fetales debidos a este tipo de intervención.

Introducción: La diabetes mellitus gestacional (DMG) se define como la intolerancia a la glucosa o hiperglucemia (alta concentración de glucosa en sangre) con inicio o primer reconocimiento durante el embarazo y está considerada como una de las complicaciones más frecuentes del embarazo (entre el 1-20%). La modificación del estilo de vida a través del ejercicio es el tratamiento de primera línea para la diabetes gestacional y parece estar relacionado con muchos beneficios para la salud de la madre y del bebé.

Metodología: La búsqueda se realiza en EBSCOhost, PubMed, Web of Science, Cochrane y PEDro. Se limita a los años 2016-2020 y se aceptan publicaciones en cualquier idioma. Se seleccionan 20 artículos.

Resultados: Los 20 artículos revisados se centran en la posible relación entre el ejercicio físico y la disminución del riesgo de desarrollo de diabetes gestacional, evitando así sus frecuentes complicaciones.

Conclusión: El ejercicio físico parece ser beneficioso para las mujeres embarazadas con diabetes gestacional y para la prevención de esta. El ejercicio aeróbico, de resistencia, la combinación de ambos y los ejercicios de relajación parecen tener evidencia sobre estos efectos. No obstante, se requiere más investigación para evidenciar estas conclusiones.

Palabras clave

Diabetes, gestacional, embarazo, ejercicio físico, prevención.

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Introducción

La diabetes mellitus gestacional (DMG) se define como la intolerancia a la glucosa o hiperglucemia (alta concentración de glucosa en sangre) con inicio o primer reconocimiento durante el embarazo que generalmente se resuelve alrededor del momento del nacimiento (1). Esta patología está considerada como una de las complicaciones más frecuentes del embarazo (entre el 1-20%) y se ha demostrado que las mujeres que la padecen tienen mayor riesgo de sufrir complicaciones del embarazo, posteriormente desarrollar diabetes tipo 2, enfermedades cardiovasculares y síndrome metabólico (2). La diabetes gestacional se detecta a través de una prueba de tolerancia oral a la glucosa de 75g y se analizan las concentraciones de glucosa en sangre (3). Además de las complicaciones maternas, la diabetes gestacional se asocia con resultados fetales como macrosomía fetal, distocia de hombros, hipoglucemia neonatal (3) y, a largo plazo, estos niños también tienen mayor riesgo de desarrollar obesidad, síndrome metabólico, diabetes tipo 2 e hipertensión (4).

El ejercicio físico se define como cualquier actividad física que mantiene o mejora la condición física y la salud de las personas y que se realiza de manera planificada, estructurada y repetida. Según la OMS, para un buen estado de salud, se recomiendan como mínimo 150 minutos de actividad física semanales de intensidad moderada. Se sabe que los beneficios de la actividad física para la población general son muchos, entre los cuales se encuentran la reducción del riesgo de desarrollar enfermedades cardiovasculares y oncológicas, mejora de la salud psicológica, mejora de la salud ósea y una menor probabilidad de desarrollo de enfermedades metabólicas como el sobrepeso y la obesidad. Estos beneficios son claros para la población general, pero no para las mujeres embarazadas. Las preocupaciones sobre la seguridad del ejercicio físico durante el embarazo son uno de los factores limitantes más importantes en el cumplimiento de este tipo de intervención (5). La falta de tiempo asociada con la gestión del hogar y de los niños (si procede), el cansancio y las condiciones físicas también dificultan su realización (5).

La diabetes gestacional también se asocia con la aparición de hipertensión arterial gestacional y preeclampsia (6). Estas enfermedades tienen factores de riesgo comunes, como son la obesidad, la resistencia a la insulina, edad materna avanzada y aumento de peso gestacional excesivo (6). Por ello, se recomienda que las mujeres sin contraindicaciones sean físicamente activas durante el embarazo (6). Los posibles beneficios del ejercicio para todas las mujeres embarazadas incluyen una mejora de la condición física, un menor aumento de peso gestacional y, por consecuente, un menor riesgo de diabetes gestacional y trastornos hipertensivos del embarazo (7). No se han observado riesgos teóricos como parto prematuro, bebé pequeño para la edad gestacional o aborto espontáneo en mujeres sanas que realizan ejercicio de intensidad moderada durante el embarazo (7). Sin embargo, como se ha mencionado anteriormente, pocas mujeres embarazadas cumplen con las recomendaciones actuales de actividad física. Las estimaciones muestran que sólo aproximadamente el 25% de las mujeres embarazadas realizan suficiente actividad durante el embarazo (7).

Las contraindicaciones absolutas para el ejercicio, en este caso aeróbico, durante el embarazo consisten en patologías graves, como enfermedad cardíaca desordenada, enfermedad pulmonar restrictiva, cerclaje o cuello uterino incompetente, gestación múltiple con riesgo de parto prematuro, sangrado persistente, placenta previa, parto prematuro, rotura de membranas, preeclampsia y anemia grave (8).

La modificación del estilo de vida a través del ejercicio es el tratamiento de primera línea para la diabetes gestacional y es un complemento importante para la diabetes tipo 1 y tipo 2 durante el embarazo (7). Más del 75% de las mujeres con diabetes gestacional pueden alcanzar un control glucémico sólo con intervenciones en el estilo de vida (7). En personas diabéticas que no están embarazadas, el ejercicio físico mejora la sensibilidad a la insulina, aunque los efectos varían según el tipo, la intensidad y la duración del ejercicio (7). El ejercicio durante el embarazo tiene efectos positivos sobre la mujer embarazada y sobre el feto (9). Los principales beneficios para la mujer son mejora de la condición física, control del peso corporal, menor duración del trabajo de parto, recuperación más rápida después del parto, prevención de afecciones de salud como DMG, hipertensión y preeclampsia inducidas por el embarazo y reducción de los riesgos de prematuridad del nacimiento (9). También se han observado beneficios psicológicos como la reducción de la ansiedad y depresión, mejorando el estado de bienestar (9). Respecto al feto, mejora la transferencia de oxígeno y reduce la difusión de dióxido de carbono a través de la placenta debido a la reducción de la grasa corporal de la madre, lo que tiene un impacto positivo en el desarrollo fetal (9). Además, mejora la resistencia de las arterias fetales reduciendo el riesgo de enfermedades cardiovasculares en la edad adulta (9). La literatura existente sugiere que la actividad física antes y durante el embarazo puede ser una estrategia de salud para la prevención y el tratamiento de la diabetes gestacional (10). Este efecto se explica debido a la prevención del aumento de peso gestacional excesivo y resulta un método eficaz para el control de los niveles de azúcar en sangre (10).

Las mujeres embarazadas con diabetes comprenden una población única a la que se deben aplicar pautas específicas basadas en evidencia para garantizar la seguridad del ejercicio y la eficacia para mejorar los resultados maternos y fetales (7). Las pautas recomiendan que las mujeres embarazadas realicen 150 minutos a la semana de actividad física de intensidad moderada (7). Sin embargo, hasta el momento no se han definido unas pautas o recomendaciones concretas aplicables a cualquier mujer embarazada con diabetes gestacional. A día de hoy, no se puede especificar el tipo de ejercicio físico, la duración, la intensidad y la frecuencia. El objetivo de este trabajo es reunir toda la evidencia con respecto a este tema para sacar en claro una conclusión sobre cómo debe ser el ejercicio que realicen las mujeres embarazadas para prevenir y/o tratar la diabetes gestacional.

Objetivos

Objetivo general**:**

- Justificar los efectos del ejercicio físico para prevenir y tratar la diabetes gestacional en mujeres embarazadas.

Objetivos específicos:

- Analizar el tipo de ejercicio físico más beneficioso en mujeres embarazadas con diabetes gestacional.
- Identificar los resultados relevantes perinatales y maternos debidos a la realización de ejercicio físico con diabetes gestacional.

Estrategia de búsqueda bibliográfica

En este trabajo se ha llevado a cabo una búsqueda bibliográfica y su posterior revisión sobre la evidencia científica existente en cuanto a los efectos del ejercicio físico en mujeres embarazadas para la prevención y tratamiento de diabetes gestacional, el tipo de ejercicio que proporciona mayores beneficios para este tipo de población y los resultados relevantes maternos y fetales debidos a la realización de ejercicio físico durante el embarazo con diabetes gestacional. Se analizan estudios publicados desde el 2016 al 2020 en cualquier idioma disponible, y realizados en mujeres embarazadas con diabetes gestacional o para evitar el desarrollo de esta.

Las palabras clave que se repiten en todos los estudios y a través de las cuales se ha llevado a cabo la búsqueda son diabetes, gestacional, actividad física, control glucémico, embarazo, ejercicio físico, glucosa y prevención. De estas palabras clave, se han elegido las siguientes que representan este trabajo: diabetes, gestacional, embarazo, ejercicio físico, prevención.

Los descriptores usados para realizar la búsqueda bibliográfica se han consultado en la plataforma DeCS, para traducir los descriptores del español al inglés y así facilitar la búsqueda de artículos en las bases de datos. El objetivo de la traducción de los descriptores es poder acceder a aquellas publicaciones relacionadas con nuestro tema de investigación. Los descriptores utilizados son effects, exercise, pregnancy, diabetes, perinatal, maternal, outcomes.

Se han establecido los siguientes booleanos:

- 1er nivel: (effects) AND (exercise) AND (pregnancy) AND (diabetes).
- 2^{o} nivel: (Perinatal) AND (maternal) AND (outcomes) AND (exercise) AND (pregnancy) AND (diabetes).

Los límites aplicados han sido búsquedas a 5 años y los filtros de materia (gestational diabetes, exercise) aplicados en el metabuscador EBSCOhost.

En primer lugar, se realizó una búsqueda informal en PubMed para obtener una visión general sobre la temática de este trabajo. Posteriormente, se realizaron las búsquedas en el metabuscador EBSCOhost, en las bases de datos específicas PubMed y Web of Science, y en las bases de datos de revisiones Cochrane y PEDro.

Criterios de inclusión

Los criterios de inclusión establecidos para realizar el trabajo fueron los siguientes:

- Año de publicación: artículos publicados entre 2016 y 2020. La elección de un período de 5 años se justifica debido a la actualización constante de la información.
- Participantes: se escogen artículos sobre mujeres embarazadas con diabetes gestacional o para evitar su desarrollo. No se establecen filtros en función del período del embarazo en el que se encuentren ni la edad de la mujer.
- Intervención: ejercicio físico en cualquiera de sus formas en mujeres embarazadas para la prevención y/o tratamiento de la diabetes gestacional.
- Idioma: no se establecen filtros de idioma.

Criterios de exclusión

Los criterios de exclusión establecidos para realizar el trabajo fueron los siguientes:

- Participantes: pacientes que además de diabetes gestacional, padezcan otro tipo de patologías como dolor pélvico, dolor lumbar, incontinencia urinaria y/o fecal o disfunciones de suelo pélvico.
- Artículos en los que el tratamiento de la diabetes gestacional sea con fármacos como la metformina o la dapagliflozina u hormonas como la insulina.
- Artículos que hablan sobre embarazo y COVID-19.
- Artículos sin interés para mi tema de investigación.
- Dificultades para la obtención de la fuente primaria de información.

La estrategia de búsqueda bibliográfica se puede consultar de manera esquemática como anexo 1 en el apartado de anexos.

Resultados de la búsqueda bibliográfica

La revisión bibliográfica se ha llevado a cabo en el metabuscador EBSCOhost, en las bases de datos específicas PubMed y Web of Science, y en las bases de datos de revisiones Cochrane y PEDro. La selección de los artículos se realizó a través de los títulos, palabras clave y resúmenes. Posteriormente, se descartaban los artículos que no se adaptaban correctamente al tema de investigación de este trabajo. Los artículos seleccionados se escogieron en base a si daban respuesta a los objetivos de este trabajo y si la muestra se adaptaba a la población concreta que se quiere estudiar, mujeres embarazadas con diabetes gestacional o con posibilidad de desarrollarla. No se establecieron rangos de edad en la población, ya que esta es específica de mujeres en edad fértil.

Las combinaciones de booleanos se realizaron de primer y de segundo nivel, y no se utilizó el booleano OR ya que no se quería ampliar la búsqueda debido a que se buscaban unos resultados muy concretos en una población muy específica. Las combinaciones booleanas fueron las siguientes:

- 1er nivel: (effects) AND (exercise) AND (pregnancy) AND (diabetes).
- 2º nivel: (Perinatal) AND (maternal) AND (outcomes) AND (exercise) AND (pregnancy) AND (diabetes).

Se definió un tercer nivel de combinación de booleanos, siendo este (type) AND (exercise) AND (pregnancy) AND (diabetes). No se realizó ninguna búsqueda formal con esta combinación ya que los artículos que aparecían en las búsquedas informales relacionados con el objetivo referido al tipo de ejercicio físico más beneficioso en mujeres embarazadas con diabetes gestacional eran los mismos que cuando se realizaba la búsqueda con la combinación booleana de 1er nivel. Se ha llegado a los artículos que contestan al primer objetivo específico a través de la primera combinación booleana.

En una búsqueda avanzada en el metabuscador EBSCOhost seleccionando los artículos de los años 2016-2020, se obtienen los siguientes resultados:

- 1er nivel, (effects) AND (exercise) AND (pregnancy) AND (diabetes): se obtienen un total de 428 resultados con el filtro de materia gestational diabetes. De estos 428 resultados, se seleccionan 7 artículos y de estos se descartan 4 artículos y se escogen 3. Los criterios de exclusión del resto de estudios han sido: artículos sin interés para el tema de investigación, dificultad de acceso a la fuente primaria de información, artículos repetidos ya seleccionados en otras bases de datos, artículos que no se ajustan a los criterios de inclusión, estudios relacionados con fertilización in vitro, tratamiento de la diabetes gestacional con dapagliflozina, metformina e insulina, artículos relacionados con incontinencia urinaria, dolor lumbar, dolor pélvico y artículos que hablan sobre ejercicio físico en el embarazo pero no de diabetes gestacional.

- 2º nivel, (perinatal) AND (maternal) AND (outcomes) AND (exercise) AND (pregnancy) AND (diabetes): se obtienen un total de 21 resultados con los filtros de materia gestational diabetes y exercise. De estos 21 resultados, se seleccionan 4 y finalmente se descartan todos. Los criterios de exclusión de los resultados han sido: artículos que no se ajustan a los criterios de inclusión del trabajo, artículos sin interés para el tema de investigación y artículos ya seleccionados en otras bases de datos.

En una búsqueda avanzada en la base de datos específica PubMed seleccionando los artículos de los años 2016-2020, se alcanzan los siguientes resultados:

- 1^er^ nivel, (effects) AND (exercise) AND (pregnancy) AND (diabetes): se obtienen un total de 335 resultados, se seleccionan 22 publicaciones y, de estos, se escogen de 14 artículos. Los criterios de exclusión del resto de publicaciones han sido: artículos que hablan únicamente de yoga (sin que haya embarazo ni diabetes), dolor pélvico, dolor lumbar, avances en la diabetes sin mencionar a mujeres embarazadas, dapagliflozina y metformina como tratamiento de la diabetes, ganancia de peso durante el embarazo sin referencias a la diabetes gestacional, incontinencia urinaria, patología de suelo pélvico en embarazo, parto a pretérmino debido a obesidad, plantas medicinales durante el embarazo y ejercicio físico en el embarazo pero sin enfoque a la diabetes gestacional.
- 2º nivel, (perinatal) AND (maternal) AND (outcomes) AND (exercise) AND (pregnancy) AND (diabetes): se obtienen un total de 42 resultados, de los cuales se seleccionan 6 artículos y finalmente se descartan los 6 debido a que no se ajustan al tema de investigación de este trabajo. Los criterios de exclusión de las publicaciones han sido: estudios sin interés para el tema de investigación, artículos sobre factores cardiometabólicos, intervenciones psicosociales y estudios obtenidos en otras bases de datos.

En una búsqueda avanzada en la base de datos específica Web of Science seleccionando los artículos de los años 2016-2020, se obtienen los siguientes resultados:

- 1[er] nivel, (effects) AND (exercise) AND (pregnancy) AND (diabetes): se obtienen un total de 250 resultados, de los cuales se seleccionan 2 metaanálisis y finalmente se descartan ambos. Los criterios de exclusión de los estudios han sido: artículos que cuyo tratamiento de la diabetes es la insulina, intervenciones en el sueño durante el embarazo, patología de suelo pélvico, estudios realizados en poblaciones específicas, estudios sobre mecanismo redox, intervenciones en la dieta, publicaciones sobre embarazo y COVID-19, dificultad de acceso a la fuente primaria y artículos ya seleccionados en otras bases de datos.

En una búsqueda avanzada en la base de datos de revisión PEDro seleccionando los artículos de los años 2016-2020, se encuentran los siguientes resultados:

- 1[er] nivel, (effects) AND (exercise) AND (pregnancy) AND (diabetes): se obtienen un total de 43 resultados, de los cuales se seleccionan 7 y finalmente no se escoge ninguno. Los criterios de exclusión de las publicaciones han sido: artículos cuya intervención no es ejercicio físico ni sobre población con diabetes gestacional, estudios sin interés para el tema de investigación artículos sobre polución, vacunación, sepsis, calidad del sueño y estudios que ya se han escogido de otras bases de datos.

En una búsqueda avanzada en la base de datos de revisión Cochrane seleccionando los artículos de los años 2016-2020, se extraen los siguientes resultados:

- 1[er] nivel, (effects) AND (exercise) AND (pregnancy) AND (diabetes): se alcanzan 12 resultados de los cuales no se selecciona ninguno. Los criterios de exclusión de los estudios han sido: intervenciones sobre el estilo de vida entre las cuales no está el ejercicio físico, intervenciones con fármacos, estudios sobre biometrías fetales, artículos ya seleccionados en otras bases de datos y otros que no se adaptan al tema de investigación.
- 2º nivel, (perinatal) AND (maternal) AND (outcomes) AND (exercise) AND (pregnancy) AND (diabetes): se obtienen 8 resultados entre los cuales se escoge una revisión sistemática sobre resultados maternos y fetales. Los criterios de exclusión de las publicaciones que restan han sido: estudios sin interés para mi

tema de investigación, intervenciones sobre dieta y otros aspectos del estilo de vida, y artículos sobre tratamiento de la diabetes con farmacología.

En el apartado de anexos se puede consultar como anexo 2 el diagrama de flujo de los resultados de la búsqueda bibliográfica, como anexo 3 la tabla PICO correspondiente a cada artículo, como anexo 4 las fichas de revisión bibliográfica y como anexo 5 la tabla de resultados de la escala CASPe.

Discusión

La discusión de este trabajo se va a desarrollar mediante la división en tres apartados para una mejor organización y comprensión de la información extraída de la literatura científica encontrada en la búsqueda bibliográfica. Los apartados en lo que se dividirá el trabajo se corresponden a los objetivos de este y son los siguientes:

- Efectos del ejercicio físico para prevenir y tratar la diabetes gestacional en mujeres embarazadas.
- Tipo de ejercicio físico más beneficioso en mujeres embarazadas con diabetes gestacional.
- Resultados maternos y fetales relevantes debidos a la realización de ejercicio físico con diabetes gestacional.

<u>1. Efectos del ejercicio físico para prevenir y tratar la diabetes gestacional en mujeres embarazadas.</u>

El ejercicio físico en mujeres embarazadas aporta un conjunto de beneficios para la salud ya conocidos, pero existen beneficios concretos para las mujeres con diabetes gestacional. Según Peters et al., las mujeres embarazadas consiguen beneficios en el estado físico y en el control del peso, evitando así un aumento de peso gestacional, pero también consiguen un mejor control de los niveles de glucosa en sangre y se retrasa la necesidad de insulina, reduciendo el riesgo potencial de hipoglucemia (7). Los resultados obtenidos en el estudio de Sklempe et al. corroboran las conclusiones de Peters et al., ya que los niveles de glucosa postprandial fueron significativamente menores en el grupo que realizó ejercicio físico y los niveles de glucosa en ayunas se correlacionaron positivamente con la masa corporal (4, 11). Sin embargo, estos autores concluyen que los datos disponibles sobre los efectos del ejercicio en las mujeres embarazadas con diabetes gestacional son limitados, incluidos los efectos agudos de este (11). Los estudios analizados por Bianchi et al. apoyan el ejercicio físico como una herramienta útil en la prevención de diabetes gestacional y se mostró una reducción del riesgo del 28% de desarrollar diabetes gestacional (12). En el tratamiento de mujeres con diabetes gestacional, existe evidencia de que el ejercicio es una terapia beneficiosa, mejorando significativamente el control glucémico postprandial y en ayunas (12), como ya han afirmado Peters et al. y Sklempe et al.; sin embargo, se requieren estudios que evalúen el tipo, el momento, la duración y el cumplimiento del ejercicio físico (12). Barakat et al. relacionan la aparición de diabetes gestacional con el aumento excesivo de peso durante el embarazo, al igual que la anterior mención sobre los estudios de Peters et al. y Sklempe et al. En concreto, la prevalencia está aumentando en paralelo con el sobrepeso y la obesidad en la población embarazada, por lo que la literatura existente sugiere que el ejercicio físico antes y durante el embarazo puede ser una estrategia eficaz para la prevención y el tratamiento de la diabetes gestacional por la influencia que tiene en la prevención del aumento de peso, además de que también se ha identificado como un método eficaz para controlar los niveles de glucosa en sangre (10). Sin embargo, algunos estudios previos realizados llevaron a cabo programas de ejercicio físico con muestras pequeñas, por lo que los resultados no son concluyentes (10). Sobre la prevención, Savvaki et al. también asocian la reducción del riesgo de desarrollo de diabetes gestacional con la realización de ejercicio físico antes y durante el embarazo (9). Concretamente, la realización de ejercicio físico durante las primeras 20 semanas de gestación, reduce un 50% el riesgo de diabetes gestacional (10). El metaanálisis de Ming et al. respalda la evidencia de que el ejercicio físico protege a las mujeres frente a la diabetes gestacional, informando sobre la disminución significativa de aparición de diabetes gestacional en mujeres embarazadas que realizaban ejercicio (13). El ensayo clínico de Wang et al. relaciona, como otros autores nombrados anteriormente, la diabetes gestacional con el sobrepeso y la obesidad, proporcionando esta combinación unos resultados más graves (14). Por lo que el ejercicio realizado de forma regular tiene el potencial de reducir el riesgo de diabetes gestacional; sin embargo, su eficacia sigue siendo controvertida (14). Aunque según el estudio posterior de Davenport et al., el ejercicio prenatal se asoció con un 24% menos de probabilidades de desarrollar diabetes gestacional en comparación con la no realización de ejercicio y un ensayo clínico incluido en este estudio demostró una disminución en las probabilidades de desarrollo de diabetes gestacional del 38%, hipertensión arterial del 39% y preeclampsia del 41%, estando estos dos últimos trastornos muy relacionados con la diabetes gestacional (6). El estudio de Yu et al. asocia la intervención con ejercicio a una incidencia significativamente menor de diabetes gestacional (15). Sin embargo, no muestra ningún impacto en la glucosa 2 horas después de la prueba oral ni tampoco se asocia con una reducción de la preeclampsia en comparación con la atención estándar (15), siendo este resultado contradictorio a los del estudio de Davenport et al. Frente a los resultados de Yu et al., se sitúan los resultados del estudio de Zheng et al., los cuales informan que la intervención con ejercicio físico reduciría significativamente los niveles de glucosa en sangre 2 horas después de la prueba oral en comparación con la atención estándar (2). Para tratar la diabetes gestacional se requiere mantener los niveles de glucosa en sangre dentro de unos niveles normales. Según Di Biase et al., las intervenciones con ejercicios pueden ser útiles para ayudar con el control glucémico, aumentando la absorción de glucosa y, además, mejora la sensibilidad a la insulina (16). Sin embargo, la publicación de Nasiri-Amiri et al. expone que no hubo relación estadísticamente significativa entre los estudios con intervención en el primer trimestre del embarazo y aquellos con intervención en el segundo trimestre del embarazo, ni se observó el efecto del ejercicio sobre la reducción de la incidencia de diabetes en estudios con un tiempo de intervención de más de tres veces por semana, aunque sí en estudios que tuvieron un tiempo de intervención de tres veces a la semana o menos (17). Los resultados de la investigación de Halvatsiotis et al. describen una relación inversa entre ejercicio de intensidad vigorosa, niveles semanales más altos de actividad física y apariencia de diabetes gestacional (8). En el ensayo clínico de Guelfi et al. se realizó un programa de ejercicio domiciliario supervisado de 14 semanas y se concluye que este programa no reduce la incidencia de diabetes gestacional ni altera el grado general de intolerancia a la glucosa o sensibilidad a la insulina (5). Sin embargo, la intervención se asoció con mejoras en la aptitud cardiovascular materna, aumentos en la automaticidad del ejercicio y una reducción en la angustia psicológica general indicada por la escala de ansiedad, estrés y depresión de 21 ítems (5), al igual que el estudio de Savvaki et al., que demuestran beneficios psicológicos, como reducción de la ansiedad y la depresión, en las mujeres embarazadas que practican ejercicio físico (10).

2. Tipo de ejercicio físico más beneficioso en mujeres embarazadas con diabetes gestacional.

En cuanto al tipo de ejercicio físico más recomendado en mujeres embarazadas con diabetes gestacional o para la prevención de esta, se habla de ejercicio aeróbico, ejercicio de resistencia y ejercicios de relajación. Los ejercicios aeróbicos consisten en ciclismo, nadar o caminar. La mayoría de las guías de la sociedad obstétrica recomiendan que las mujeres embarazadas hagan ejercicio durante 20-30 min como máximo al día o 150 min a la semana (7, 9) de intensidad moderada (13). Según Peters et al., no se puede recomendar una dosis de ejercicio para mujeres con diabetes durante el embarazo que pueda mejorar de manera más efectiva el control glucémico, ni tampoco se ha establecido la seguridad y eficacia de una mayor intensidad o un mayor volumen de ejercicio (7). A pesar de ello, se ha observado que las intervenciones supervisadas de ejercicio resultan más beneficiosas que el ejercicio independiente para mejorar los resultados glucémicos (7). La combinación de ejercicios aeróbicos y ejercicios de resistencia del estudio de Sklempe et al. ofrece importantes beneficios para mujeres embarazadas con diabetes gestacional, mejorando el control glucémico (4). Cada sesión de ejercicio duró de 50 a 55 minutos y consistió en ejercicio aeróbico (20 min), ejercicios de resistencia (20-25 min), ejercicios de suelo pélvico y estiramientos, y un período de relajación de 10 min para finalizar la sesión (4). Estas indicaciones se contradicen con las guías de recomendación que indican un máximo de ejercicio de 20-30 min al día. La parte aeróbica de la sesión se realizó en cinta de correr y tuvo como objetivo lograr una frecuencia cardíaca dentro de la zona aeróbica, es decir, los valores objetivo eran 13-14 en la escala de Borg (4). Los ejercicios de resistencia incorporaron todos los grupos musculares principales y se realizaron en cada sesión con los mismos valores objetivo en la escala de Borg que para la parte aeróbica de la sesión (4). Se realizaron seis ejercicios diferentes en tres series de 10-15 repeticiones en cada serie (4). No obstante, Sklempe et al. concluyen que deben desarrollarse e incorporarse pautas para el tipo, la frecuencia, la duración y la intensidad óptimos del ejercicio en las pautas generales para el tratamiento de la diabetes gestacional (4). Savvaki et al. sugieren que las mujeres embarazadas con diabetes gestacional deben seguir las mismas recomendaciones que otras mujeres embarazadas y el ejercicio debe ajustarse a las necesidades del embarazo y personalizarse según las necesidades de cada mujer (9). Estos autores consideran que una frecuencia de dos a cuatro veces por semana y una duración del ejercicio de 30 minutos resulta eficaz y segura (9). Hay evidencia de que 16-28 METs (unidad metabólica del ejercicio) por semana a una intensidad del 60% de la reserva de frecuencia cardíaca reduce el riesgo de diabetes gestacional y, posiblemente, hipertensión inducida por el embarazo y preeclampsia (9). Un programa de ejercicio de 28 METs por semana equivale a caminar a una velocidad de 3,2 km/h durante 11,2h por semana (9). Según el American College of Obstetricians and Gynecologists, el ejercicio al 60-70% de la reserva de frecuencia cardíaca es seguro para la mayoría de las mujeres embarazadas (9). La revisión sistemática de Bianchi et al. recomienda a las mujeres embarazadas con diabetes gestacional (o para prevenirla) la realización de ejercicio físico (de tipo aérobico y de resistencia) durante un mínimo de 15 minutos por sesión, 3 veces a la semana (de acuerdo con una frecuencia cardíaca adecuada), aumentándose gradualmente durante el segundo trimestre hasta un máximo de aproximadamente 30 minutos por sesión, 4 veces a la semana, y su mantenimiento en su estilo de vida tras el embarazo (12). El ejercicio físico se recomienda siempre y cuando no existan complicaciones ni contraindicaciones (12). El programa de ejercicio físico propuesto por Barakat et al. se trata de un programa de intervención de ejercicio moderado tres días a la semana (55-60 min por sesión) desde la semana 8-10 de embarazo (inmediatamente después de la primera ecografía prenatal) hasta el final del tercer trimestre (semanas 38-39) (10). La sesión consiste en un calentamiento gradual, ejercicios aeróbicos, fortalecimiento muscular ligero, ejercicios de coordinación y equilibrio, ejercicios de estiramiento, fortalecimiento del suelo pélvico y relajación y charla final (10). Esta programación se contradice con las guías generales de recomendación que establecen como máximo 30 min al día de ejercicio, frente a los 60 min por sesión que proponen Barakat et al. Los beneficios del ejercicio físico requieren su realización durante 30 minutos a una intensidad moderada durante cinco días, o 150 minutos de actividad aeróbica cada semana en promedio, dependiendo del nivel de actividad o condición físicas de la mujer antes del embarazo (18). Laredo-Aguilera et al. recomiendan que las mujeres embarazadas con diabetes mellitus gestacional realicen ejercicio durante al menos 20 a 50 minutos como mínimo 2 veces por semana con una intensidad al menos moderada (18). La duración de las intervenciones varía entre 6 y 16 semanas, por lo que no se puede establecer una duración específica (18). En cuanto al ejercicio, existen dos tipos de modalidades: actividad aeróbica y ejercicio de fuerza o una combinación de ambos, como en el estudio de Sklempe et al. (18). La actividad de Davenport et al. consiste en caminar de 3 a 4 veces por semana durante unos 40 min (6, 18). El yoga se incluye en este estudio como una modalidad de ejercicios de resistencia (18). Durante ocho semanas, la población estudiada realizó este ejercicio dos veces por semana durante 50 min (18). Las variables analizadas en esta modalidad de ejercicio son el ayuno, la glucosa posprandial y la hemoglobina glucosilada (18). Estas tres variables son menores en el grupo de intervención con una diferencia significativa (18). Por lo tanto, se puede afirmar que el yoga es un ejercicio efectivo para controlar estas variables (18). En otro estudio incluido en esta publicación, la intervención consiste en caminar todos los días durante 20 minutos, y los resultados del ayuno, la glucosa posprandial y la hemoglobina son más bajos en los grupos de ejercicio con una diferencia significativa (18). El estrés y los estímulos psicoactivos causan condiciones hiperglucémicas y aumentan la presión arterial en mujeres con diabetes, por lo que es importante reducir el estrés en esta población (19). Los ejercicios de relajación son uno de los tratamientos complementarios y seguros durante el embarazo, teniendo efectos sobre el sistema simpático, aumentando la calma y reduciendo el estrés mental (19). El entrenamiento de relajación propuesto por Geranmayeh et al. consiste en entrenamiento respiratorio, relajación progresiva e imágenes guiadas, que tienen como objetivo mejorar la salud mental y física (19). Al grupo de intervención se le enseñaron técnicas de relajación cuerpo-mente durante 10 semanas (19). Se enseñó a grupos de 1 a 4 participantes en sesiones semanales de 45 minutos utilizando una técnica de juego de roles y un folleto educativo (19). Al inicio de las sesiones 1-2, el investigador se acostó en la cama en posición lateral y realizó técnicas respiratorias y ejercicio, los participantes hicieron los ejercicios en presencia del investigador y, posteriormente, en casa dos veces al día (19). El contenido educativo de cada sesión cubrió temas importantes y comunes del embarazo, el mecanismo y las causas de la diabetes, la naturaleza del estrés y su impacto en el cuerpo, los factores estresantes del embarazo y el parto vaginal (19).

3. Resultados maternos y fetales relevantes debidos a la realización de ejercicio físico con diabetes gestacional.

Respecto a los resultados maternos y fetales, el desarrollo de la diabetes gestacional conlleva consecuencias para la salud tanto de la madre como del bebé. Además, existen algunos datos que sugieren un aumento de malformaciones fetales y mortalidad perinatal (10). La realización de ejercicio físico durante el embarazo disminuye las probabilidades de desarrollar esta patología y, por tanto, disminuye el riesgo de sufrir complicaciones. En la revisión sistemática de Brown et al. el ejercicio no pareció reducir el riesgo de preeclampsia como medida de los trastornos hipertensivos del embarazo, el parto por cesárea o el riesgo de inducción del trabajo de parto (1). Ninguno de los ensayos incluidos en este estudio informó sobre el trauma perineal, la depresión postparto o el desarrollo de diabetes tipo 2 (1). En cuanto a los bebés, no ocurrieron muertes alrededor del momento del nacimiento y no hubo evidencia de ninguna diferencia en el riesgo de mala salud o niveles bajos de azúcar en sangre (1). Ninguno de los ensayos informó el número de bebés grandes para la edad gestacional o bebés que desarrollaron diabetes en la niñez o la edad adulta o discapacidad neurosensorial que se hizo evidente durante la niñez (1). Por el contrario, el estudio de Sklempe et al. informa que, a largo plazo, las madres tienen mayor riesgo de desarrollar diabetes tipo 2, síndrome metabólico, obesidad, morbilidades cardiovasculares y diabetes gestacional recurrente (4). Además de las complicaciones maternas, según Bgeginski et al., la diabetes gestacional se asocia con resultados fetales como macrosomía fetal, distocia de hombros, hipoglucemia neonatal (3) y, a largo plazo, los niños también tienen un mayor riesgo de desarrollar obesidad, síndrome metabólico, diabetes tipo 2 e hipertensión (4). El posterior estudio de Savvaki et al. expone que los principales beneficios de la realización de ejercicio físico incluyen la mejora de la condición física, control del peso corporal, menor duración del trabajo de parto, recuperación más rápida después del parto, prevención de afecciones de salud como diabetes gestacional, hipertensión y preeclampsia inducidas por el embarazo y reducción de los riesgos de prematuridad en el nacimiento (9). Respecto al feto, además de lo mencionado anteriormente por Bgeginski et al., el ejercicio regular reduce la grasa corporal de la madre, y esto mejora la transferencia de oxígeno y reduce la difusión de dióxido de carbono a través de la placenta, lo que tiene un impacto positivo en el desarrollo fetal (9). El ejercicio durante el embarazo mejora la resistencia de las arterias fetales y reduce el riesgo de enfermedades cardíacas durante la edad adulta (9). Además, los sonidos y los estímulos vibratorios que acompañan al ejercicio pueden acelerar el desarrollo del cerebro fetal (9). Según Ming et al. y Wang et al., las mujeres con diabetes gestacional tienen un mayor riesgo de sufrir muerte fetal, malformaciones fetales, parto prematuro, macrosomía, polihidramnios, infección y cesárea que la población general (13, 14). Además, tanto las mujeres como sus bebés tienen más probabilidades de tener sobrepeso u obesidad y desarrollar diabetes mellitus tipo 2, enfermedades cardiovasculares a posteriori, como afirmaba el estudio de Sklempe et al (4, 13). Los niveles más bajos de glucosa en sangre posprandial se asocian con menos complicaciones perinatales según Bianchi et al. (12). Los beneficios para la salud del feto son aumento de líquido amniótico, aumento en la viabilidad y el volumen de la placenta, aumento de función vascular, más rápido crecimiento de la placenta y mayor tejido velloso, menor peso al nacer y riesgo de parto prematuro, mejora del neurodesarrollo y menor porcentaje de grasa corporal fetal (12). Estos resultados no tienen suficiente evidencia para confirmar que estas asociaciones entre ejercicio físico y diabetes gestacional son correctas, se necesita más investigación. En cuanto al modo de parto en mujeres embarazadas con diabetes gestacional, Awad et al. demuestran que el ejercicio durante el embarazo es efectivo para disminuir las complicaciones del trabajo de parto y cambiar el modo de parto hacia un parto normal y sin complicaciones tanto en mujeres diagnosticadas con diabetes gestacional como en su descendencia (20).

4. Otros aspectos

La información se ha generado desde una perspectiva de intervención sobre los usuarios afectados (población embarazada con diabetes gestacional o probabilidad de su desarrollo). Se ha encontrado información relevante para la práctica clínica, para el usuario y para el sistema de salud, ya que la práctica de ejercicio físico tiene beneficios para la población estudiada y eso conlleva menor riesgo de complicaciones y/o patologías, disminuyendo el gasto para el sistema sanitario y aumentando la salud de la población. Debería proporcionarse esta información a las mujeres embarazadas con motivo de su propio beneficio, dado que gran parte de la población no es consciente de la importancia de estos datos. En un artículo se menciona que, debido a la falta de conocimiento sobre los riesgos y beneficios del ejercicio, la mayoría de las mujeres tienden a evitarlo durante el embarazo (9). Por lo que debería ser necesaria la educación para la salud por parte de los médicos y enfermeros/as que realizan los grupos de preparación al parto. Sería interesante que se continuara investigando sobre el tema propuesto en este trabajo con intervenciones de mayor muestra que extraigan unos posteriores resultados concluyentes, ya que la información proporcionada en las publicaciones utilizadas no tiene evidencia suficiente que la respalde. Es cierto que las asociaciones se han expuesto con unos resultados estadísticamente significativos, pero deberían plantearse más estudios con una correcta metodología para establecer unas recomendaciones con evidencia. La mayor limitación a la hora de extraer resultados sobre este trabajo ha sido la necesidad de mayor evidencia. No existen unas recomendaciones firmes sobre el tipo de ejercicio, la duración, la frecuencia y la intensidad a la que se debe realizar. Tampoco son del todo claros los resultados maternos y fetales que se deben al ejercicio físico y los que no, ya que existen desacuerdos entre autores que se proponen los mismos objetivos.

Conclusiones

El ejercicio físico parece ser beneficioso para la prevención y el tratamiento de la diabetes gestacional, por lo que debería ser la principal intervención realizada para esta patología. Los principales beneficios obtenidos son la reducción de los niveles de glucosa en sangre y el control del aumento de peso gestacional.

El ejercicio aeróbico, el ejercicio de resistencia, la combinación de estos dos y el ejercicio de relajación son las modalidades más estudiadas en cuanto a los beneficios que proporcionan en esta población. No existen recomendaciones firmes respaldadas por evidencia sobre el tipo de ejercicio, la duración, la frecuencia y la intensidad a la que se debe realizar.

Las complicaciones maternas y fetales en embarazos con diabetes gestacional son muy frecuentes. La realización de ejercicio físico durante el embarazo disminuye las probabilidades de desarrollar esta patología y, por tanto, disminuye el riesgo de sufrir complicaciones. Los beneficios para la salud son, entre otros, mejora de la condición física, control del peso corporal, menor duración del trabajo de parto, recuperación más rápida después del parto, prevención de afecciones cardiovasculares, reducción de los riesgos de prematuridad en el nacimiento, mejora de la resistencia de las arterias fetales, reducción del riesgo de enfermedades cardíacas durante la edad adulta, aumento de líquido amniótico, aumento en la viabilidad y el volumen de la placenta, aumento de función vascular, menor peso al nacer y mejora del neurodesarrollo del bebé.

Sin embargo, los resultados obtenidos no tienen suficiente evidencia para confirmar que las asociaciones entre ejercicio físico y diabetes gestacional son correctas. Son necesarios más estudios para sacar en claro unas conclusiones.

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Anexos

BASES CONCEPTUALES Y METODOLÓGICAS EN CIENCIAS DE LA SALUD
BLOQUE TEMÁTICO 2: FUENTES DOCUMENTALES
UNIDAD DIDÁCTICA 3: BASES DE DATOS EN CIENCIAS DE LA SALUD

ESTRATEGIA DE BÚSQUEDA BIBLIOGRÁFICA

1. Completar el siguiente esquema, para desarrollar la Fase de ejecución de la Búsqueda Bibliográfica:

Estrategia de búsqueda bibliográfica			
Pregunta de Investigación	¿Cómo afecta el ejercicio físico en la diabetes gestacional en mujeres embarazadas?		
Objetivos	- General: Justificar los efectos del ejercicio físico para prevenir y tratar la diabetes gestacional en mujeres embarazadas. - Específico 1: Analizar el tipo de ejercicio físico más beneficioso en mujeres embarazadas con diabetes gestacional. - Específico 2: Identificar los resultados relevantes perinatales y maternos debidos a la realización de ejercicio físico con diabetes gestacional.		
Palabras Clave	Diabetes, gestacional, embarazo, ejercicio físico, prevención.		
Descriptores	Los descriptores se presentarán en Castellano e Inglés para su uso en las bases de datos traducidos al lenguaje documental a partir de las palabras clave generadas en DESC		
		Castellano	Inglés
	Raíz	efectos, ejercicio físico, embarazo, diabetes	effects, exercise, pregnancy, diabetes
	Secundario(s)	perinatal, materno, resultados, ejercicio físico, embarazo, diabetes	perinatal, maternal, outcomes, exercise, pregnancy, diabetes
	Marginale(s)		
Booleanos	Especificar los tres niveles de combinación con booleanos		
	1er Nivel	Effects AND exercise AND pregnancy AND diabetes	
	2do Nivel	Perinatal AND maternal AND outcomes AND exercise AND pregnancy AND diabetes	
	3er Nivel		
Área de Conocimiento	Ej: Si deseo estudiar los cuidados a un paciente con Demencia en tratamiento con Neurolépticos: Ciencias de la Salud, Fisiología, Neurología, Enfermería, farmacología. Ciencias de la Salud, fisioterapia, embarazo, ejercicio físico.		

Selección de Bases de Datos	***Metabuscadores*** EBSCOhost √ BVS ☐ OVID ☐ CSIC ☐ Otras ☐	***Bases de Datos Específicas*** Pubmed √ Embase ☐ IME ☐ Ibecs ☐ Psyinfo ☐ LILACS ☐ Cuiden ☐ CINHAL ☐ Web of Knowledge ☐ Otras (especificar): Web of Science √	***Bases de Datos Revisiones*** Cochrane √ Excelencia Clínica ☐ PEDro √ JBI ☐ Otras (especificar) ☐
Años de Publicación	Búsquedas a 5 años		
Idiomas	Todos		
Otros Límites	1.		
	2.		
	3.		

Resultados de la Búsqueda

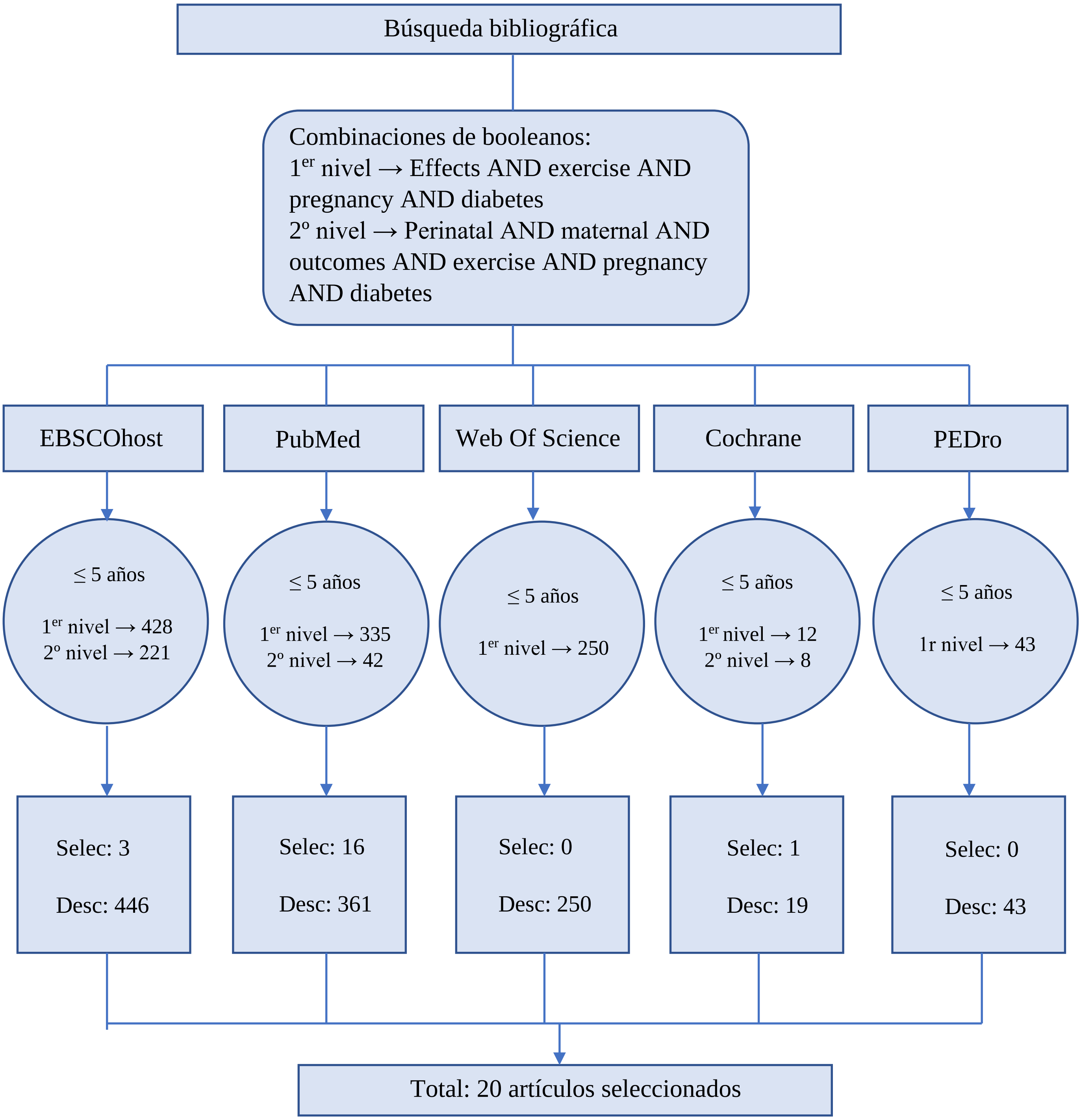
Metabuscador	EBSCOhost			
Combinaciones	1er Nivel	Effects AND exercise AND pregnancy AND diabetes	3er Nivel	
	2do Nivel	Perinatal AND maternal AND outcomes AND exercise AND pregnancy AND diabetes	Otros	
Límites introducidos	Búsquedas a 5 años, filtro de materia (gestational diabetes, exercise).			
Resultados	1er Nivel	N° 428	Resultado final	
	2do Nivel	N° 21	3	
	3er Nivel	N°	Criterios de Exclusión	
	Otros	N°	Sin interés para mi tema de investigación	446
			Déficit de calidad del estudio	
			Dificultades para la obtención de fuentes primarias	
Base de Datos Específica 1	PubMed			
Combinaciones	1er Nivel	Effects	3er Nivel	

		AND exercise AND pregnancy AND diabetes		
	2do Nivel	Perinatal AND maternal AND outcomes AND exercise AND pregnancy AND diabetes	Otros	
Límites introducidos	Búsquedas a 5 años			
Resultados	1er Nivel	Nº 335	Resultado final	
	2do Nivel	Nº 42	16	
	3er Nivel	Nº	Criterios de Exclusión	
	Otros	Nº	Sin interés para mi tema de investigación	361
			Déficit de calidad del estudio	
			Dificultades para la obtención de fuentes primarias	
Base de Datos Específica 2	Web Of Science			
Combinaciones	1er Nivel	Effects AND exercise AND pregnancy AND diabetes	3er Nivel	
	2do Nivel		Otros	
Límites introducidos	Búsquedas a 5 años			
Resultados	1er Nivel	Nº 250	Resultado final	
	2do Nivel	Nº	0	
	3er Nivel	Nº	Criterios de Exclusión	
	Otros	Nº	Sin interés para mi tema de investigación	244
			Déficit de calidad del estudio	
			Dificultades para la obtención de fuentes primarias	6
Base de Datos Específica 3				
Combinaciones	1er Nivel		3er Nivel	
	2do Nivel		Otros	
Límites introducidos				
Resultados	1er Nivel	Nº	Resultado final	
	2do Nivel	Nº		
	3er Nivel	Nº	Criterios de Exclusión	
	Otros	Nº	Sin interés para mi tema de investigación	
			Déficit de calidad del estudio	
			Dificultades para la obtención de fuentes primarias	

Base de Datos de Revisión 1	Cochrane			
Combinaciones	1er Nivel	Effects AND exercise AND pregnancy AND diabetes	3er Nivel	
	2do Nivel	Perinatal AND maternal AND outcomes AND exercise AND pregnancy AND diabetes	Otros	
Límites introducidos	Búsquedas a 5 años			
Resultados	1er Nivel	Nº 12	Resultado final	
	2do Nivel	Nº 9	1	
	3er Nivel	Nº	Criterios de Exclusión	
	Otros	Nº	Sin interés para mi tema de investigación	20
			Déficit de calidad del estudio	
			Dificultades para la obtención de fuentes primarias	
Base de Datos de Revisión 2	PEDro			
Combinaciones	1er Nivel	Effects AND exercise AND pregnancy AND diabetes	3er Nivel	
	2do Nivel		Otros	
Límites introducidos	Búsquedas a 5 años			
Resultados	1er Nivel	Nº 43	Resultado final	
	2do Nivel	Nº	0	
	3er Nivel	Nº	Criterios de Exclusión	
	Otros	Nº	Sin interés para mi tema de investigación	43
			Déficit de calidad del estudio	
			Dificultades para la obtención de fuentes primarias	

Obtención de la Fuente Primaria	
Directamente de la base de datos	
Préstamo Interbibliotecario	
Biblioteca digital de la UIB	
Biblioteca física de la UIB	
Otros (especificar)	

Anexo 2: Diagrama de flujo de resultados.



Anexo 3: Tabla PICO

Autor, año	Diseño	Muestra	Inclusión*	Exclusión*	G.Exp	G.Cont	Seguimiento	Variables	Resultados (pre-post)
Peters TM, Brazeau AS - 2019	Revisión sistemática	No se especifica ninguna muestra. La población son mujeres embarazadas con diabetes gestacional.	No se especifican criterios de inclusión.	No se especifican criterios de exclusión.	No se especifica el grupo experimental.	No se especifica el grupo control.	El ejercicio parece ser seguro para las mujeres embarazadas con diabetes ya que probablemente obtengan beneficios similares en el estado físico y el control del peso que las mujeres embarazadas sin diabetes. Además, las mujeres embarazadas con diabetes que hacen ejercicio obtienen beneficios adicionales, como un mejor control de la glucosa para las mujeres con diabetes gestacional, pero también enfrentan desafíos adicionales como el riesgo potencial de hipoglucemia en mujeres que toman insulina. Además, la necesidad de insulina puede retrasarse para las mujeres embarazadas que realizan ejercicio.	Tipo de ejercicio, entorno, momento, frecuencia y duración, intensidad, control glucémico, dosis de insulina, peso gestacional.	Los autores determinaron que las intervenciones de ejercicio aeróbico redujeron la glucosa en sangre capilar y pueden reducir la dosis y la necesidad de insulina. Por otro lado, el ejercicio de resistencia no afectó los niveles de glucosa, aunque un menor número de mujeres que participaron en el entrenamiento de resistencia requirieron insulina en comparación con los controles. Los beneficios y riesgos específicos del ejercicio para las mujeres embarazadas con diabetes tipo 2 no están claros. En cuanto a los efectos del ejercicio sobre los resultados maternos y neonatales, en la diabetes tipo 2 el flujo sanguíneo de la arteria umbilical

									medido por ecografía Doppler mejoró en el grupo de ejercicio, con índices más bajos de resistencia y pulsatilidad que sugieren una mejor placentación, lo que puede conferir mejores resultados fetales en embarazos de alto riesgo. En cuanto a la diabetes tipo 1, después de una intervención con ejercicio, no hubo diferencia en el aumento de peso gestacional, pero tenían menos probabilidades de tener una cesárea. Además, la descendencia de mujeres con diabetes tipo 1 en el grupo de ejercicio experimentó menos hipoglucemia, hipocalcemia, hiperbilirrubinemia y macrosomía en comparación con los controles, aunque no se observaron diferencias para el peso neonatal o el

									índice de masa corporal.
Brown J, Ceysens G, Boulvain M - 2017	Revisión sistemática	Mujeres embarazadas con diagnóstico de diabetes gestacional. 11 ensayos aleatorios con 638 mujeres. 222 bebés en total entre los ensayos elegidos.	Mujeres embarazadas con diagnóstico de diabetes mellitus gestacional. Se incluyó cualquier tipo de programa de ejercicios (+/- atención estándar) dirigido a mujeres con DMG en cualquier etapa del embarazo en comparación con 1) atención estándar u 2) otra intervención.	Se excluyó a las mujeres con diabetes pregestacional conocida.	Grupo de ejercicio, intervención experimental: programa de ejercicio domiciliario de 5 sesiones por semana continuadas hasta la semana 34 de gestación. Se supervisaron 3 sesiones por semana, 2 sin supervisión, utilizando un cicloergómetro estacionario en posición vertical. Las sesiones fueron de 25 a 30 minutos en la semana 1, aumentando a 40-45 minutos en la semana 4	Grupo de control: continuó con su régimen habitual de actividad física durante la duración de la intervención.	Para la mujer, las concentraciones de glucosa en sangre tanto en ayunas como después de una comida se redujeron en comparación con los grupos de control. Actualmente, no hay datos suficientes para que podamos determinar si también hay beneficios para el bebé.	Presión arterial, edad gestacional, glucosa en sangre, índice de masa corporal	Para las madres, el ejercicio no pareció reducir el riesgo de preeclampsia como medida de los trastornos hipertensivos del embarazo (dos ensayos, 48 mujeres, evidencia de baja calidad), parto por cesárea (cinco ensayos, 316 mujeres, evidencia de calidad moderada) o el riesgo de inducción del trabajo de parto (un ensayo, 40 mujeres, evidencia de baja calidad). Las madres tenían un índice de masa corporal similar durante el seguimiento en los grupos de ejercicio y control (tres ensayos, 254 mujeres, evidencia de alta calidad). El ejercicio se asoció con niveles más bajos de glucosa en sangre en ayunas (cuatro ensayos) y niveles de glucosa en

					(n = 20).				sangre después de una comida (tres ensayos). Los programas de ejercicio variaron entre los ensayos, al igual que su duración y si fueron supervisados o no. Ninguno de los ensayos incluidos informó sobre el trauma perineal, la depresión posparto o el desarrollo de diabetes tipo 2. Para los bebés, no ocurrieron muertes alrededor del momento del nacimiento (un ensayo, 19 bebés, evidencia de baja calidad) y no hubo evidencia de ninguna diferencia en el riesgo de mala salud (dos ensayos, 169 bebés, evidencia de calidad moderada) o niveles bajos de azúcar en sangre (un ensayo, 34 bebés, evidencia de baja calidad). Ninguno de los ensayos informó

									el número de bebés grandes para la edad gestacional o bebés que desarrollaron diabetes en la niñez o la edad adulta o discapacidad neurosensorial que se hizo evidente durante la niñez.
Sklempe Kokic I, Ivanisevic M, Biolo G, Simunic B, Kokic T, Pisot R. - 2018	ECA	42 mujeres embarazadas (entre 20 y 40 años) diagnosticadas con diabetes mellitus gestacional divididas al azar en dos grupos. El límite superior para la edad gestacional en el momento de la inclusión se estableció en 30 semanas, para permitir un período mínimo de ejercicio de 6 semanas, hasta al menos la semana 36 de embarazo. De las 42 mujeres, se quedaron 38 ya	Los criterios de inclusión fueron: un diagnóstico establecido de diabetes gestacional de acuerdo con los criterios publicados por la Asociación Internacional de Grupos de Estudio de Diabetes y Embarazo, 21 entre 20 y 40 años. El límite superior para la edad gestacional en el momento de la inclusión se estableció en 30 semanas, para permitir un período mínimo de ejercicio de 6 semanas, hasta al	Los criterios de exclusión fueron: antecedentes médicos de diabetes y abortos espontáneos, tratamiento farmacológico antes de la inscripción en el ensayo, comorbilidades existentes y contraindicaciones para el ejercicio según se describe en los criterios publicados por el Colegio Americano de Obstetras y Ginecólogos.	El grupo experimental se trató con atención prenatal estándar para la diabetes mellitus gestacional y un programa de ejercicio supervisado regular más caminatas diarias enérgicas de al menos 30 minutos. El programa de ejercicios se inició desde el momento del diagnóstico de diabetes	El grupo de control recibió solo atención prenatal estándar para la diabetes mellitus gestacional	Una de las limitaciones de este estudio fue la falta de seguimiento.	Tipo de ejercicio, frecuencia y duración, intensidad, sensibilidad a la insulina, glucosa en sangre, frecuencia cardíaca.	Si bien el nivel promedio de glucosa en ayunas fue más bajo en el grupo experimental, esto no fue significativo (P = 0,367). Sin embargo, cuando se calculó un promedio de 3 niveles de glucosa posprandial, esto fue significativamente menor en el grupo experimental (P <0,001, d = 1,38, r = 0,57). El nivel de glucosa en ayunas se correlacionó positivamente con la masa corporal en las semanas 30 y 36 de embarazo. Hubo una fuerte correlación negativa entre el deporte y los

		que 4 abandonaron el ensayo.	menos la semana 36 de embarazo.		hasta el nacimiento. Se realizó dos veces por semana y las sesiones duraron 50 - 55min.				niveles de ejercicio en las semanas 30 y 36 de embarazo y una correlación positiva entre los niveles de inactividad y los niveles de glucosa posprandial. No hay correlación entre los parámetros glucémicos y: duración de la intervención, adherencia al protocolo o número de sesiones de ejercicio asistidas.
Savvaki D, Taousani E, Goulis DG, Tsirou E, Voziki E, Douda H, Nikolettos N, Tokmakidis SP. - 2018	Revisión sistemática	No se especifica, ya que, al ser una revisión sistemática, no habla de muestras concretas.	No se especifican criterios de inclusión.	No se especifican criterios de exclusión.	No se especifica el grupo experimental.	No se especifica el grupo control.	Se ha visto que el ejercicio físico reduce el riesgo de diabetes gestacional y, posiblemente, hipertensión inducida por el embarazo y preeclampsia. Además, los ejercicios aeróbicos como los de resistencia se consideran seguros y no ejercen ningún efecto adverso durante el embarazo.	Peso, sensibilidad a la insulina, tensión arterial, transferencia de oxígeno, difusión de CO_2, niveles de glucosa en sangre.	Todas las guías recomiendan un entrenamiento aeróbico de 60 a 150 min/semana, con un límite superior de 30 min/día. El ejercicio es seguro, incluso a diario. El ejercicio de resistencia es sugerido por cinco guías nacionales (Australia, Canadá, Dinamarca, Noruega y Reino Unido). Existen discrepancias con respecto a la

									intensidad recomendada de ejercicio. Canadá, Japón, España y Reino Unido utilizan criterios objetivos (frecuencia cardíaca y consumo máximo de oxígeno) y subjetivos (escala de Borg y test del habla) para determinar la efectividad y seguridad del ejercicio. Solo Canadá brinda recomendaciones específicas, según la edad de la mujer y el nivel de condición física. Las mujeres con diabetes gestacional sin tratamiento con insulina no necesitan tomar precauciones adicionales durante el ejercicio. Sin embargo, debido a su condición de hiperglucemia, deben cumplir con la recomendación emitida para diabetes tipo 2. La prescripción y

									supervisión del ejercicio debe realizarse de forma similar a los embarazos sin complicaciones. Finalmente, las mujeres con diabetes gestacional en tratamiento con insulina deben seguir las mismas recomendaciones que para las mujeres embarazadas con diabetes tipo 1.
Sklempe Kokic I, Ivanisevic M, Kokic T, Simunic B, Pisot R. - 2018	ECA	18 mujeres embarazadas (edad: 32,8 ± 3,8) diagnosticadas con DMG.	Los criterios de inclusión fueron: diagnóstico establecido de DMG y edad entre 20 y 40 años.	Los criterios de exclusión fueron: diabetes diagnosticada antes del embarazo, tratamiento farmacológico de la DMG, comorbilidades existentes y contraindicaciones para el ejercicio según el Colegio Americano de Obstetras y Ginecólogos.	Grupo experimental: tratadas con terapia de nutrición médica, cambio de estilo de vida y sesiones regulares de ejercicio supervisado.	Grupo de control: tratadas con terapia de nutrición médica y cambio de estilo de vida.	La intervención de ejercicio consistió en un programa de ejercicio aeróbico y de resistencia estructurado individualmente realizado dos veces por semana desde el momento del diagnóstico hasta al menos las 36 semanas de embarazo. El programa de ejercicios incluyó 20 minutos de ejercicio aeróbico, 20-25 minutos de ejercicio de resistencia y 10 minutos de enfriamiento.	Glucosa en sangre, frecuencia cardíaca materna y fetal, presión arterial, temperatura timpánica, índice de masa corporal.	Los niveles de glucosa cayeron desde la línea de base, de 4,7 ± 0,6 a 3,9 ± 0,4 mmol/L. No hubo diferencias en las respuestas al ejercicio entre 2º y 3er trimestre, ni entre las que hacen ejercicio antes del embarazo y las que no hacen ejercicio. La combinación de ejercicio aeróbico y de resistencia para mujeres diagnosticadas con DMG no tiene efectos dañinos a

									corto plazo si se realiza de acuerdo con las pautas. Asimismo, el ejercicio puede considerarse útil para controlar la hiperglucemia en el embarazo en mujeres afectadas por DMG.
Ming WK, Ding W, Zhang CJP, Zhong L, Long Y, Li Z, Sun C, Wu Y, Chen H, Chen H, Wang Z. - 2018	Revisión sistemática, metaanálisis.	Ocho ensayos clínicos aleatorios, incluyendo un total de 3256 mujeres embarazadas, fueron elegidos para este metaanálisis.	Se incluyeron ensayos controlados aleatorios que investigaron el efecto preventivo del ejercicio sobre la DMG en mujeres de peso normal.	Se excluyeron las intervenciones que incluían cualquier factor de confusión (p. ej. dietético).	El grupo de intervención incluyó ejercicio.	Las mujeres embarazadas del grupo de control recibieron atención prenatal regular en todos los ensayos.	Todas las intervenciones adoptaron programas integrales de ejercicio de intensidad ligera a moderada que se realizaron tres veces por semana. La duración de cada período de ejercicio osciló entre 35 y 60 min. Siete ensayos comenzaron en el primer trimestre y continuaron hasta el final del tercer trimestre, y solo un ensayo abarcó las semanas 20 a 36 de gestación.	Peso de las mujeres, peso gestacional, edad gestacional, peso al nacer, probabilidad de cesárea, tensión arterial,	Se incluyeron ocho estudios en esta revisión sistemática y metaanálisis. Se demostró que el ejercicio durante el embarazo disminuye la aparición de DMG [RR = 0,58; IC del 95% (0,37; 0,90), P = 0.01 y RR = 0.60, IC del 95% (0.36, 0.98), P = 0,04 basado en diferentes criterios de diagnóstico, respectivamente] en mujeres de peso normal. Con respecto a los resultados secundarios, el ejercicio durante el embarazo puede disminuir el aumento de peso gestacional [MD = - 1,61, IC del 95% (- 1,99, - 1,22),

									P < 0.01], y no tuvo efectos significativos sobre la edad gestacional al nacer [MD = - 0,55, IC del 95% (- 1,57, 0,47), P = 0,29], peso al nacer [DM = - 18,70, IC del 95% (- 52,49, 15,08), P = 0,28] y las probabilidades de cesárea [RR = 0,88; IC del 95% (0,72; 1,08), P = 0,21], respectivamente. Además, el ejercicio durante el embarazo también puede disminuir el riesgo de hipertensión gestacional, parto prematuro y macrosomía, lo que puede disminuir significativamente la morbilidad y mortalidad perinatal.
Bianchi C, Battini L, Aragona M, Lencioni C, Ottanelli S, Romano M, Calabrese M, Cuccuru I, De Bellis A, Mori ML, Leopardi A,	Revisión sistemática	Al tratarse de una revisión sistemática, no se especifica la población. Se sabe que son mujeres embarazadas.	No se especifican criterios de inclusión debido a que es una revisión de la evidencia.	No se especifican criterios de exclusión debido a que es una revisión de la evidencia.	No se especifica el grupo experimental.	No se especifica el grupo control.	Además del ejercicio físico, el enfoque para la DMG incluye: educación materna, modificaciones de la dieta, tratamiento farmacológico y vigilancia fetal. Durante el embarazo,	Glucosa en sangre, frecuencia cardíaca, tensión arterial, esfuerzo percibido.	Se ha demostrado que el ejercicio es una herramienta terapéutica beneficiosa durante el embarazo. Es seguro y ventajoso para las funciones cardiovasculares

Sabbatini G, Bottone P, Miccoli R, Trojano G, Salerno MG, Del Prato S, Bertolotto A - 2017							se asegura que no surjan complicaciones ni contraindicaciones que dificulten el tratamiento con ejercicio físico y pueda provocar consecuencias.		(estado físico, presión arterial, edema periférico), preeclampsia, venas varicosas y trombosis venosa profunda, disminuyó el dolor lumbar y tuvo beneficios sobre el estado de ánimo y el bienestar psicológico; disminución del riesgo de parto prematuro, duración del trabajo de parto y complicaciones del parto; además, el ejercicio tiene un papel importante en la limitación del aumento de peso y la retención de grasa después del parto, mejorando la autoimagen. Además, los estudios observacionales apoyan la actividad física como una herramienta útil para reducir el riesgo de DMG, y un metaanálisis reciente de 10 ensayos de intervención elegibles mostró una reducción

									del riesgo del 28% (IC del 95%: 9-42%) en la intervención en comparación con el grupo control, proporcionando un efecto protector contra el desarrollo de DMG. En el tratamiento de mujeres con DMG, existe evidencia de que el ejercicio, particularmente el entrenamiento aeróbico estructurado y/o de resistencia, es una terapia complementaria beneficiosa.
Barakat R, Refoyo I, Coteron J, Franco E. - 2018	ECA	Un total de 594 embarazadas sanas de habla hispana (caucásicas). Completaron el estudio un total de 456 participantes.	Mujeres con embarazos únicos y sin complicaciones (sin diabetes tipo 1, 2 o gestacional al inicio del estudio), sin antecedentes ni riesgo de parto prematuro (es decir, ≥ 1 parto prematuro anterior) y que no participaron en ningún otro	Las mujeres que no planeaban dar a luz en el mismo hospital obstétrico o sin seguimiento médico durante el embarazo no se incluyeron en el estudio. Tampoco se incluyó a las mujeres que tenían alguna afección médica grave	Las mujeres que fueron asignadas al azar al Grupo de Ejercicios (EG) recibieron una atención estándar similar y realizaron un programa de ejercicios durante el embarazo.	Las mujeres asignadas al azar al grupo de control (GC) recibieron atención obstétrica estándar de profesion	Se realizó un programa de intervención de ejercicio moderado tres días a la semana (55-60 min por sesión) desde la semana 8-10 de embarazo (inmediatamente después de la primera ecografía prenatal) hasta el final del tercer trimestre (semanas 38-39). El programa constaba de: calentamiento gradual, ejercicios aeróbicos,	Frecuencia cardíaca, peso gestacional, esfuerzo percibido y nivel de glucosa en sangre.	Se evaluó la elegibilidad de 594 mujeres embarazadas y se incluyeron 456 (EG n = 234; CG n = 222). Los resultados mostraron un mayor porcentaje de gestantes con aumento de peso excesivo en el grupo control que en el grupo experimental (30,2% vs 20,5% respectivamente; odds ratio, 0,597;

			ensayo.	(contraindicaciones) que les impidiera hacer ejercicio de manera segura. Se excluyó a las mujeres si no se ajustaban a las especificaciones del grupo asignado		ales de la salud.	fortalecimiento muscular ligero, ejercicios de coordinación y equilibrio, ejercicios de estiramiento, fortalecimiento del suelo pélvico, relajación y charla final.		intervalo de confianza del 95%, 0,389-0,916; p = 0,018). De manera similar, la prevalencia de diabetes gestacional fue significativamente mayor en el grupo control que en el grupo experimental (6,8% frente a 2,6% respectivamente; razón de posibilidades, 0,363; intervalo de confianza del 95%, 0,138-0,953; p = 0,033).
Geranmayeh M, Bikdeloo S, Azizi F, Mehran A. - 2019	Estudio cuasiexperimental, casos y controles	Los participantes incluyeron 80 mujeres embarazadas con diabetes mellitus gestacional. Durante el estudio, cinco mujeres del grupo de control y dos mujeres del grupo de intervención fueron excluidas del estudio debido a la	Edad gestacional de 24 a 26 semanas, diagnóstico de diabetes gestacional por un médico, controlar la diabetes gestacional usando dieta, habilidad para hablar y comprender el farsi.	Historia de trastornos psicológicos, historia de asma, presión arterial crónica o enfermedades renales y cardíacas, historia de aborto espontáneo, muerte fetal, muerte de recién nacidos o infertilidad, uso	Técnicas de relajación cuerpo-mente + folleto educativo + técnicas respiratorias + seguimiento telefónico.	Educación de rutina en la clínica + información sobre enfermedades, autocuidado, dieta y ejercicios para el embarazo.	Al grupo de intervención se le enseñaron técnicas de relajación cuerpo-mente durante 10 semanas. Se enseñó a grupos de 1 a 4 participantes en sesiones semanales de 45 minutos utilizando una técnica de juego de roles y un folleto educativo. Al inicio de las sesiones 1-2, el investigador se acostó en la cama en posición	Niveles de glucosa en sangre, niveles de cortisol plasmático, presión arterial, secreción de adrenalina, pulso, actividad simpática.	No se observó una diferencia estadísticamente significativa entre la puntuación media de glucosa en sangre en ayunas antes y después del estudio en el grupo de control (P = 0,051). El azúcar en sangre en ayunas en el grupo de control no mostró cambios antes y después del período de estudio, pero en el grupo de

		necesidad de inyecciones de insulina. Dos participantes fueron excluidas del estudio antes de la quinta semana. Estos participantes fueron reemplazados por otros nuevos.		de medicamentos que afectan el azúcar en sangre y la presión, uso de inyecciones de insulina, interrupción del embarazo, eventos estresantes, como la muerte de un familiar, disputas familiares graves, accidentes o cirugía durante el período de estudio, no completar los ejercicios de relajación durante más de 3 días consecutivos, falta de voluntad para participar, complicaciones del embarazo, como hemorragia en el tercer trimestre e infección grave,			lateral y realizó técnicas respiratorias y ejercicio. Se pidió a los participantes que hicieran los ejercicios en presencia del investigador y luego en casa dos veces al día con la ayuda de CD educativos. Se registró el desempeño de las técnicas en casa. Al final de cada semana, el investigador hizo un seguimiento telefónico de los participantes del grupo de intervención para enfatizar la importancia de realizar los ejercicios con regularidad. El contenido educativo de cada sesión cubrió temas importantes y comunes del embarazo, el mecanismo y las causas de la diabetes, la naturaleza del estrés y su impacto en el cuerpo, los factores estresantes del embarazo y el parto vaginal. El investigador brindó una visión general de los materiales educativos		intervención, esta diferencia fue estadísticamente significativa y se redujo ($P < 0{,}001$). Hubo una diferencia estadísticamente significativa entre la presión arterial sistólica media antes y después del estudio en ambos grupos ($P < 0.001$) - esto se incrementó en el grupo de control y se redujo en el grupo de intervención. También hubo una reducción estadísticamente significativa en la presión arterial diastólica media antes y después del estudio en el grupo de control ($P = 0.02$). Hubo una pequeña reducción en el grupo de intervención, aunque esto no fue estadísticamente significativo ($P = 0{,}461$).

				necesidad de intervenciones psiquiátricas, incluidas visitas al psiquiatra y uso de medicamentos.			proporcionados y los ejercicios realizados en la sesión anterior. Además, se recopilaron listas de verificación de los ejercicios, se respondieron preguntas y se controló la idoneidad de la realización de los ejercicios. El grupo de control recibió educación de rutina en la clínica, con información sobre enfermedades, autocuidado, dieta y ejercicios para el embarazo. Cabe señalar que las participantes del grupo control también tuvieron embarazos de alto riesgo y por esta razón tuvieron sesiones prenatales más frecuentes que embarazos de bajo riesgo. Durante el período de estudio, también fueron visitadas una vez cada 10-14 días, pero no recibían llamadas telefónicas. Al final del estudio, se entregaron		

							los folletos educativos al grupo de control.		
Wang C, Wei Y, Zhang X, Zhang Y, Xu Q, Sun Y, Su S, Zhang L, Liu C, Feng Y, Shou C, Guelfi KJ, Newnham JP, Yang H. - 2017	ECA	300 mujeres chinas embarazadas, 150 en el grupo experimental y 150 en el grupo control. Acaban el estudio 112 mujeres en el grupo experimental y 114 mujeres en el grupo control. 39 y 38 participantes eran obesas en cada grupo, respectivamente.	Se determinó sobrepeso y obesidad basado en las recomendaciones del índice de masa corporal (IMC) del Grupo de China sobre obesidad del Ministerio de Salud chino contabilizando diferencias interraciales: sobrepeso IMC 24-<28 kg/m2 y obesidad IMC 28 kg/m2. Embarazadas no fumadoras con un IMC antes del embarazo de 24 kg/m2 a <12+6 semanas de gestación fueron elegibles para el estudio.	Los criterios de exclusión fueron los siguientes: (1) edad <18 años; (2) mujeres que no están dispuestas a proporcionar consentimiento informado; (3) mujeres con insuficiencia cervical (histórico dilatación cervical indolora que conduce a partos recurrentes en el segundo trimestre en ausencia de otras causas; cuello uterino dilatado en examen manual o con espéculo; ultrasonido transvaginal longitud cervical <25 mm a <24 semanas de	Los participantes asignados en el grupo de intervención realizaron un programa de ciclismo supervisado que incluía al menos 3 sesiones por semana.	Los participantes asignador al grupo control continuaron con sus actividades diarias habituales y no se desanimó a participar en sesiones de ejercicio por su cuenta.	Al inicio de la intervención, cada sesión de ejercicio consistió en ciclismo estacionario durante 30 minutos, comenzando con 5 minutos calentamiento a baja intensidad, que fue 55-65% de la frecuencia cardíaca prevista para la edad máximo (FC máx.) y una clasificación de esfuerzo percibido (RPE) según Escala Borg entre 9-11. RPE es la puntuación percibida de dificultad cuando se realiza ejercicio, y se utiliza con frecuencia para controlar subjetivamente la intensidad del ejercicio según la percepción individual. A continuación, los participantes completaron un período de ciclismo a intervalos que constaba de 30 segundos de pedaleo rápido	Niveles de glucosa en sangre, esfuerzo percibido, frecuencia cardíaca, edad, índice de masa corporal, peso gestacional, resistencia a la insulina.	Las mujeres asignadas al azar al grupo de ejercicio tuvieron una significativa menor incidencia de diabetes mellitus gestacional (22,0% vs 40,6%; P < 001). Esto representa una reducción clínicamente importante del 45,8% en la incidencia de DMG. Estas mujeres también tuvieron un aumento de peso gestacional significativamente menor a las 25 semanas de gestación y al final del embarazo y niveles reducidos de resistencia a la insulina a las 25 semanas de gestación. Otros resultados secundarios, incluido el aumento de peso gestacional entre las 25-36 semanas de gestación, niveles de resistencia a la

				gestación en embarazo único con 1 parto espontáneo prematuros a las 14-36 semanas); (4) mujeres en cualquier medicación para enfermedades preexistentes como hipertensión, diabetes, enfermedad cardíaca, enfermedad renal, lupus eritematoso sistémico, enfermedad de la tiroides o psicosis; y (5) mujeres que estaban siendo tratadas con metformina o corticosteroides.			(esprints, esfuerzos de mayor intensidad) al 75-85% FC máx. y RPE 15-16 cada 2 minutos durante 3-5 intervalos. Este sprint fue seguido por 5 minutos de ciclismo continuo a intensidad baja-moderada (60-70% de la FC máx.; RPE 10-12) antes de comenzar otro período de intervalos.		insulina a las 36 semanas de gestación, trastornos hipertensivos del embarazo, parto por cesárea (excepto útero cicatricial), edad gestacional media al nacer, parto prematuro, macrosomía (definida como peso al nacer> 4000 g) y lactantes grandes para la edad gestacional también fueron menores en el grupo de ejercicio en comparación con el grupo de control, pero sin diferencia significativa. Sin embargo, los bebés nacidos de las mujeres que siguieron la intervención de ejercicio tuvieron un peso al nacer significativamente más bajo en comparación con los nacidos de mujeres asignadas al grupo control.
Davenport MH, Ruchat SM, Poitras VJ,	Revisión sistemáti ca,	Mujeres embarazadas sin contraindicación	Se incluyeron estudios de todos los diseños	Se excluyeron los estudios si el ejercicio se	Intervención con ejercicio físico.	No se especific an los	Las intervenciones que combinan ejercicio + cointervenciones	Tensión arterial, frecuencia, intensidad, duración, volumen o	Las pruebas de calidad 'moderada' a 'alta' de los ensayos

Jaramillo Garcia A, Gray CE, Barrowman N, Skow RJ, Meah VL, Riske L, Sobierajski F, James M, Kathol AJ, Nuspl M, Marchand AA, Nagpal TS, Slater LG, Weeks A, Adamo KB, Davies GA, Barakat R, Mottola MF. - 2018	metaanálisis	absoluta o relativa para el ejercicio. Se incluyeron un total de 106 estudios (n=273182).	(excepto estudios de caso) si se publicaron en inglés, español o francés, y contenían información sobre población (mujeres embarazadas sin contraindicación para el ejercicio), intervención (medidas subjetivas u objetivas de frecuencia, intensidad, duración, volumen o tipo de ejercicio, solo ["solo ejercicio"] o en combinación con otros componentes de la intervención [por ejemplo, dietético; "ejercicio + cointervención"]), comparador (sin ejercicio o diferente frecuencia, intensidad, duración, volumen y tipo de ejercicio) y resultados	realizó después del comienzo del trabajo de parto. Se excluyeron las revisiones narrativas o sistemáticas y los metaanálisis.		grupos de control.	fueron menos efectivas que el ejercicio solo para DMG (p = 0,007), GH (p = 0,04) y EP (p = 0,05). Por lo general, estos estudios fueron intervenciones de asesoramiento sobre estilos de vida saludables (incluida la dieta y actividad física) en mujeres embarazadas con sobrepeso u obesidad. En estas intervenciones, las mujeres no fueron supervisadas durante el ejercicio y el 67% de los estudios informaron un cumplimiento deficiente (definido como < 60% de los participantes que realizaron el 100% de las sesiones de ejercicio prescritas). Se ha sugerido que la supervisión es fundamental para el cumplimiento y el efecto de la intervención. Por tanto, el cumplimiento de la intervención de ejercicio puede ser un	tipo de ejercicio, índice de masa corporal, sensibilidad a la insulina, peso gestacional.	controlados aleatorios revelaron que las intervenciones de solo ejercicio, pero no las cointervenciones de ejercicio +, redujeron las probabilidades de DMG (n = 6934; OR 0,62; IC del 95%: 0,52 a 0,75), GH (n = 5316; OR 0,61; IC del 95%: 0,43 a 0,85) y PE (n = 3322; OR 0,59; IC del 95%: 0,37 a 0,9) en comparación con ningún ejercicio. Para lograr al menos una reducción del 25% en las probabilidades de desarrollar DMG, PE y GH, las mujeres embarazadas deben acumular al menos 600 MET-min/semana de ejercicio de intensidad moderada (p. ej., 140 minutos de caminata rápida, aeróbicos acuáticos, ciclismo estacionario o entrenamiento de resistencia).

			(GDM, GH, PE). Fueron elegibles los estudios primarios de cualquier diseño, excepto los estudios de casos.				determinante crítico del efecto protector del ejercicio sobre la diabetes gestacional y los trastornos hipertensivos del embarazo; esto podría estar relacionado con la realización real de la intervención según lo previsto. Aunque muchos estudios informaron un cumplimiento deficiente de la intervención prescrita, nuestros hallazgos demostraron una reducción sustancial en el riesgo de desarrollar DMG, GH y EP. Esto sugiere que el efecto protector del ejercicio contra estas enfermedades puede ser aún mayor en las mujeres que se ajustan al ejercicio.		
Yu Y, Xie R, Shen C, Shu L. - 2017	Revisión sistemáti ca, metaanáli sis	6ECA con 2164 pacientes.	Los criterios de inclusión de estudios fueron los siguientes: población de estudio, gestante; intervención,	No se especifican criterios de exclusión de estudios.	Intervención con ejercicio.	Activida des diarias habituale s.	-	Edad gestacional, nivel de glucosa en sangre, peso al nacer, puntuación de Apgar.	En comparación con la intervención de control, la intervención con ejercicios se asoció con una incidencia significativamente

			ejercicio; control, cuidado estándar; medida de resultado, incidencia de diabetes mellitus gestacional; y diseño del estudio, ECA.						menor de diabetes mellitus gestacional (diferencia de medias estándar ¼ 0,59; IC del 95% ¼ 0,39 -. 88; pag ¼. 01), pero no tuvo ningún efecto sobre la edad gestacional al nacer (diferencia de medias estándar ¼ 0,03; IC del 95% ¼ 0,12 a 0,07; pag ¼. 60), el número de nacimientos prematuros (O ¼ 0,85; IC del 95% ¼ 0,43 - 1,66; pag ¼. 63), glucosa 2 horas después de la prueba de tolerancia a la glucosa oral (OGTT) (diferencia media estándar ¼ 1,02; IC del 95% ¼ 2,75 a 0,71; pag ¼. 25), peso al nacer (diferencia media estándar ¼ 0,13; IC del 95% ¼ 0,26 a 0,01; pag ¼. 06) y una puntuación de Apgar inferior a 7 (OR ¼. 78; IC del 95% ¼ 0,21 - 2,91; pag ¼. 71).

Di Biase N, Balducci S, Lencioni C, Bertolotto A, Tumminia A, Dodesini AR, Pintaudi B, Marcone T, Vitacolonna E, Napoli A. - 2018	Revisión sistemática	Mujeres embarazadas con diabetes gestacional o con posibilidad de desarrollarla.	Se incluyeron ECA, estudios prospectivos en idioma inglés, revisiones, metaanálisis y publicaciones de la Colaboración Cochrane.	Se excluyeron los artículos con pocos informes de casos o estudios retrospectivos no justificados, estudios en idioma no inglés o metodológicamente incorrectos.	El grupo de intervención realizaba ejercicio físico.	Al grupo de control se le daban recomendaciones genéricas para aumentar la actividad física.	El ejercicio aeróbico o de resistencia, realizado a una intensidad moderada al menos tres veces por semana, ayuda de manera segura a controlar las concentraciones de glucosa en sangre posprandial y otras medidas de control glucémico en mujeres diagnosticadas con DMG. Durante el embarazo, un programa estructurado de AF puede ayudar a las mujeres con DM1 sin complicaciones a lograr un control metabólico óptimo. La monitorización continua de la glucosa durante la AF en mujeres embarazadas con diabetes mellitus insulinodependiente podría ser útil para realizar la AF de forma segura. La monitorización debe tener como objetivo mantener la glucemia en aproximadamente 6,7 mmol/l.	Intensidad, frecuencia, duración y tipo de ejercicio, sensibilidad a la insulina, niveles de glucosa en sangre, frecuencia cardíaca, esfuerzo percibido (Borg), peso materno.	Las mujeres diagnosticadas con DMG tienen un mayor riesgo de desarrollar diabetes mellitus tipo 2 (DM2) en años posteriores. Un estudio más reciente informó que el entrenamiento de resistencia tres veces a la semana durante 30 minutos durante el embarazo es seguro y conduce a una reducción en la incidencia de DMG y mejora los resultados perinatales. Estas publicaciones apuntan a la conclusión de que para reducir la incidencia de DMG, es necesaria una combinación de ejercicio aeróbico y de acondicionamiento muscular a la intensidad y frecuencia utilizadas. Las intervenciones con ejercicios pueden ser útiles para ayudar con el control glucémico y pueden

									mejorar los resultados maternos y fetales. El ejercicio mejora la sensibilidad a la insulina y aumenta la absorción de glucosa. El ejercicio aeróbico o de resistencia, realizado a una intensidad moderada al menos tres veces por semana, ayuda de manera segura a controlar las concentraciones de glucosa en sangre posprandial y otras medidas de control glucémico en mujeres diagnosticadas con DMG. Durante el embarazo, un programa estructurado de AF puede ayudar a las mujeres con DM1 sin complicaciones a lograr un control metabólico óptimo.
Zheng J, Wang H, Ren M. - 2017	Revisión sistemática, metaanálisis	Cinco ensayos clínicos aleatorizados con 1872 mujeres embarazadas.	Los criterios de inclusión fueron los siguientes: población de estudio, gestante; intervención, ejercicio a las 10–	No se especifican los criterios de exclusión.	El grupo experimental fue intervenido con ejercicio físico.	El grupo de control realizó actividades diarias habituale	-	Edad gestacional, niveles de glucosa en sangre, peso al nacer, puntuación de Apgar, duración e intensidad del ejercicio, tensión arterial.	En general, en comparación con la intervención de control, se encontró que la intervención con ejercicios reduce significativamente el

			22 semanas de embarazo; control, cuidado estándar; medida de resultado, incidencia de diabetes mellitus gestacional, parto prematuro y edad gestacional al nacer; y diseño del estudio, ECA.			s.			riesgo de diabetes mellitus gestacional (diferencia de medias estándar 0,62; IC del 95%: 0,43 a 0,89; P = 0,01), pero no demostró influencia sobre el parto prematuro (OR 0,93; IC del 95% 0,44–1,99; P = 0,86), edad gestacional al nacer (diferencia media estándar - 0,03; IC del 95% - 0,12 a 0,07; P = 0,60), glucosa 2 horas después de la OGTT (diferencia media estándar - 1,02; IC del 95% - 2,75 a 0,71; P = 0,25), peso al nacer (diferencia media estándar - 0,10; IC del 95% - 0,25 a 0,04; P = 0,16), puntuación de Apgar inferior a 7 (OR 0,78; IC del 95%: 0,21 a 2,91; P = 0,71) y preeclampsia (OR 1,05; IC del 95%: 0,53 a 2,07; P = 0,88). En comparación con la intervención de

									control, se encontró que la intervención con ejercicios redujo significativamente la incidencia de diabetes mellitus gestacional, pero no tuvo una influencia significativa en el parto prematuro, la edad gestacional al nacer, la glucosa 2 h después de la OGTT, el peso al nacer, la puntuación de Apgar menor de 7, y preeclampsia.
Nasiri-Amiri F, Sepidarkish M, Shirvani MA, Habibipour P, Tabari NSM. - 2019	Revisión sistemática, metaanálisis	Se incluyeron un total de ocho publicaciones con un tamaño de muestra de 1441 mujeres embarazadas.	Los criterios de inclusión consistieron en ensayos clínicos controlados aleatorios realizados en mujeres embarazadas obesas y con sobrepeso y todas las mujeres embarazadas de un solo hijo que no tenían ninguna contraindicación para hacer ejercicio.	Artículos de revisión y descriptivos, estudios sobre individuos no obesos y con sobrepeso, estudios cuyas intervenciones fueron tanto el ejercicio como otros estilos de vida como la modificación nutricional, los estudios que no compararon los grupos de control e	El grupo de intervención realizó un entrenamiento con ejercicios durante el embarazo además de la atención prenatal de rutina.	El grupo de control recibió atención prenatal de rutina.	En varios estudios, los programas de ejercicio comenzaron en el primer trimestre y continuaron hasta el parto. En tres estudios, las actividades de ejercicio comenzaron en el segundo trimestre y duraron hasta las 34-37 semanas de gestación. En dos estudios, las actividades de ejercicio comenzaron menos de 17 semanas (en el primer y segundo trimestre) y continuaron hasta 6	Glucosa plasmática en ayunas, frecuencia y duración del ejercicio, secreción de cortisol, índice de masa corporal.	El resultado principal del estudio reciente fue comparar la incidencia de diabetes gestacional en el grupo de intervención (entrenamiento con ejercicios durante el embarazo) y el grupo de control. En el caso de la incidencia de diabetes, se ingresaron ocho ensayos clínicos con un tamaño de muestra de 1441 en el metaanálisis. En consecuencia, 143 y

				intervención y no respondieron la pregunta de investigación fueron excluidos del estudio.			semanas después del parto. En un estudio, el programa de ejercicios se repitió dos veces por semana. En cuatro estudios, se repitió tres veces por semana. En un estudio, el programa de ejercicio se repitió diariamente durante una semana y se repitió de tres a cinco veces por semana en otro estudio. En todos los estudios, la duración del ejercicio fue de entre 15 y 60 min.		196 mujeres embarazadas padecían diabetes en el grupo de intervención y el grupo de control, respectivamente. Además, no hubo una relación estadísticamente significativa entre los estudios con intervención en el primer trimestre del embarazo y aquellos con intervención en el segundo trimestre del embarazo. En los estudios que tuvieron un tiempo de intervención de tres veces a la semana o menos, se observó el efecto de la intervención en la reducción de la incidencia de diabetes. Sin embargo, el efecto de la intervención sobre la reducción de la incidencia de diabetes no se observó en estudios con un

									tiempo de intervención de más de tres veces por semana. La glucosa plasmática en ayunas (FPG) se evaluó en seis ensayos clínicos con un tamaño de muestra de 819 participantes (423 y 396 en el grupo de intervención y el grupo de control, respectivamente), añadidos en el metaanálisis final. La media de FPG no tuvo diferencias significativas entre los grupos de intervención y control. Además, no se encontraron diferencias significativas entre los estudios con intervención en el primer trimestre del embarazo y aquellos con intervención en el segundo trimestre del embarazo. No hubo diferencias

									significativas entre los grupos de intervención y control en los estudios cuyo tiempo de intervención fue tres veces por semana o menos frente a estudios con intervención de más de tres veces por semana. La insulina plasmática en ayunas (FPI) se investigó en tres ensayos clínicos con un tamaño de muestra de 235 participantes (119 y 116 en los grupos de intervención y control, respectivamente), ingresados en el metaanálisis final. El FPI medio no tuvo diferencias significativas entre los grupos de intervención y control.
Bgeginski R, Ribeiro PAB, Mottola MF, Ramos JGL. -	Revisión sistemáti ca, metaanáli	Los ocho ECA incluidos en este análisis totalizaron 469	Los estudios que incluían mujeres embarazadas con diagnóstico de	Los estudios excluidos tenían criterios resumidos de la	91 mujeres con DMG conformaron el grupo de	143 mujeres con DMG	Los grupos de control recibieron UPN para mujeres con DMG y todos los grupos	Edad, concentraciones de glucosa en sangre en ayunas, duración del programa (en	El efecto general del ejercicio, supervisado o asesorado, no fue significativamente

2017	sis	mujeres embarazadas.	DMG en los que la asignación al tratamiento se asignó al azar, con un grupo de control que recibía atención prenatal estándar para la DMG se consideraron para una evaluación de elegibilidad adicional. Se requirió que los ECA tuvieran al menos un brazo de intervención de EXE, definido como sesiones de ejercicio realizadas con el personal del estudio al menos una vez a la semana durante todo el programa, o asesoramiento sobre AF en el que las mujeres con DMG recibieron asesoramiento para la actividad física o realizaron ejercicio sin ningún tipo de supervisión directa. Para su	siguiente manera: 1) intervenciones que consistían únicamente en ejercicios del suelo pélvico, estiramiento o relajación; 2) estudios sobre mujeres embarazadas diagnosticadas con diabetes tipo 1 o tipo 2 antes del embarazo; 3) estudios que analizaron intervenciones de ejercicio en factores de riesgo o prevención de DMG; 4) intervenciones que duraron menos de cuatro semanas; 5) estudios que no proporcionaron datos sobre glucosa en sangre; 6) estudios no publicados en	intervención con ejercicio físico.	conformaron el grupo de control y recibieron asesoramiento sobre actividad física.	recibieron asesoramiento nutricional adicional a las intervenciones. Para las pruebas de EXE, la frecuencia varió de 2 a 3 veces por semana y el tiempo de cada sesión supervisada varió de 20 a 45 minutos. La duración de las intervenciones varió de 4 a 7 semanas y finalizó al final del tercer trimestre o el parto. El modo de ejercicio supervisado incluía caminar, andar en bicicleta estacionaria, montar en bicicleta, entrenamiento de resistencia tipo circuito. La intensidad del ejercicio se evaluó mediante monitores de frecuencia cardíaca y la escala de Borg de esfuerzo percibido. Para los ensayos de asesoramiento sobre AF, la frecuencia varió de 2 a 7 veces por semana y el tiempo de cada sesión de ejercicio varió de 15 a 20	semanas), requerimientos de insulina, índice de masa corporal antes del embarazo, aumento de peso durante el embarazo, edad gestacional al nacer, peso y longitud al nacer y puntajes APGAR en 1 y 5 minutos.	diferente (P = 0,11) en comparación con las intervenciones de UPN sobre las concentraciones de glucosa en sangre en ayunas. Sin embargo, cuando se probaron las diferentes intervenciones de ejercicio, el asesoramiento sobre AF mostró una disminución significativa en las concentraciones de glucosa en sangre en ayunas de: 3,88 mg/dl versus control. Se examinó el tipo de intervención (modalidad de ejercicio) en los cambios absolutos de la glucemia en ayunas. El ejercicio aeróbico solo se eligió para la mayoría de los estudios, y el efecto general, no fue significativamente diferente (5 intervenciones, 219 pacientes; P = 0,30) en comparación con el control de las

			inclusión, se requirió que los estudios proporcionaran valores absolutos antes y después de la intervención de la glucemia en ayunas o diferencias entre los valores medios y de dispersión.	inglés, español, italiano o portugués. No se aplicaron restricciones con respecto al año de publicación.			minutos. La duración de las intervenciones varió de ocho a 14 semanas y finalizó al final del tercer trimestre o el parto. El modo de actividad física incluyó caminar, yoga y entrenamiento de resistencia en circuito y la intensidad del ejercicio se evaluó mediante el esfuerzo percibido.		concentraciones de glucosa en sangre en ayunas. Los resultados secundarios se analizaron solo para las pruebas de ejercicio supervisadas semanalmente, ya que las pruebas de asesoramiento sobre actividad física no informaron estos datos, y no fueron significativamente diferentes.
Laredo-Aguilera JA, Gallardo-Bravo M, Rabanales-Sotos JA, Cobo-Cuenca AI, Carmona-Torres JM. - 2020	Revisión sistemática	Las participantes de los siete artículos son mujeres embarazadas con DMG diagnosticada durante el embarazo cuyas edades oscilan entre los 18 y los 50 años. La muestra total de participantes es de 782 mujeres. La edad gestacional de las mujeres en el momento de la intervención es	Los criterios de inclusión incluyen publicaciones en los últimos 12 años (desde el 1 de enero de 2008 hasta el 31 de diciembre de 2019), la población de gestantes sin rango de edad con DMG diagnosticada en el embarazo y no a priori o después de la gestación, un tipo específico de ejercicio o actividad física realizado como	Los criterios de exclusión son los ensayos con animales y una cantidad o tipo de actividad física no específica por mujeres. También se descartaron los artículos que no diferenciaban la actividad física de la dieta de las gestantes. Se excluyeron todos los estudios de prevención de la	No se especifica el grupo experimental.	No se especifica el grupo control.	Las mujeres embarazadas con diabetes mellitus gestacional deben hacer ejercicio durante al menos 20 a 50 minutos como mínimo 2 veces por semana con una intensidad al menos moderada. La duración de las intervenciones varía entre 6 y 16 semanas; por lo tanto, no se puede establecer una duración específica. En cuanto al ejercicio, existen dos tipos de modalidades: actividad aeróbica (AA) y	Glucosa posprandial, niveles de hemoglobina glicosilada (HbcA1), requerimiento y la cantidad de insulina utilizada.	Ejercicios aeróbicos, de resistencia o una combinación de ambos son eficaces en el control de glucosa, HbcA1 e insulina. Debido a la variabilidad de los ejercicios de los estudios analizados y la variabilidad de la forma de las diferentes mujeres embarazadas, no permite recomendar un tipo de ejercicio en particular. Sin embargo, cualquier tipo de actividad física de intensidad y

		entre la semana 24 y el final del embarazo (aproximadamente la semana 40).	intervención, y estudios en inglés o español.	diabetes gestacional y las revisiones sistemáticas debido a una calidad científica inadecuada.			ejercicio de fuerza (RE) o una combinación de ambos, como en el estudio de Sklempe et al. Tres de las siete intervenciones mencionan la actividad aeróbica como una medida de intervención en el control de la DMG. La actividad aeróbica del estudio de Halse et al. consiste en utilizar una bicicleta estática con intervalos de mayor intensidad con una duración final de entrenamiento de 45 min en el último trimestre. Sin embargo, la actividad de Davenport et al. consiste en caminar de 3 a 4 veces por semana durante unos 40 min. En otro estudio, se analiza el efecto de una banda elástica utilizada para realizar un circuito de 8 ejercicios de resistencia, donde la duración del entrenamiento aumenta a medida que avanza el embarazo. Sklempe y col. combinan ambas		duración adecuadas pueden beneficiar a las mujeres embarazadas con DMG. Las mujeres embarazadas con DMG deben hacer ejercicio al menos de 20 a 50 minutos como mínimo dos veces por semana. La intensidad de la actividad debe ser al menos moderada. Si bien el ejercicio proporciona el mayor beneficio según los estudios analizados, la dieta también es importante para controlar los valores de glucosa, HbcA1 y la cantidad requerida de insulina. Debido a la escasez de artículos encontrados sobre el tema investigado, la influencia de la actividad física para el control de la DMG requiere una mayor investigación por parte de diferentes profesionales para un mejor control de la

							modalidades (AA y RE) y también incluyen ejercicios pélvicos y de estiramiento con la correspondiente relajación. El tipo de actividad de estudio que se realiza en Tailandia es el yoga. Esta forma de ejercicio se ha incluido dentro de la modalidad de ejercicios de resistencia. Durante ocho semanas, la población estudiada realizó este ejercicio dos veces por semana durante 50 min.		GDM.
Guelfi KJ, Ong MJ, Crisp NA, Fournier PA, Wallman KE, Grove JR, Doherty DA, Newnham JP. - 2016	ECA	Un total de 169 mujeres embarazadas completaron el estudio.	Los participantes fueron elegibles para la inclusión si tenían menos de 14 semanas de gestación, eran mayores de 18 años y podían participar en un programa de ejercicio de 14 semanas.	Mujeres con diabetes preexistente, prueba basal de tolerancia a la glucosa oral (OGTT) elevada, embarazo múltiple o una afección médica que restringió la participación en el ejercicio, aquellas que toman agentes hipoglucemiante	84 formaron el grupo experimental con intervención de ejercicio físico (programa de ciclismo estacionario supervisado en el hogar de 14 semanas).	85 mujeres formaron el grupo control (atención estándar) .	Cada sesión comenzaba con un calentamiento de 5 minutos que consistía en pedalear a una intensidad equivalente a 55 - 65% de la frecuencia cardíaca máxima predicha por la edad y una calificación de esfuerzo percibido de 9 - 11 en la escala de Borg. El período de acondicionamiento posterior se dividió en períodos de 5 minutos de ciclismo continuo de	Concentraciones de glucosa e insulina, tolerancia a la glucosa, sensibilidad a la insulina, concentraciones de hemoglobina glicosilada, péptido C sérico y colesterol. Se midieron la altura, la masa corporal, cinco pliegues cutáneos periféricos, cuatro circunferencias de las extremidades, frecuencia cardíaca en reposo y presión	La tasa de recurrencia de DMG fue similar entre los grupos (control 40% [n=34]; ejercicio 40,5% [n=34]; P=0.95) y la gravedad de la DMG en el momento del diagnóstico no se vio afectada por el programa de ejercicio con respuestas similares de glucosa e insulina a la OGTT (glucosa 2 horas post-OGTT 7.7 ± 1.5 en comparación con 7.6

				s orales, o aquellos que ya participaban en un programa de ejercicio estructurado no eran elegibles para el estudio.			intensidad moderada (65 - 75% de frecuencia cardíaca máxima; calificación del esfuerzo percibido 12 - 13) alternando con periodos de ciclos de intervalos de 5 minutos. Se utilizaron dos tipos de intervalos; uno involucró un aumento en la frecuencia de pedaleo durante 15 segundos y el otro involucró un aumento en la resistencia al pedaleo durante 30 segundos (intensidad objetivo 75 - 85% de frecuencia cardíaca máxima; calificación del esfuerzo percibido 14 - 16) repetido cada 2 minutos. Un enfriamiento de 5 minutos concluyó cada sesión (55 - 65% de frecuencia cardíaca máxima; calificación del esfuerzo percibido 9 - 11) seguido de un ligero estiramiento. La duración de cada sesión se incrementó progresivamente en	arterial.	± 1.6 mmol/L; P>0.05). El modelo homeostático de evaluación, el índice de sensibilidad a la insulina, la hemoglobina glicosilada y el péptido C sérico también fueron similares entre grupos post-intervención. La aptitud cardiovascular materna, basada en la producción de potencia al 75% de la frecuencia cardíaca máxima, se incrementó en respuesta al ejercicio, lo que resulta en una mayor aptitud física en el grupo de ejercicio en comparación con las mujeres en el grupo de control después de la intervención. Es de destacar que las mujeres que realizaban más de 20 minutos de ejercicio físico de intensidad moderada al ingresar al estudio tuvieron

							incrementos de 5 minutos cada 2 - 3 semanas, según tolerancia, de 20 a 30 minutos hasta una duración máxima de la sesión de 60 minutos. El grado de progresión dependió del nivel de condición física inicial de la mujer y sus síntomas de embarazo en curso.		una incidencia reducida de DMG independientemente de su asignación de grupo en comparación con las mujeres que realizaban menos de 20 minutos de actividad moderada diaria. No hubo diferencias en los resultados obstétricos o neonatales entre los grupos, excepto que hubo más neonatos varones nacidos de participantes en el grupo de ejercicio en comparación con las mujeres en el grupo de control.
Halvatsiotis P, Panagiotou O, Koulouvaris P, Raptis A, Bamias A, Kalantaridou S, Valsamakis G. - 2020	Revisión sistemáti ca	En este artículo no se especifica la muestra. La población son mujeres embarazadas con diabetes gestacional o en prevención de esta.	No se especifican criterios de inclusión.	No se especifican criterios de exclusión.	Grupo de intervención con ejercicio físico.	No se especific a el grupo control.	Se recomienda que la actividad física, aunque se fomente a diario, se realice al menos tres días a la semana y se debe hacer al menos 150 minutos de ejercicio aeróbico de intensidad moderada (aumenta la frecuencia cardíaca y comienza a sudar) cada semana (que involucre los músculos grandes del	Duración, frecuencia, intensidad y tipo de ejercicio, control glucémico posprandial, glucosa en sangre en ayunas, niveles de hemoglobina glicosilada.	La participación en programas de ejercicio incluso antes del embarazo parece particularmente eficaz para la prevención de la diabetes gestacional, la hipertensión y la preeclampsia. Más específicamente, se demostró que los programas de

							cuerpo). En particular, es preferible realizar ejercicio aeróbico 3-5 veces a la semana. El ejercicio aeróbico favorece el control del peso, mantenimiento del acondicionamiento físico, y también parece reducir los riesgos de diabetes mellitus gestacional (DMG) en grupos específicos. El tiempo puede oscilar entre 150 min/semana de ejercicio de intensidad moderada o 75 min/semana de ejercicio aeróbico intenso, distribuidos en diferentes días. Los 150 minutos se pueden dividir en ejercicios de 30 minutos 5 días a la semana o en ejercicios más pequeños de 10 minutos cada día. En cuanto a los ejercicios de resistencia de intensidad ligera a moderada, pueden mejorar la resistencia muscular y la flexibilidad sin complicaciones para el		ejercicio de intensidad moderada de al menos 600 MET-min / semana (por ejemplo, 140 minutos de caminata, aeróbicos acuáticos, ciclismo o entrenamiento de resistencia) contribuyen a una disminución del 25% en el desarrollo de DMG, hipertensión y preeclampsia. Además, se ha registrado suficiente información a favor de una relación inversa entre la actividad física y el riesgo de hipertensión gestacional y preeclampsia. Dado que la aparición de DMG en una mujer está directamente relacionada con la aparición posterior de DM tipo 2, el papel beneficioso del ejercicio en combinación con una dieta saludable en el embarazo diabético es de particular

							embarazo. En cuanto a la participación de la gestante en programas de entrenamiento de resistencia (pesas libres, máquinas o peso corporal) es preferible que se realice 2 - 3 veces por semana en días no consecutivos.		importancia. El ejercicio facilita un mayor ritmo de flujo de glucosa intracelular hacia las células musculares, incluso cuando los niveles de insulina están alterados. Las contracciones musculares durante el ejercicio estimulan el movimiento de los transportadores de glucosa GLUT4 desde el compartimento intracelular a la superficie de la célula muscular mediante la activación de la quinasa AMP, aumentando el NO - óxido nítrico y aumentando los radicales libres de oxígeno (ROS - especies de oxígeno reactivas). También hay evidencia de que el ejercicio puede aumentar tanto la actividad como el número de GLUT4 estimulando su expresión genética.

									La acción de la insulina es bastante similar ya que también estimula el movimiento de los transportadores de glucosa GLUT4 a la superficie de las células musculares. Sin embargo, la transferencia de la señal de insulina a las células musculares sigue una ruta metabólica diferente, al menos en sus etapas iniciales, a la de la señal de contracción muscular. Por supuesto, existe un criterio de valoración común en las dos vías metabólicas implicadas en la activación de dos proteínas intracelulares, TBC1D1/TBC1D4. Por lo tanto, el ejercicio tiene un efecto beneficioso en la reducción de los niveles elevados de HbA1c y las necesidades de

									insulina en pacientes con DM tipo 2 y los datos del metaanálisis describen una correlación lineal entre la intensidad del ejercicio y el control glucémico.
Awad E, Ahmed H, Yousef A, Saab IM. - 2019	ECA	60 mujeres embarazadas.	Mujeres embarazadas con diabetes gestacional, a las 20-24 semanas de gestación, con edades comprendidas entre los 25 y los 35 años, con un índice de masa corporal que no superaba los 40 kg/m2.	Mujeres diagnosticadas con complicaciones vasculares, diabetes mellitus inestable, neuropatía periférica, disfunción autonómica, nefropatía o retinopatía, gemelos, placenta previa, anomalías fetales, retraso del crecimiento intrauterino, así como con antecedentes de trabajo de parto prematuro, abortos repetidos, hemorragia antes del parto o	El grupo de intervención se sometió a un programa de ejercicio con una dieta moderadamente restringida y terapia con insulina (grupo A).	El grupo de control recibió únicamente el mismo protocolo de dieta con terapia con insulina (grupo B).	El ejercicio realizado se caracterizó por una frecuencia mínima de 3 veces por semana, una intensidad fijada en un esfuerzo percibido moderadamente intenso, un tiempo de 60 minutos por día y un tipo de impacto bajo. Estas pautas de ejercicio se utilizaron tanto para ejercicios aeróbicos como de fuerza durante 12 semanas. Los participantes del Grupo A realizaron el ejercicio 3-4 veces por semana, comenzando la fase activa del entrenamiento aeróbico con 15 minutos a una intensidad de frecuencia cardíaca objetivo y aumentando el tiempo gradualmente hasta un máximo de 30	Puntuación de Apgar, edad gestacional, índice de masa corporal, tensión arterial.	No hubo diferencias estadísticamente significativas (p> 0,05) entre los sujetos de ambos grupos en cuanto a edad, IMC o edad gestacional. Sin embargo, la prueba de chi-cuadrado reveló diferencias significativas entre los grupos en el modo de distribución del parto ($p < 0,05$). El análisis estadístico con ANoVA de diseño mixto analizó a 60 pacientes asignados en 2 grupos iguales y reveló un efecto intrasujeto significativo ($F = 306,82$, $p = 0,0001$) y efecto entre sujetos ($F = 50,129$, $p = 0,0001$). Sin embargo, no hubo un

				preeclampsia fueron excluidas del estudio.			minutos por sesión de ejercicio. Cada actividad aeróbica fue precedida por un calentamiento de 10 a 15 minutos y seguida de un enfriamiento de 10 a 15 minutos.		efecto significativo del tratamiento * tiempo ($F = 0,58$, $p = 0,449$). Las pruebas de comparación múltiple por pares revelaron que hubo un aumento significativo ($p < 0,05$) en la puntuación de Apgar después de 5 minutos en comparación con el de 1 minuto en los recién nacidos de ambos grupos. En cuanto a los efectos entre sujetos, múltiples comparaciones por pares mostraron un aumento significativo a favor del grupo A en comparación con el grupo B en 1 minuto y 5 minutos ($p < 0,05$).

FICHA REVISIÓN BIBLIOGRÁFICA

Nº Ficha (por orden)	Código de Referencia interna
1	Peters

Cita Bibliográfica (Según Vancouver)	Peters TM, Brazeau AS. Exercise in Pregnant Women with Diabetes. Curr Diab Rep. 2019 Aug 6;19(9):80. doi: 10.1007/s11892-019-1204-8. PMID: 31388772.	
Introducción	***Justificación del artículo***	La diabetes es cada vez más común entre las mujeres embarazadas y el ejercicio físico es el tratamiento de primera línea.
	Objetivo del estudio	Aclarar si el ejercicio físico también beneficia a las mujeres embarazadas con diabetes gestacional.
Metodología	***Tipo de estudio***	Revisión bibliográfica: ; Ensayo Clínico: Revisión Sistemática: x; Casos controles: Meta-análisis: ; Cohortes: Marco Teórico: ; Descriptivo: Revisión histórica: ; Cualitativa:
	Año de realización	2019
	Técnica recogida de datos	Encuesta/Cuestionario validado: (especificar) Encuesta/cuestionario de elaboración propia: (especificar) Escala (Validada/No validada): (especificar) Registros: (especificar) Técnicas cualitativas: (especificar) Otras: No se especifica la técnica de recogida de datos ya que es una revisión de la evidencia.
	Población y muestra	No se especifica ninguna muestra. La población son mujeres embarazadas con diabetes gestacional.
Resultados relevantes	Los autores determinaron que las intervenciones de ejercicio aeróbico redujeron la glucosa en sangre capilar y pueden reducir la dosis y la necesidad de insulina. Por otro lado, el ejercicio de resistencia no afectó los niveles de glucosa, aunque un menor número de mujeres que participaron en el entrenamiento de resistencia requirieron insulina en comparación con los controles. Los beneficios y riesgos específicos del ejercicio para las mujeres embarazadas con diabetes tipo 2 no están claros.	

<table>
<tr><td></td><td>En cuanto a los efectos del ejercicio sobre los resultados maternos y neonatales, en la diabetes tipo 2 el flujo sanguíneo de la arteria umbilical medido por ecografía Doppler mejoró en el grupo de ejercicio, con índices más bajos de resistencia y pulsatilidad que sugieren una mejor placentación, lo que puede conferir mejores resultados fetales en embarazos de alto riesgo. En cuanto a la diabetes tipo 1, después de una intervención con ejercicio, no hubo diferencia en el aumento de peso gestacional, pero tenían menos probabilidades de tener una cesárea. Además, la descendencia de mujeres con diabetes tipo 1 en el grupo de ejercicio experimentó menos hipoglucemia, hipocalcemia, hiperbilirrubinemia y macrosomía en comparación con los controles, aunque no se observaron diferencias para el peso neonatal o el índice de masa corporal.</td></tr>
<tr><td>Discusión planteada</td><td>Comparación entre la diabetes tipo 1, diabetes tipo 2 y los efectos del ejercicio aeróbico, ejercicio de resistencia y yoga.
Efectos del ejercicio sobre los resultados maternos y neonatales.</td></tr>
<tr><td>Conclusiones del estudio</td><td>El ejercicio parece ser seguro para las mujeres embarazadas con diabetes ya que probablemente obtengan beneficios similares en el estado físico y el control del peso que las mujeres embarazadas sin diabetes. Además, las mujeres embarazadas con diabetes que hacen ejercicio obtienen beneficios adicionales, como un mejor control de la glucosa para las mujeres con diabetes gestacional, pero también enfrentan desafíos adicionales como el riesgo potencial de hipoglucemia en mujeres que toman insulina. Además, la necesidad de insulina puede retrasarse para las mujeres embarazadas que realizan ejercicio. Sin embargo, la base de evidencia para estas recomendaciones no es concluyente, particularmente para mujeres con diabetes preexistente.</td></tr>
<tr><td>Valoración (Escala Liker)</td><td><table>
<tr><td>Liker 1</td><td></td><td>Poco relevante para el objetivo de nuestro estudio (valorar su exclusión)</td></tr>
<tr><td>Liker 2</td><td>x</td><td>Relevante para el marco teórico de justificación del estudio pero de poca calidad metodológica</td></tr>
<tr><td>Liker 3</td><td></td><td>Relevante por la metodología de investigación pero con resultados poco interesantes para nuestro estudio</td></tr>
<tr><td>Liker 4</td><td></td><td>Relevante por la metodología, resultados, conclusiones y marco teórico</td></tr>
</table></td></tr>
<tr><td>Otros aspectos u observaciones</td><td>Para la medición del ejercicio se usan varios métodos como el autoinforme y las medidas objetivas, como podómetros, acelerómetros y monitores de frecuencia cardíaca, en combinación con medidas de esfuerzo, como objetivos de frecuencia cardíaca específicos del embarazo o índices de intensidad subjetiva a través del Borg modificado.</td></tr>
</table>

FICHA REVISIÓN BIBLIOGRÁFICA

Nº Ficha (por orden)	Código de Referencia interna
2	Brown

Cita Bibliográfica (Según Vancouver)	Brown J, Ceysens G, Boulvain M. Exercise for pregnant women with gestational diabetes for improving maternal and fetal outcomes. Cochrane Database Syst Rev. 2017 Jun 22;6(6):CD012202. doi: 10.1002/14651858.CD012202.pub2. PMID: 28639706; PMCID: PMC6481507.	
Introducción	***Justificación del artículo***	Analizar las complicaciones tanto a corto como a largo plazo para la madre y su bebé asociadas a la diabetes mellitus gestacional.
	Objetivo del estudio	Evaluar los efectos de las intervenciones con ejercicio físico para mejorar los resultados maternos y fetales en mujeres con diabetes gestacional.
Metodología	***Tipo de estudio***	Revisión bibliográfica: – ; Ensayo Clínico: – ; Revisión Sistemática: x ; Casos controles: – ; Meta-análisis: – ; Cohortes: – ; Marco Teórico: – ; Descriptivo: – ; Revisión histórica: – ; Cualitativa: –
	Año de realización	2017
	Técnica recogida de datos	Encuesta/Cuestionario validado: (especificar); Encuesta/cuestionario de elaboración propia: (especificar); Escala (Validada/No validada): (especificar); Registros: (especificar); Técnicas cualitativas: (especificar); Otras: No se especifica ya que es una revisión de la bibliografía
	Población y muestra	Mujeres embarazadas con diagnóstico de diabetes gestacional. 11 ensayos aleatorios con 638 mujeres. 222 bebés en total entre los ensayos elegidos.
Resultados relevantes	Para las madres, el ejercicio no pareció reducir el riesgo de preeclampsia como medida de los trastornos hipertensivos del embarazo (dos ensayos, 48 mujeres, evidencia de baja calidad), parto por cesárea (cinco ensayos, 316 mujeres, evidencia de calidad moderada) o el riesgo de inducción del trabajo de parto (un ensayo, 40 mujeres, evidencia de baja calidad). Las madres tenían un índice de masa corporal similar durante el seguimiento en los grupos de ejercicio y control (tres ensayos, 254 mujeres, evidencia	

	de alta calidad). El ejercicio se asoció con niveles más bajos de glucosa en sangre en ayunas (cuatro ensayos) y niveles de glucosa en sangre después de una comida (tres ensayos). Los programas de ejercicio variaron entre los ensayos, al igual que su duración y si fueron supervisados o no. Ninguno de los ensayos incluidos informó sobre el trauma perineal, la depresión posparto o el desarrollo de diabetes tipo 2. Para los bebés, no ocurrieron muertes alrededor del momento del nacimiento (un ensayo, 19 bebés, evidencia de baja calidad) y no hubo evidencia de ninguna diferencia en el riesgo de mala salud (dos ensayos, 169 bebés, evidencia de calidad moderada) o niveles bajos de azúcar en sangre (un ensayo, 34 bebés, evidencia de baja calidad). Ninguno de los ensayos informó el número de bebés grandes para la edad gestacional o bebés que desarrollaron diabetes en la niñez o la edad adulta o discapacidad neurosensorial que se hizo evidente durante la niñez.
Discusión planteada	La discusión se centra en la comparación de las intervenciones con ejercicio físico en el grupo de intervención frente al grupo de control o con otras intervenciones, en mujeres embarazadas con diabetes gestacional para observar las diferencias en los resultados maternos y fetales. Los resultados se exponen en el apartado anterior.
Conclusiones del estudio	No hubo evidencia de alta calidad suficiente para poder determinar las diferencias entre los grupos de ejercicio y de control para los resultados de interés. Para la mujer, las concentraciones de glucosa en sangre tanto en ayunas como después de una comida se redujeron en comparación con los grupos de control. Actualmente, no hay datos suficientes para que podamos determinar si también hay beneficios para el bebé. La evidencia actual es insuficiente para aconsejar a las mujeres que se inscriban en programas de ejercicio o en contra de ellas. Incluso si el ejercicio no proporciona ningún beneficio durante el embarazo, este cambio en el estilo de vida puede persistir después del nacimiento y puede ayudar a prevenir la aparición de la diabetes tipo 2 y sus complicaciones a largo plazo.
Valoración (Escala Liker)	Liker 1 | | Poco relevante para el objetivo de nuestro estudio (valorar su exclusión) Liker 2 | | Relevante para el marco teórico de justificación del estudio pero de poca calidad metodológica Liker 3 | x | Relevante por la metodología de investigación pero con resultados poco interesantes para nuestro estudio Liker 4 | | Relevante por la metodología, resultados, conclusiones y marco teórico
Otros aspectos u observaciones	

FICHA REVISIÓN BIBLIOGRÁFICA

Nº Ficha (por orden)	Código de Referencia interna
3	Sklempe

Cita Bibliográfica (Según Vancouver)	Sklempe Kokic I, Ivanisevic M, Biolo G, Simunic B, Kokic T, Pisot R. Combination of a structured aerobic and resistance exercise improves glycaemic control in pregnant women diagnosed with gestational diabetes mellitus. A randomised controlled trial. Women Birth. 2018 Aug;31(4):e232-e238. doi: 10.1016/j.wombi.2017.10.004. Epub 2017 Oct 18. PMID: 29055674.					
Introducción	***Justificación del artículo***	Analizar el tipo de ejercicio más beneficioso en mujeres embarazadas con diabetes mellitus.				
	Objetivo del estudio	Investigar el impacto sobre los parámetros de control glucémico de un programa de ejercicio estructurado que consiste en ejercicios aeróbicos y de resistencia en mujeres embarazadas diagnosticadas de diabetes gestacional.				
Metodología	***Tipo de estudio***	Revisión bibliográfica		Ensayo Clínico	x	
		Revisión Sistemática		Casos controles		
		Meta-análisis		Cohortes		
		Marco Teórico		Descriptivo		
		Revisión histórica		Cualitativa		
	Año de realización	2017				
	Técnica recogida de datos	Encuesta/Cuestionario validado	(especificar)			
		Encuesta/cuestionario de elaboración propia	(especificar)			
		Escala (Validada/No validada)	(especificar)			
		Registros	Registros de la masa corporal, la circunferencia del brazo, el grosor de los pliegues cutáneos y el control de glucosa en sangre. Los datos sobre el peso neonatal, la longitud, la puntuación de Apgar y el estado de salud se extrajeron de la carta de alta hospitalaria y se utilizaron para calcular el índice de masa corporal neonatal y			

			el índice ponderal de acuerdo con las ecuaciones estándar.
		Técnicas cualitativas	(especificar)
		Otras	(especificar)
	Población y muestra	42 mujeres embarazadas (entre 20 y 40 años) diagnosticadas con diabetes mellitus gestacional divididas al azar en dos grupos. El límite superior para la edad gestacional en el momento de la inclusión se estableció en 30 semanas, para permitir un período mínimo de ejercicio de 6 semanas, hasta al menos la semana 36 de embarazo. De las 42 mujeres, se quedaron 38 ya que 4 abandonaron el ensayo.	
Resultados relevantes	Si bien el nivel promedio de glucosa en ayunas fue más bajo en el grupo experimental, esto no fue significativo (P = 0,367). Sin embargo, cuando se calculó un promedio de 3 niveles de glucosa posprandial, esto fue significativamente menor en el grupo experimental (P <0,001, d = 1,38, r = 0,57). El nivel de glucosa en ayunas se correlacionó positivamente con la masa corporal en las semanas 30 y 36 de embarazo. Hubo una fuerte correlación negativa entre el deporte y los niveles de ejercicio en las semanas 30 y 36 de embarazo y una correlación positiva entre los niveles de inactividad y los niveles de glucosa posprandial. No hay correlación entre los parámetros glucémicos y: duración de la intervención, adherencia al protocolo o número de sesiones de ejercicio asistidas.		
Discusión planteada	El propósito de este ensayo fue investigar el impacto de un programa estructurado de ejercicios aeróbicos y de resistencia (combinados) en el curso y los resultados de la diabetes mellitus gestacional.		
Conclusiones del estudio	La combinación de ejercicios aeróbicos y de resistencia ofrece importantes beneficios para mujeres con diabetes mellitus gestacional. Deben desarrollarse e incorporarse pautas para el tipo, la frecuencia, la duración y la intensidad óptimos del ejercicio en las pautas generales para el tratamiento de la DMG.		
Valoración (Escala Liker)	Liker 1		Poco relevante para el objetivo de nuestro estudio (valorar su exclusión)
	Liker 2		Relevante para el marco teórico de justificación del estudio pero de poca calidad metodológica
	Liker 3		Relevante por la metodología de investigación pero con resultados poco interesantes para nuestro estudio
	Liker 4	x	Relevante por la metodología, resultados, conclusiones y marco teórico
Otros aspectos u observaciones	Cada sesión de ejercicio duró de 50 a 55 minutos y consistió en ejercicio aeróbico (20 min), ejercicios de resistencia (20-25 min), ejercicios de suelo pélvico y estiramientos, y un período de relajación para finalizar la sesión (10 min).		

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FICHA REVISIÓN BIBLIOGRÁFICA

Nº Ficha (por orden)	Código de Referencia interna
4	Savvaki

Cita Bibliográfica (Según Vancouver)	Savvaki D, Taousani E, Goulis DG, Tsirou E, Voziki E, Douda H, Nikolettos N, Tokmakidis SP. Guidelines for exercise during normal pregnancy and gestational diabetes: a review of international recommendations. Hormones (Athens). 2018 Dec;17(4):521-529. doi: 10.1007/s42000-018-0085-6. Epub 2018 Dec 3. PMID: 30511333.	
Introducción	***Justificación del artículo***	Analizar las recomendaciones sobre la realización de ejercicio físico durante el embarazo con diabetes gestacional.
	Objetivo del estudio	Recopilar las principales pautas para el ejercicio físico durante el embarazo normal y el embarazo complicado con diabetes mellitus gestacional.
Metodología	***Tipo de estudio***	(ver tabla)
	Año de realización	2018
	Técnica recogida de datos	(ver tabla)
	Población y muestra	No se especifica, ya que, al ser una revisión sistemática, no habla de muestras concretas.
Resultados relevantes	Todas las guías recomiendan un entrenamiento aeróbico de 60 a 150 min/semana, con un límite superior de 30 min/día. El ejercicio es seguro, incluso a diario. El ejercicio de resistencia es sugerido por cinco guías nacionales (Australia, Canadá, Dinamarca, Noruega y Reino Unido). Existen discrepancias con respecto a la intensidad recomendada de ejercicio. Canadá, Japón, España y Reino Unido utilizan criterios objetivos (frecuencia cardíaca y consumo máximo de oxígeno) y subjetivos (escala de Borg y test del habla) para	

Tipo de estudio:

Revisión bibliográfica		Ensayo Clínico	
Revisión Sistemática	x	Casos controles	
Meta-análisis		Cohortes	
Marco Teórico		Descriptivo	
Revisión histórica		Cualitativa	

Técnica recogida de datos:

Encuesta/Cuestionario validado	Se utilizan cuestionarios validados para evaluar las necesidades del embarazo de cada mujer e individualizar un plan de entrenamiento.
Encuesta/cuestionario de elaboración propia	(especificar)
Escala (Validada/No validada)	(especificar)
Registros	(especificar)
Técnicas cualitativas	(especificar)
Otras	No se especifica, ya que es una revisión de la evidencia.

	determinar la efectividad y seguridad del ejercicio. Solo Canadá brinda recomendaciones específicas, según la edad de la mujer y el nivel de condición física. Las mujeres con diabetes gestacional sin tratamiento con insulina no necesitan tomar precauciones adicionales durante el ejercicio. Sin embargo, debido a su condición de hiperglucemia, deben cumplir con la recomendación emitida para diabetes tipo 2. La prescripción y supervisión del ejercicio debe realizarse de forma similar a los embarazos sin complicaciones. Finalmente, las mujeres con diabetes gestacional en tratamiento con insulina deben seguir las mismas recomendaciones que para las mujeres embarazadas con diabetes tipo 1.
Discusión planteada	Todas las organizaciones internacionales recomiendan el ejercicio durante el embarazo, siempre que no haya complicaciones durante el período gestacional. Sin embargo, a pesar de estas recomendaciones, la mayoría de las mujeres embarazadas no hacen ejercicio, lo que explica que no están de buen humor o tienen una sensación de cansancio e incomodidad durante el embarazo. Sin embargo, un factor principal en la resistencia a hacer ejercicio durante el embarazo se debe a la falta de incentivos y aliento por parte de los profesionales de la salud. Solo una minoría de mujeres mencionó que sus médicos sugirieron que deberían participar en programas regulares de ejercicio. Posibles razones de este error son la falta de educación adecuada al respecto entre los médicos, la estructura de los sistemas de salud que no permite tales prácticas, creencias obsoletas de que el ejercicio durante el embarazo puede ser nocivo y el hecho de que la condición física de las mujeres es a menudo mala al comienzo del embarazo. Dar a las mujeres una receta de ejercicio adecuada puede alentarlas a participar en la actividad física de manera segura y eficiente durante el embarazo y, por lo tanto, además de muchos otros beneficios, a prevenir y/o controlar la diabetes mellitus gestacional (DMG).
Conclusiones del estudio	Los profesionales de la salud deben estar informados sobre la correcta planificación y ejecución de los programas de ejercicio físico para lograr de manera segura la máxima efectividad de los beneficios relacionados con la salud inducidos por el ejercicio en las mujeres embarazadas. Las mujeres con DMG deben tomar precauciones adicionales durante el ejercicio. Por sus altos niveles de azúcar en sangre (hiperglucemia), deben cumplir con la recomendación emitida para mujeres con diabetes tipo 2. Se sugiere que las mujeres embarazadas con DMG deben seguir las mismas recomendaciones que otras mujeres embarazadas. Las mujeres embarazadas que reciben tratamiento con insulina deben ser conscientes de los efectos del ejercicio, que puede aumentar la sensibilidad a la insulina e inducir hipoglucemia, especialmente durante el primer trimestre. Debido a la falta de conocimiento sobre los riesgos y beneficios del ejercicio, la mayoría de las mujeres tienden a evitarlo durante el embarazo. Sin embargo, bajo la supervisión adecuada, el ejercicio regula los niveles de glucosa, aumenta la sensibilidad a la insulina y es seguro y beneficioso para el tratamiento de la DMG.
Valoración (Escala Liker)	Liker 1 | | Poco relevante para el objetivo de nuestro estudio (valorar su exclusión) Liker 2 | | Relevante para el marco teórico de justificación del estudio pero de poca calidad metodológica Liker 3 | | Relevante por la metodología de investigación pero con resultados poco interesantes para nuestro estudio Liker 4 | x | Relevante por la metodología, resultados, conclusiones y marco teórico
Otros aspectos u observaciones	

FICHA REVISIÓN BIBLIOGRÁFICA

Nº Ficha (por orden)	Código de Referencia interna
5	Sklempe II

Cita Bibliográfica (Según Vancouver)	Sklempe Kokic I, Ivanisevic M, Kokic T, Simunic B, Pisot R. Acute responses to structured aerobic and resistance exercise in women with gestational diabetes mellitus. Scand J Med Sci Sports. 2018 Jul;28(7):1793-1800. doi: 10.1111/sms.13076. Epub 2018 Mar 9. PMID: 29461654.	
Introducción	***Justificación del artículo***	Ampliar la información sobre las respuestas agudas al ejercicio durante el embarazo en mujeres con diabetes gestacional debido a que esta es escasa.
	Objetivo del estudio	Investigar las respuestas agudas (FC, FHR, presión arterial sistólica y diastólica, temperatura corporal y nivel de glucosa) a una sola sesión de ejercicio realizada varias veces durante el embarazo en mujeres diagnosticadas con diabetes gestacional.
Metodología	***Tipo de estudio***	Revisión bibliográfica: ; Ensayo Clínico: x; Revisión Sistemática: ; Casos controles: ; Meta-análisis: ; Cohortes: ; Marco Teórico: ; Descriptivo: ; Revisión histórica: ; Cualitativa: . El estudio se diseñó como el análisis secundario de los datos de un ensayo controlado aleatorio.
	Año de realización	2018
	Técnica recogida de datos	Encuesta/Cuestionario validado: (especificar); Encuesta/cuestionario de elaboración propia: (especificar); Escala (Validada/No validada): (especificar); Registros: Registros de la tasa de referencia, la tasa promedio durante las partes aeróbicas y de resistencia de la sesión, y la tasa al final de la sesión. La frecuencia cardíaca fetal, la temperatura de la membrana timpánica materna y la presión arterial se midieron al inicio del estudio e inmediatamente después de las partes aeróbicas y de resistencia de

Tipo de estudio:

Revisión bibliográfica		Ensayo Clínico	x
Revisión Sistemática		Casos controles	
Meta-análisis		Cohortes	
Marco Teórico		Descriptivo	
Revisión histórica		Cualitativa	

Técnica recogida de datos:

Encuesta/Cuestionario validado	(especificar)
Encuesta/cuestionario de elaboración propia	(especificar)
Escala (Validada/No validada)	(especificar)
Registros	Registros de la tasa de referencia, la tasa promedio durante las partes aeróbicas y de resistencia de la sesión, y la tasa al final de la sesión. La frecuencia cardíaca fetal, la temperatura de la membrana timpánica materna y la presión arterial se midieron al inicio del estudio e inmediatamente después de las partes aeróbicas y de resistencia de

			la sesión. También se midieron los niveles de glucosa en sangre. Todos los resultados se midieron en cada sesión de ejercicio. Las mediciones antes del inicio y al final de la sesión de ejercicio se tomaron al menos 5 minutos antes y después de la sesión, respectivamente
		Técnicas cualitativas	(especificar)
		Otras	Los datos se obtuvieron del ensayo original.
	Población y muestra	18 mujeres embarazadas (edad: 32,8 ± 3,8) diagnosticadas con DMG.	
Resultados relevantes	Los niveles de glucosa cayeron desde la línea de base, de 4,7 ± 0,6 a 3,9 ± 0,4 mmol/L. No hubo diferencias en las respuestas al ejercicio entre 2º y 3er trimestre, ni entre las que hacen ejercicio antes del embarazo y las que no hacen ejercicio. La combinación de ejercicio aeróbico y de resistencia para mujeres diagnosticadas con DMG no tiene efectos dañinos a corto plazo si se realiza de acuerdo con las pautas. Asimismo, el ejercicio puede considerarse útil para controlar la hiperglucemia en el embarazo en mujeres afectadas por DMG.		
Discusión planteada	Los datos sobre las respuestas fisiológicas agudas al ejercicio durante el embarazo son limitados, especialmente para las mujeres afectadas por DMG. Este estudio representa una de las colecciones más grandes de respuestas agudas al ejercicio en mujeres embarazadas y es el primero en ofrecer datos completos para la población afectada por DMG. Hemos demostrado que el ejercicio para gestantes diagnosticadas con DMG induce cambios en la FC materna y fetal, así como ligeros cambios en la presión arterial materna, pero lejos de los niveles que causarían preocupación. La disminución registrada en los niveles de glucosa en sangre después del ejercicio podría ser clínicamente valiosa en el manejo de la DMG y posiblemente reducir la necesidad de insulina y / o agentes hipoglucemiantes orales. Además, el ejercicio provoca respuestas agudas similares tanto para las personas que hacen ejercicio regularmente antes del embarazo como para las que no hacen ejercicio. Se debe recomendar a las mujeres que continúen o comiencen a hacer ejercicio regularmente durante el embarazo si no tienen contraindicaciones, especialmente aquellas afectadas por DMG. Las respuestas hemodinámicas agudas al ejercicio aeróbico y de resistencia durante el embarazo son similares a las observadas en la población general de embarazadas, con un aumento de la frecuencia cardíaca y poco o ningún cambio en la presión arterial.		
Conclusiones del estudio	Una combinación de ejercicio aeróbico y de resistencia para mujeres afectadas por DMG no causa preocupaciones a corto plazo y no tiene efectos adversos si se realiza de acuerdo con las pautas oficiales. La FC materna y la FCF aumentan durante el ejercicio y hay ligeros cambios en los valores de la presión arterial en comparación con los niveles iniciales, pero dentro de límites saludables. La temperatura timpánica se eleva ligeramente durante el ejercicio aeróbico, pero permanece lejos de niveles peligrosos. Todos los valores vuelven a la línea de base al final de la sesión de ejercicio. Existe una disminución significativa en los		

	niveles de glucosa que podría ser potencialmente útil para controlar la hiperglucemia durante el embarazo en mujeres afectadas por DMG.
Valoración (Escala Liker)	<table><tr><td>Liker 1</td><td></td><td>Poco relevante para el objetivo de nuestro estudio (valorar su exclusión)</td></tr><tr><td>Liker 2</td><td>x</td><td>Relevante para el marco teórico de justificación del estudio pero de poca calidad metodológica</td></tr><tr><td>Liker 3</td><td></td><td>Relevante por la metodología de investigación pero con resultados poco interesantes para nuestro estudio</td></tr><tr><td>Liker 4</td><td></td><td>Relevante por la metodología, resultados, conclusiones y marco teórico</td></tr></table>
Otros aspectos u observaciones	La intervención de ejercicio consistió en un programa de ejercicio aeróbico y de resistencia estructurado individualmente realizado dos veces por semana desde el momento del diagnóstico hasta al menos las 36 semanas de embarazo. El programa de ejercicios incluyó 20 minutos de ejercicio aeróbico, 20-25 minutos de ejercicio de resistencia y 10 minutos de enfriamiento. La principal limitación de este estudio fue el pequeño tamaño de la muestra. Compensamos el pequeño número de participantes con una gran cantidad de sesiones de ejercicio individuales. Sin embargo, es posible que la población estudiada no sea representativa de la población general afectada por DMG.

FICHA REVISIÓN BIBLIOGRÁFICA

Nº Ficha (por orden)	Código de Referencia interna
6	Ming

Cita Bibliográfica (Según Vancouver)	Ming WK, Ding W, Zhang CJP, Zhong L, Long Y, Li Z, Sun C, Wu Y, Chen H, Chen H, Wang Z. The effect of exercise during pregnancy on gestational diabetes mellitus in normal-weight women: a systematic review and meta-analysis. BMC Pregnancy Childbirth. 2018 Nov 12;18(1):440. doi: 10.1186/s12884-018-2068-7. PMID: 30419848; PMCID: PMC6233372.	
Introducción	***Justificación del artículo***	La diabetes mellitus gestacional (DMG) es una de las complicaciones más comunes durante el embarazo y tiene efectos adversos tanto a corto como a largo plazo sobre la salud de las madres y los fetos.
	Objetivo del estudio	La mayoría de la población con diabetes gestacional comprende mujeres de peso normal (según el índice de masa corporal [IMC] antes del embarazo). Sin embargo, las revisiones sistemáticas y los metaanálisis existentes se centraron en la población con sobrepeso u obesidad. Exclusivamente en la población de peso normal, hay pocas revisiones de los resultados del embarazo y un artículo reciente se centró en el ejercicio durante el embarazo en la población de peso normal y el riesgo de parto prematuro. Se sintetiza la evidencia disponible de ECA de ejercicio durante el embarazo para prevenir la DMG en mujeres con peso normal.
Metodología	***Tipo de estudio***	(ver tabla)
	Año de realización	2018
	Técnica recogida de datos	(ver tabla)
	Población y muestra	Ocho ensayos clínicos aleatorios, incluyendo un total de 3256 mujeres embarazadas, fueron elegidos para este metaanálisis.

Tipo de estudio:

Revisión bibliográfica		Ensayo Clínico	
Revisión Sistemática	x	Casos controles	
Meta-análisis	x	Cohortes	
Marco Teórico		Descriptivo	
Revisión histórica		Cualitativa	

Técnica recogida de datos:

Encuesta/Cuestionario validado	(especificar)
Encuesta/cuestionario de elaboración propia	(especificar)
Escala (Validada/No validada)	(especificar)
Registros	(especificar)
Técnicas cualitativas	(especificar)
Otras	No se especifica, ya que es una revisión de la evidencia.

Resultados relevantes	Se incluyeron ocho estudios en esta revisión sistemática y metaanálisis. Se demostró que el ejercicio durante el embarazo disminuye la aparición de DMG [RR = 0,58; IC del 95% (0,37; 0,90), P = 0.01 y RR = 0.60, IC del 95% (0.36, 0.98), P = 0,04 basado en diferentes criterios de diagnóstico, respectivamente] en mujeres de peso normal. Con respecto a los resultados secundarios, el ejercicio durante el embarazo puede disminuir el aumento de peso gestacional [MD = - 1,61, IC del 95% (- 1,99, - 1,22), P < 0.01], y no tuvo efectos significativos sobre la edad gestacional al nacer [MD = - 0,55, IC del 95% (- 1,57, 0,47), P = 0,29], peso al nacer [DM = - 18,70, IC del 95% (- 52,49, 15,08), P = 0,28] y las probabilidades de cesárea [RR = 0,88; IC del 95% (0,72; 1,08), P = 0,21], respectivamente. Además, el ejercicio durante el embarazo también puede disminuir el riesgo de hipertensión gestacional, parto prematuro y macrosomía, lo que puede disminuir significativamente la morbilidad y mortalidad perinatal.	
Discusión planteada	Este metaanálisis de ocho estudios sugiere que el ejercicio durante el embarazo tiene un impacto protector significativo sobre la aparición de DMG y reduce el aumento de peso gestacional. El ejercicio durante el embarazo no reduce la edad gestacional de parto ni aumenta las probabilidades de una cesárea en la mayoría de las mujeres embarazadas de peso normal. La edad gestacional media al momento del parto, el peso al nacer y las probabilidades de una cesárea son similares en las mujeres que hacen ejercicio con regularidad y en las mujeres que reciben atención prenatal de rutina.	
Conclusiones del estudio	El ejercicio durante el embarazo puede disminuir visiblemente la aparición de DMG sin reducir la edad gestacional en el momento del parto y sin aumentar las probabilidades de cesárea en mujeres de peso normal, además de disminuir el aumento de peso gestacional, que se asocia con resultados adversos como hipertensión gestacional, preeclampsia. Por lo tanto, los hallazgos respaldan las recomendaciones del Royal College of Obstetricians and Gynaecologists (RCOG) de que las mujeres con embarazos sin complicaciones deben realizar 30 minutos de actividad física moderada al menos cuatro veces por semana en todos los trimestres.	
Valoración (Escala Liker)		
Otros aspectos u observaciones		

Liker 1		Poco relevante para el objetivo de nuestro estudio (valorar su exclusión)
Liker 2		Relevante para el marco teórico de justificación del estudio pero de poca calidad metodológica
Liker 3		Relevante por la metodología de investigación pero con resultados poco interesantes para nuestro estudio
Liker 4	x	Relevante por la metodología, resultados, conclusiones y marco teórico

FICHA REVISIÓN BIBLIOGRÁFICA

Nº Ficha (por orden)	Código de Referencia interna
7	Bianchi

Cita Bibliográfica (Según Vancouver)	Bianchi C, Battini L, Aragona M, Lencioni C, Ottanelli S, Romano M, Calabrese M, Cuccuru I, De Bellis A, Mori ML, Leopardi A, Sabbatini G, Bottone P, Miccoli R, Trojano G, Salerno MG, Del Prato S, Bertolotto A; Tuscany working group on "Diabetes, Pregnancy and Exercise". Prescribing exercise for prevention and treatment of gestational diabetes: review of suggested recommendations. Gynecol Endocrinol. 2017 Apr;33(4):254-260. doi: 10.1080/09513590.2016.1266474. Epub 2017 Jan 13. PMID: 28084847.	
Introducción	***Justificación del artículo***	Evaluar los beneficios de realizar ejercicio físico para la prevención y el tratamiento de la diabetes gestacional durante el embarazo.
	Objetivo del estudio	Resumir las recomendaciones sobre la realización de ejercicio físico para prevenir y tratar la diabetes gestacional.
Metodología	***Tipo de estudio***	
	Año de realización	2017
	Técnica recogida de datos	
	Población y muestra	Al tratarse de una revisión sistemática, no se especifica la población. Se sabe que son mujeres embarazadas.
Resultados relevantes	Se ha demostrado que el ejercicio es una herramienta terapéutica beneficiosa durante el embarazo. Es seguro y ventajoso para las funciones cardiovasculares (estado físico, presión arterial, edema periférico), preeclampsia, venas varicosas y trombosis venosa profunda, disminuyó el dolor lumbar y tuvo beneficios sobre el estado de ánimo y el bienestar psicológico; disminución del riesgo de parto prematuro, duración del trabajo de parto y complicaciones del parto; además, el ejercicio tiene un papel importante en la limitación del	

Tipo de estudio:

Revisión bibliográfica		Ensayo Clínico	
Revisión Sistemática	x	Casos controles	
Meta-análisis		Cohortes	
Marco Teórico		Descriptivo	
Revisión histórica		Cualitativa	

Técnica recogida de datos:

Encuesta/Cuestionario validado	(especificar)
Encuesta/cuestionario de elaboración propia	(especificar)
Escala (Validada/No validada)	(especificar)
Registros	(especificar)
Técnicas cualitativas	(especificar)
Otras	Al tratarse de una revisión sistemática, no se especifica.

	aumento de peso y la retención de grasa después del parto, mejorando la autoimagen. Además, los estudios observacionales apoyan la actividad física como una herramienta útil para reducir el riesgo de DMG, y un metaanálisis reciente de 10 ensayos de intervención elegibles mostró una reducción del riesgo del 28% (IC del 95%: 9-42%) en la intervención en comparación con el grupo control, proporcionando un efecto protector contra el desarrollo de DMG. En el tratamiento de mujeres con DMG, existe evidencia de que el ejercicio, particularmente el entrenamiento aeróbico estructurado y/o de resistencia, es una terapia complementaria beneficiosa.
Discusión planteada	El objetivo principal del ejercicio físico en la DMG es el control de la glucosa en sangre para reducir el riesgo elevado de complicaciones a corto y largo plazo tanto para la madre como para la descendencia. Además del ejercicio físico, el enfoque para la DMG incluye: educación materna, modificaciones de la dieta, tratamiento farmacológico y vigilancia fetal. Si no se logra un control glucémico adecuado con modificaciones en el estilo de vida, se prescribe un tratamiento farmacológico con el objetivo de alcanzar los niveles de glucosa en sangre materna objetivo.
Conclusiones del estudio	Se recomienda a las mujeres embarazadas con diabetes gestacional (o para prevenirla) la realización de ejercicio físico (de tipo aeróbico y de resistencia) durante un mínimo de 15 minutos por sesión, 3 veces a la semana (de acuerdo con una frecuencia cardíaca adecuada), aumentándose gradualmente durante el segundo trimestre hasta un máximo de aproximadamente 30 minutos por sesión, 4 veces a la semana, y su mantenimiento en su estilo de vida tras el embarazo. El ejercicio físico se recomienda siempre y cuando no existan complicaciones ni contraindicaciones.
Valoración (Escala Liker)	Liker 1 | | Poco relevante para el objetivo de nuestro estudio (valorar su exclusión) Liker 2 | | Relevante para el marco teórico de justificación del estudio pero de poca calidad metodológica Liker 3 | | Relevante por la metodología de investigación pero con resultados poco interesantes para nuestro estudio Liker 4 | x | Relevante por la metodología, resultados, conclusiones y marco teórico
Otros aspectos u observaciones	

FICHA REVISIÓN BIBLIOGRÁFICA

Nº Ficha (por orden)	Código de Referencia interna
8	Barakat

Cita Bibliográfica (Según Vancouver)	Barakat R, Refoyo I, Coteron J, Franco E. Exercise during pregnancy has a preventative effect on excessive maternal weight gain and gestational diabetes. A randomized controlled trial. Braz J Phys Ther. 2019 Mar-Apr;23(2):148-155. doi: 10.1016/j.bjpt.2018.11.005. Epub 2018 Nov 17. PMID: 30470666; PMCID: PMC6428908.	
Introducción	***Justificación del artículo***	Defender el ejercicio físico como método preventivo de la diabetes gestacional.
	Objetivo del estudio	Examinar los efectos de un programa de ejercicio durante el embarazo sobre el aumento de peso materno y la prevalencia de diabetes gestacional. Como objetivo secundario, examinar el efecto del programa de ejercicios sobre otros resultados maternos y neonatales.
Metodología	***Tipo de estudio***	Revisión bibliográfica [ ] / Ensayo Clínico [x] Revisión Sistemática [ ] / Casos controles [ ] Meta-análisis [ ] / Cohortes [ ] Marco Teórico [ ] / Descriptivo [ ] Revisión histórica [ ] / Cualitativa [ ]
	Año de realización	2018
	Técnica recogida de datos	Encuesta/Cuestionario validado: (especificar) Encuesta/cuestionario de elaboración propia: (especificar) Escala (Validada/No validada): (especificar) Registros: Los datos se recogían a través de registros de frecuencia cardíaca, peso gestacional, esfuerzo percibido y nivel de glucosa en sangre. Técnicas cualitativas: (especificar) Otras: (especificar)
	Población y muestra	Un total de 594 embarazadas sanas de habla hispana (caucásicas). Completaron el estudio un total de 456 participantes.
Resultados relevantes	Se evaluó la elegibilidad de 594 mujeres embarazadas y se incluyeron 456 (EG n = 234; CG n = 222). Los resultados mostraron un mayor porcentaje de gestantes con aumento de peso	

<table>
<tr><td></td><td>excesivo en el grupo control que en el grupo experimental (30,2% vs 20,5% respectivamente; odds ratio, 0,597; intervalo de confianza del 95%, 0,389-0,916; p = 0,018). De manera similar, la prevalencia de diabetes gestacional fue significativamente mayor en el grupo control que en el grupo experimental (6,8% frente a 2,6% respectivamente; razón de posibilidades, 0,363; intervalo de confianza del 95%, 0,138-0,953; p = 0,033).</td></tr>
<tr><td>Discusión planteada</td><td>El objetivo del presente estudio fue examinar si el ejercicio físico regular y supervisado durante el embarazo puede influir en la prevención del aumento excesivo de peso materno y la DMG, ambos factores estrechamente relacionados. La principal fortaleza del estudio actual es la combinación de resistencia a la luz, tonificación, danza aeróbica, coordinación, estiramiento y entrenamiento de los músculos del suelo pélvico en el mismo programa durante el embarazo y examinar los efectos resultantes en los resultados. El principal hallazgo de este estudio es que el programa de ejercicios redujo el aumento de peso total (medio) de la madre, así como los casos de aumento de peso excesivo y DMG. Estos resultados son relevantes desde el punto de vista clínico y sanitario debido a la creciente prevalencia de estos dos parámetros en los últimos años, en paralelo al alarmante aumento del sobrepeso y la obesidad a nivel mundial. Además, la interpretación de estos resultados promueve el uso de ejercicio físico moderado y supervisado durante el embarazo como un método para aumentar la prevención de las complicaciones del embarazo y mejorar la calidad de vida de las embarazadas sin efectos adversos sobre el bienestar materno y fetal.</td></tr>
<tr><td>Conclusiones del estudio</td><td>Los resultados de este ensayo indican que un programa de ejercicio físico supervisado iniciado temprano y mantenido durante el embarazo puede reducir el riesgo de aumento excesivo de peso materno y diabetes mellitus gestacional.</td></tr>
<tr><td>Valoración (Escala Liker)</td><td><table>
<tr><td>Liker 1</td><td></td><td>Poco relevante para el objetivo de nuestro estudio (valorar su exclusión)</td></tr>
<tr><td>Liker 2</td><td></td><td>Relevante para el marco teórico de justificación del estudio pero de poca calidad metodológica</td></tr>
<tr><td>Liker 3</td><td></td><td>Relevante por la metodología de investigación pero con resultados poco interesantes para nuestro estudio</td></tr>
<tr><td>Liker 4</td><td>x</td><td>Relevante por la metodología, resultados, conclusiones y marco teórico</td></tr>
</table></td></tr>
<tr><td>Otros aspectos u observaciones</td><td></td></tr>
</table>

FICHA REVISIÓN BIBLIOGRÁFICA

Nº Ficha (por orden)	Código de Referencia interna
9	Geranmayeh

Cita Bibliográfica (Según Vancouver)	Geranmayeh M, Bikdeloo S, Azizi F, Mehran A. Effect of relaxation exercise on fasting blood glucose and blood pressure in gestational diabetes. British Journal of Midwifery. 2019;27(9):572–7. Available from: http://0-search.ebscohost.com.llull.uib.es/login.aspx?direct=true&AuthType=cookie,ip,uid&db=edselc&AN=edselc.2-52.0-85072223743&lang=es&site=eds-live	
Introducción	***Justificación del artículo***	Justificar qué tipo de ejercicio tiene más beneficios en mujeres embarazadas con diabetes gestacional.
	Objetivo del estudio	Evaluar el efecto del ejercicio de relajación sobre la glucosa en sangre y la presión arterial en mujeres con diabetes mellitus gestacional.
Metodología	***Tipo de estudio***	Revisión bibliográfica: ; Ensayo Clínico: ; Revisión Sistemática: ; Casos controles: x; Meta-análisis: ; Cohortes: ; Marco Teórico: ; Descriptivo: ; Revisión histórica: ; Cualitativa: . Estudio cuasiexperimental
	Año de realización	2019
	Técnica recogida de datos	Encuesta/Cuestionario validado: ; Encuesta/cuestionario de elaboración propia: Cuestionario de datos demográficos que incluye preguntas sobre datos personales y médicos.; Escala (Validada/No validada): Escalas de depresión, ansiedad y estrés (DASS).; Registros: Registros del desempeño de las técnicas en casa, registros de peso y altura.; Técnicas cualitativas: (especificar); Otras: (especificar)
	Población y muestra	Los participantes incluyeron 80 mujeres embarazadas con diabetes mellitus gestacional. Durante el estudio, cinco mujeres del grupo de control y dos mujeres del grupo de intervención fueron excluidas del estudio debido a la necesidad de inyecciones de insulina. Dos participantes fueron excluidas del

		estudio antes de la quinta semana. Estos participantes fueron reemplazados por otros nuevos.
Resultados relevantes	No se observó una diferencia estadísticamente significativa entre la puntuación media de glucosa en sangre en ayunas antes y después del estudio en el grupo de control (P = 0,051). El azúcar en sangre en ayunas en el grupo de control no mostró cambios antes y después del período de estudio, pero en el grupo de intervención, esta diferencia fue estadísticamente significativa y se redujo (P < 0,001). Hubo una diferencia estadísticamente significativa entre la presión arterial sistólica media antes y después del estudio en ambos grupos (P < 0.001) - esto se incrementó en el grupo de control y se redujo en el grupo de intervención. También hubo una reducción estadísticamente significativa en la presión arterial diastólica media antes y después del estudio en el grupo de control (P = 0.02). Hubo una pequeña reducción en el grupo de intervención, aunque esto no fue estadísticamente significativo (P = 0,461).	
Discusión planteada	Los cambios en los niveles de glucosa en sangre en ayunas en los grupos de control e intervención fueron +1.05 y -4.08, respectivamente. Esto significa que los participantes del grupo de control vieron un aumento en los niveles de glucosa en sangre en ayunas después de 10 semanas. En el grupo de intervención, las prácticas de relajación, folletos educativos y seguimientos de llamadas telefónicas contribuyeron a una disminución significativa de los niveles de glucosa en sangre en ayunas. En la segunda medición (10 semanas después de la primera), hubo una diferencia significativa en los niveles de glucosa en sangre en ayunas entre el grupo de control (5,53 ± 0,21) y los grupos de intervención (5,22 ± 0,28) (P < 0,001). Esto confirma los hallazgos del estudio de Kaviani et al (2014) en Shiraz. En otro estudio, Asaadi et al (2013) compararon la efectividad de la educación sobre relajación muscular para reducir la ira y la glucosa en sangre en pacientes con diabetes tipo 1 y tipo 2, y encontraron que la glucosa en sangre media en ambos grupos disminuyó significativamente. Un estudio de Seidi et al (2016) sobre la efectividad de la retroalimentación de biodisponibilidad sobre la depresión, la ansiedad y la glucosa en sangre en pacientes con diabetes tipo 1 mostró que la relajación redujo la ansiedad y la glucosa en sangre, pero no tuvo ningún efecto sobre su depresión. El estrés y la ansiedad pueden aumentar la supervivencia a largo plazo de hormonas como el cortisol, la epinefrina, la noradrenalina, el glucagón, la hormona del crecimiento, la prolactina y la leptina al activar el eje hipotálamo-pituitario-adrenal, lo que resulta en un aumento de la glucosa en sangre (Zare et al, 2013; Mahajan, 2014). El efecto fisiológico de la relajación en la reducción de la actividad del sistema nervioso simpático y, en consecuencia, en la reducción del cortisol plasmático, mejora el nivel de glucosa en sangre (Seidi et al, 2016). La puntuación media de la presión arterial sistólica antes y después de la intervención en los grupos fue estadísticamente significativa (P < 0,001), lo que indica una reducción de la presión arterial sistólica en el grupo de intervención. Durante el embarazo, el sistema circulatorio sufre adaptaciones fisiológicas significativas, por lo que la presión arterial disminuye y alcanza su nivel más bajo en el período de 24 a 26 semanas y luego aumenta. Durante el estudio, la presión sistólica se esperaba que aumentara debido al aumento de la edad gestacional, lo que se observó en el grupo control (media + 6,76 mmHg), pero en el grupo de intervención disminuyó. Estudios anteriores han informado el efecto del estrés y la relajación sobre la presión arterial durante el embarazo (Kaviani et al, 2014; Khani et al, 2014) también informaron el efecto de la relajación en la reducción de la presión arterial sistólica, mientras que un estudio de revisión de Chauhan y Sharma (2017) sobre el efecto de los ejercicios avanzados de relajación muscular sobre la presión arterial también mostró un efecto positivo y beneficioso del ejercicio en la reducción de la presión arterial. De manera similar, en un estudio de BasiriMoghadam et al (2014) sobre el efecto de la técnica de relajación de Jacobson sobre la presión arterial y la adecuación de la diálisis en pacientes	

	sometidos a hemodiálisis, la relajación redujo la presión arterial y aumentó la adecuación de la diálisis. Azimian et al (2017) estudiaron el efecto de la relajación y las imágenes mentales sobre la hipertensión durante el embarazo y encontraron una reducción significativa en la presión arterial sistólica y diastólica. Los ejercicios de relajación aumentan la secreción de endorfinas y disminuyen la secreción de la hormona adrenalina, los niveles de cortisol y el corazón. frecuencia y presión arterial en mujeres embarazadas (Rahimi et al, 2014). Estos ejercicios también pueden reducir la presión arterial y el pulso mediante la relajación muscular, reduciendo la resistencia vascular y la actividad simpática y controlando la respiración. Sin embargo, en un estudio de Fink (2012) sobre el efecto de la relajación y las imágenes mentales en la función cardiovascular de las mujeres embarazadas, no se observaron cambios en la presión arterial sistólica. Para explicar esta contradicción, Fink et al (2012) utilizaron ejercicios de relajación rápida en cada sesión. La presión arterial diastólica media después de la intervención en ambos grupos no fue estadísticamente significativa (P = 0,151), lo que indica que, al realizar técnicas de relajación, la presión arterial diastólica mostró una reducción limitada en el grupo de control (-2,76 mmHg) y en el grupo de intervención (-1 mmHg).
Conclusiones del estudio	Este estudio informa del efecto positivo de los ejercicios de relajación sobre la reducción de los niveles de glucosa en sangre en ayunas y la presión arterial sistólica en mujeres con diabetes gestacional. Teniendo en cuenta el impacto de la diabetes gestacional en la salud materna y fetal, y dado que hay menos énfasis en la investigación de la salud mental de las mujeres, se puede diseñar un programa integral de ejercicios de relajación para reducir los riesgos de diabetes gestacional al reducir el estrés.
Valoración (Escala Liker)	Liker 1 — Poco relevante para el objetivo de nuestro estudio (valorar su exclusión) Liker 2 — Relevante para el marco teórico de justificación del estudio pero de poca calidad metodológica Liker 3 — Relevante por la metodología de investigación pero con resultados poco interesantes para nuestro estudio Liker 4 — x — Relevante por la metodología, resultados, conclusiones y marco teórico
Otros aspectos u observaciones	

Liker 1		Poco relevante para el objetivo de nuestro estudio (valorar su exclusión)
Liker 2		Relevante para el marco teórico de justificación del estudio pero de poca calidad metodológica
Liker 3		Relevante por la metodología de investigación pero con resultados poco interesantes para nuestro estudio
Liker 4	x	Relevante por la metodología, resultados, conclusiones y marco teórico

FICHA REVISIÓN BIBLIOGRÁFICA

Nº Ficha (por orden)	Código de Referencia interna
10	Wang

<table>
<tr><td>Cita Bibliográfica (Según Vancouver)</td><td colspan="2">Wang C, Wei Y, Zhang X, Zhang Y, Xu Q, Sun Y, Su S, Zhang L, Liu C, Feng Y, Shou C, Guelfi KJ, Newnham JP, Yang H. A randomized clinical trial of exercise during pregnancy to prevent gestational diabetes mellitus and improve pregnancy outcome in overweight and obese pregnant women. Am J Obstet Gynecol. 2017 Apr;216(4):340-351. doi: 10.1016/j.ajog.2017.01.037. Epub 2017 Feb 1. PMID: 28161306.</td></tr>
<tr><td rowspan="2">Introducción</td><td>Justificación del artículo</td><td>Justificar los efectos del ejercicio físico para prevenir la diabetes gestacional en mujeres embarazadas.</td></tr>
<tr><td>Objetivo del estudio</td><td>Probar la eficacia del ejercicio regular al comienzo del embarazo para prevenir la diabetes mellitus gestacional en mujeres embarazadas con sobrepeso/obesidad.</td></tr>
<tr><td rowspan="4">Metodología</td><td>Tipo de estudio</td><td><table>
<tr><td>Revisión bibliográfica</td><td></td><td>Ensayo Clínico</td><td>x</td></tr>
<tr><td>Revisión Sistemática</td><td></td><td>Casos controles</td><td></td></tr>
<tr><td>Meta-análisis</td><td></td><td>Cohortes</td><td></td></tr>
<tr><td>Marco Teórico</td><td></td><td>Descriptivo</td><td></td></tr>
<tr><td>Revisión histórica</td><td></td><td>Cualitativa</td><td></td></tr>
</table></td></tr>
<tr><td>Año de realización</td><td>2017</td></tr>
<tr><td>Técnica recogida de datos</td><td><table>
<tr><td>Encuesta/Cuestionario validado</td><td>(especificar)</td></tr>
<tr><td>Encuesta/cuestionario de elaboración propia</td><td>Cuestionarios para evaluar información demográfica, médica y antecedentes familiares e información sobre el embarazo actual.
.</td></tr>
<tr><td>Escala (Validada/No validada)</td><td>Escala de Borg</td></tr>
<tr><td>Registros</td><td>Registros sobre niveles de glucosa en sangre.</td></tr>
<tr><td>Técnicas cualitativas</td><td>(especificar)</td></tr>
<tr><td>Otras</td><td>(especificar)</td></tr>
</table></td></tr>
<tr><td>Población y muestra</td><td>300 mujeres chinas embarazadas, 150 en el grupo experimental y 150 en el grupo control. Acaban el estudio 112 mujeres en el grupo experimental y 114 mujeres en el grupo control. 39 y 38 participantes eran obesas en cada grupo, respectivamente.</td></tr>
</table>

Resultados relevantes	Las mujeres asignadas al azar al grupo de ejercicio tuvieron una significativa menor incidencia de diabetes mellitus gestacional (22,0% vs 40,6%; P < 001). Esto representa una reducción clínicamente importante del 45,8% en la incidencia de DMG. Estas mujeres también tuvieron un aumento de peso gestacional significativamente menor a las 25 semanas de gestación y al final del embarazo y niveles reducidos de resistencia a la insulina a las 25 semanas de gestación. Otros resultados secundarios, incluido el aumento de peso gestacional entre las 25-36 semanas de gestación, niveles de resistencia a la insulina a las 36 semanas de gestación, trastornos hipertensivos del embarazo, parto por cesárea (excepto útero cicatricial), edad gestacional media al nacer, parto prematuro, macrosomía (definida como peso al nacer> 4000 g) y lactantes grandes para la edad gestacional también fueron menores en el grupo de ejercicio en comparación con el grupo de control, pero sin diferencia significativa. Sin embargo, los bebés nacidos de las mujeres que siguieron la intervención de ejercicio tuvieron un peso al nacer significativamente más bajo en comparación con los nacidos de mujeres asignadas al grupo control.	
Discusión planteada	En este artículo se discute sobre la incidencia de diabetes gestacional en mujeres chinas embarazadas de peso normal frente a mujeres con sobrepeso u obesidad, además de las complicaciones que eso supone tanto en la madre como en el bebé.	
Conclusiones del estudio	El ejercicio aeróbico sobre bicicleta iniciado temprano en el embarazo y realizado al menos 30 minutos, 3 veces por semana, se asocia con una reducción significativa de la frecuencia de diabetes mellitus gestacional en mujeres embarazadas con sobrepeso/obesidad. Y este efecto es muy relevante para ese tipo de ejercicio al inicio del embarazo ya que disminuye la ganancia de peso gestacional antes de la mitad del segundo trimestre. Además, no hubo evidencia de que el ejercicio prescrito en este estudio aumentara el riesgo de parto prematuro o redujera la edad gestacional media al nacer.	

Valoración (Escala Liker)

Liker 1		Poco relevante para el objetivo de nuestro estudio (valorar su exclusión)
Liker 2	x	Relevante para el marco teórico de justificación del estudio pero de poca calidad metodológica
Liker 3		Relevante por la metodología de investigación pero con resultados poco interesantes para nuestro estudio
Liker 4		Relevante por la metodología, resultados, conclusiones y marco teórico

Otros aspectos u observaciones	

FICHA REVISIÓN BIBLIOGRÁFICA

Nº Ficha (por orden)	Código de Referencia interna
11	Davenport

Cita Bibliográfica (Según Vancouver)	Davenport MH, Ruchat SM, Poitras VJ, Jaramillo Garcia A, Gray CE, Barrowman N, Skow RJ, Meah VL, Riske L, Sobierajski F, James M, Kathol AJ, Nuspl M, Marchand AA, Nagpal TS, Slater LG, Weeks A, Adamo KB, Davies GA, Barakat R, Mottola MF. Prenatal exercise for the prevention of gestational diabetes mellitus and hypertensive disorders of pregnancy: a systematic review and meta-analysis. Br J Sports Med. 2018 Nov;52(21):1367-1375. doi: 10.1136/bjsports-2018-099355. PMID: 30337463	
Introducción	***Justificación del artículo***	Justificar la relación entre el ejercicio físico y la prevención de la diabetes gestacional ya que ésta está asociada con problemas de salud a corto y largo plazo para la madre y el niño.
	Objetivo del estudio	Revisar las relaciones entre el ejercicio prenatal y la prevención de la diabetes gestacional (DMG), hipertensión gestacional (GH) y preeclampsia (PE).
Metodología	***Tipo de estudio***	Revisión bibliográfica [ ] / Ensayo Clínico [ ] Revisión Sistemática [x] / Casos controles [ ] Meta-análisis [x] / Cohortes [ ] Marco Teórico [ ] / Descriptivo [ ] Revisión histórica [ ] / Cualitativa [ ]
	Año de realización	2018
	Técnica recogida de datos	Encuesta/Cuestionario validado: (especificar) Encuesta/cuestionario de elaboración propia: (especificar) Escala (Validada/No validada): (especificar) Registros: (especificar) Técnicas cualitativas: (especificar) Otras: Tablas de extracción de datos creadas en DistillerSR
	Población y muestra	Mujeres embarazadas sin contraindicación absoluta o relativa para el ejercicio. Se incluyeron un total de 106 estudios (n=273182).

Resultados relevantes	Las pruebas de calidad 'moderada' a 'alta' de los ensayos controlados aleatorios revelaron que las intervenciones de solo ejercicio, pero no las co-intervenciones de ejercicio +, redujeron las probabilidades de DMG (n = 6934; OR 0,62; IC del 95%: 0,52 a 0,75), GH (n = 5316; OR 0,61; IC del 95%: 0,43 a 0,85) y PE (n = 3322; OR 0,59; IC del 95%: 0,37 a 0,9) en comparación con ningún ejercicio. Para lograr al menos una reducción del 25% en las probabilidades de desarrollar DMG, PE y GH, las mujeres embarazadas deben acumular al menos 600 MET-min/semana de ejercicio de intensidad moderada (p. ej., 140 minutos de caminata rápida, aeróbicos acuáticos, ciclismo estacionario o entrenamiento de resistencia).
Discusión planteada	En esta revisión sistemática integral de 106 estudios, hubo evidencia de calidad 'moderada' a 'alta' de ECA de solo ejercicio que indicaron que el ejercicio se asoció con una disminución del 38% en las probabilidades de desarrollar DMG (26 ECA, n = 6934), 39% para desarrollar GH (22 ECA, n = 5316) y 41% para desarrollar EP (15 ECA, n = 3322). Para lograr al menos una reducción del 25% en las probabilidades de desarrollar DMG, EP y GH, las mujeres embarazadas deben acumular al menos 600 MET-min/semana de intensidad moderada (por ejemplo, 140 minutos de caminata rápida, aeróbicos acuáticos, ciclismo estacionario o entrenamiento de resistencia). Los resultados de los análisis de metarregresión sugirieron que los beneficios se obtendrían cuando el ejercicio se realiza con una frecuencia de al menos 3 días a la semana o al menos 25 minutos por sesión. Los volúmenes de ejercicio acumulados por encima de 600 MET-min/semana se asociaron con una mayor reducción en las probabilidades de desarrollar estas enfermedades gestacionales. Esta revisión sistemática y metaanálisis se basa en el trabajo de metaanálisis publicados recientemente para incluir 59 nuevos ECA y estudios observacionales sobre la DMG (41284 mujeres adicionales), 12 nuevos ECA sobre GH (2055 mujeres adicionales) y 23 nuevos ECA y estudios observacionales relacionados con la EP (91422 mujeres adicionales). Los hallazgos demostraron menores probabilidades de desarrollar DMG, GH y EP con intervenciones de solo ejercicio en comparación con ningún ejercicio. En contraste, las intervenciones que combinan ejercicio + cointervenciones fueron menos efectivas que el ejercicio solo para DMG (p = 0,007), GH (p = 0,04) y EP (p = 0,05). Por lo general, estos estudios fueron intervenciones de asesoramiento sobre estilos de vida saludables (incluida la dieta y actividad física) en mujeres embarazadas con sobrepeso u obesidad. En estas intervenciones, las mujeres no fueron supervisadas durante el ejercicio y el 67% de los estudios informaron un cumplimiento deficiente (definido como < 60% de los participantes que realizaron el 100% de las sesiones de ejercicio prescritas). Se ha sugerido que la supervisión es fundamental para el cumplimiento y el efecto de la intervención. Por tanto, el cumplimiento de la intervención de ejercicio puede ser un determinante crítico del efecto protector del ejercicio sobre la diabetes gestacional y los trastornos hipertensivos del embarazo; esto podría estar relacionado con la realización real de la intervención según lo previsto. Aunque muchos estudios informaron un cumplimiento deficiente de la intervención prescrita, nuestros hallazgos demostraron una reducción sustancial en el riesgo de desarrollar DMG, GH y EP. Esto sugiere que el efecto protector del ejercicio contra estas enfermedades puede ser aún mayor en las mujeres que se ajustan al ejercicio.
Conclusiones del estudio	Las intervenciones de solo ejercicio redujeron las probabilidades de desarrollar DMG en un 38%, GH en un 39% y EP en un 41%. Para lograr al menos una reducción del 25% en las probabilidades de desarrollar DMG, EP y GH, las mujeres embarazadas deben acumular al menos 600 MET-min / semana de ejercicio de intensidad moderada (p. Ej., 140 minutos de caminata rápida, aeróbicos acuáticos, ciclismo estacionario o entrenamiento de resistencia).

Valoración (Escala Liker)	Liker 1		Poco relevante para el objetivo de nuestro estudio (valorar su exclusión)
	Liker 2		Relevante para el marco teórico de justificación del estudio pero de poca calidad metodológica
	Liker 3		Relevante por la metodología de investigación pero con resultados poco interesantes para nuestro estudio
	Liker 4	x	Relevante por la metodología, resultados, conclusiones y marco teórico
Otros aspectos u observaciones			

FICHA REVISIÓN BIBLIOGRÁFICA

Nº Ficha (por orden)	Código de Referencia interna
12	Yu - Xie

Cita Bibliográfica (Según Vancouver)	Yu Y, Xie R, Shen C, Shu L. Effect of exercise during pregnancy to prevent gestational diabetes mellitus: a systematic review and meta-analysis. J Matern Fetal Neonatal Med. 2018 Jun;31(12):1632-1637. doi: 10.1080/14767058.2017.1319929. Epub 2017 May 14. PMID: 28409688.	
Introducción	***Justificación del artículo***	Justificar la efectividad del ejercicio físico para la prevención de la diabetes gestacional.
	Objetivo del estudio	Evaluar el impacto del ejercicio durante el embarazo en la diabetes mellitus gestacional.
Metodología	***Tipo de estudio***	Revisión bibliográfica: ; Revisión Sistemática: x; Meta-análisis: x; Marco Teórico: ; Revisión histórica: ; Ensayo Clínico: ; Casos controles: ; Cohortes: ; Descriptivo: ; Cualitativa:
	Año de realización	2017
	Técnica recogida de datos	(ver tabla siguiente)
	Población y muestra	En el metanálisis se incluyeron 6 ECA con 2164 pacientes.
Resultados relevantes	En comparación con la intervención de control, la intervención con ejercicios se asoció con una incidencia significativamente menor de diabetes mellitus gestacional (diferencia de medias estándar ¼ 0,59; IC del 95% ¼ 0,39 -. 88; pag ¼. 01), pero no tuvo ningún efecto sobre la edad gestacional al nacer (diferencia de medias estándar ¼ 0,03; IC del 95% ¼ 0,12 a 0,07; pag ¼. 60), el número de nacimientos prematuros (O ¼ 0,85; IC del 95% ¼ 0,43 - 1,66; pag ¼. 63), glucosa 2 horas después de la prueba de tolerancia a la glucosa oral (OGTT) (diferencia media estándar ¼ 1,02; IC del 95% ¼ 2,75 a 0,71; pag ¼. 25), peso al	

Tipo de estudio:

Revisión bibliográfica		Ensayo Clínico	
Revisión Sistemática	x	Casos controles	
Meta-análisis	x	Cohortes	
Marco Teórico		Descriptivo	
Revisión histórica		Cualitativa	

Técnica recogida de datos:

Encuesta/Cuestionario validado	(especificar)
Encuesta/cuestionario de elaboración propia	(especificar)
Escala (Validada/No validada)	(especificar)
Registros	(especificar)
Técnicas cualitativas	(especificar)
Otras	No se especifica ya que se trata de una revisión sistemática y metaanálisis.

	nacer (diferencia media estándar ¼ 0,13; IC del 95% ¼ 0,26 a 0,01; pag ¼. 06) y una puntuación de Apgar inferior a 7 (OR ¼. 78; IC del 95% ¼ 0,21 - 2,91; pag ¼. 71).
Discusión planteada	Este metaanálisis sugirió que, en comparación con la intervención de control, la intervención con ejercicios podría disminuir significativamente la incidencia de diabetes mellitus gestacional, pero no tuvo una influencia significativa en la edad gestacional al nacer, el parto prematuro, la glucosa 2 horas después de la OGTT, el peso al nacer y la puntuación de Apgar menor de 7. Se informó que la intervención con ejercicios mejora la aptitud cardiovascular materna, la automaticidad del ejercicio y reduce la angustia psicológica general. Además, la intervención con ejercicios no se asoció con una reducción de la preeclampsia en comparación con la atención estándar. El problema de seguridad de la intervención con ejercicio se resolvió porque no hubo ningún aborto espontáneo, pérdida fetal, longitud cervical corta o parto prematuro. Un metaanálisis reciente informó que la intervención con ejercicios no mostró una influencia sustancial en la reducción de la incidencia de diabetes mellitus gestacional, pero no informó el análisis de parto prematuro, intolerancia a la glucosa ni peso al nacer, etc. Este metaanálisis concluyó claramente que la intervención con ejercicio podría disminuir significativamente el riesgo de diabetes mellitus gestacional y analizó otros datos de resultados, incluida la edad gestacional al nacer, el parto prematuro, la glucosa 2 horas después de la OGTT, el peso al nacer y la puntuación de Apgar menor de 7. Y, no mostraron diferencias significativas entre el grupo de ejercicio y el grupo de control. Hubo algunos resultados contradictorios con respecto al efecto de la intervención con ejercicios sobre la diabetes mellitus gestacional. La incidencia de diabetes mellitus gestacional no disminuyó después del ejercicio prenatal (ejercicios aeróbicos, de fuerza y de flexibilidad de intensidad moderada tres veces por semana durante 45 - 60min). Sin embargo, se informó que un programa de ejercicios aeróbicos, de fuerza y flexibilidad tres veces por semana reduce significativamente el riesgo de diabetes mellitus gestacional. La actividad de intensidad vigorosa antes y después del embarazo mostró cierto potencial para prevenir la diabetes mellitus gestacional. El ejercicio en el segundo trimestre podría ser tarde para reducir la incidencia de diabetes mellitus gestacional porque los cambios endocrinos y metabólicos comienzan en el primer trimestre.
Conclusiones del estudio	En comparación con la intervención de control, la intervención con ejercicios podría disminuir significativamente el riesgo de diabetes mellitus gestacional, pero no mostró ningún impacto en la edad gestacional al nacer, el parto prematuro, la glucosa 2 horas después de la OGTT, el peso al nacer y la puntuación de Apgar menor de 7. La intervención con ejercicios tiene una capacidad importante para prevenir la diabetes mellitus gestacional y debe recomendarse su administración en mujeres embarazadas.
Valoración (Escala Liker)	Liker 1 | | Poco relevante para el objetivo de nuestro estudio (valorar su exclusión) Liker 2 | | Relevante para el marco teórico de justificación del estudio pero de poca calidad metodológica Liker 3 | | Relevante por la metodología de investigación pero con resultados poco interesantes para nuestro estudio Liker 4 | x | Relevante por la metodología, resultados, conclusiones y marco teórico
Otros aspectos u observaciones	

FICHA REVISIÓN BIBLIOGRÁFICA

Nº Ficha (por orden)	Código de Referencia interna
13	Di Biase

Cita Bibliográfica (Según Vancouver)	Di Biase N, Balducci S, Lencioni C, Bertolotto A, Tumminia A, Dodesini AR, Pintaudi B, Marcone T, Vitacolonna E, Napoli A. Review of general suggestions on physical activity to prevent and treat gestational and pre-existing diabetes during pregnancy and in postpartum. Nutr Metab Cardiovasc Dis. 2019 Feb;29(2):115-126. doi: 10.1016/j.numecd.2018.10.013. Epub 2018 Nov 8. PMID: 30642790.	
Introducción	***Justificación del artículo***	Relacionar el ejercicio físico con la prevención de diabetes gestacional en las mujeres embarazadas.
	Objetivo del estudio	Proporcionar recomendaciones generales sobre la actividad física (AF) en la diabetes mellitus (DMG) pregestacional y gestacional y alentar a las mujeres a participar en actividades seguras y efectivas durante el embarazo, en ausencia de otras contraindicaciones.
Metodología	***Tipo de estudio***	(ver tabla)
	Año de realización	2018
	Técnica recogida de datos	(ver tabla)
	Población y muestra	Mujeres embarazadas con diabetes gestacional o con posibilidad de desarrollarla.

Tipo de estudio:

Revisión bibliográfica		Ensayo Clínico	
Revisión Sistemática	x	Casos controles	
Meta-análisis		Cohortes	
Marco Teórico		Descriptivo	
Revisión histórica		Cualitativa	

Técnica recogida de datos:

Encuesta/Cuestionario validado	(especificar)
Encuesta/cuestionario de elaboración propia	(especificar)
Escala (Validada/No validada)	(especificar)
Registros	(especificar)
Técnicas cualitativas	(especificar)
Otras	Al tratarse de una revisión sistemática, no se especifica la técnica de recogida de datos.

Resultados relevantes	Las mujeres diagnosticadas con DMG tienen un mayor riesgo de desarrollar diabetes mellitus tipo 2 (DM2) en años posteriores. Un estudio más reciente informó que el entrenamiento de resistencia tres veces a la semana durante 30 minutos durante el embarazo es seguro y conduce a una reducción en la incidencia de DMG y mejora los resultados perinatales. Estas publicaciones apuntan a la conclusión de que para reducir la incidencia de DMG, es necesaria una combinación de ejercicio aeróbico y de acondicionamiento muscular a la intensidad y frecuencia utilizadas. Las intervenciones con ejercicios pueden ser útiles para ayudar con el control glucémico y pueden mejorar los resultados maternos y fetales. El ejercicio mejora la sensibilidad a la insulina y aumenta la absorción de glucosa. El ejercicio aeróbico o de resistencia, realizado a una intensidad moderada al menos tres veces por semana, ayuda de manera segura a controlar las concentraciones de glucosa en sangre posprandial y otras medidas de control glucémico en mujeres diagnosticadas con DMG. Durante el embarazo, un programa estructurado de AF puede ayudar a las mujeres con DM1 sin complicaciones a lograr un control metabólico óptimo.
Discusión planteada	La AF practicada durante el embarazo es insuficiente. Un enfoque inicial para ayudar a las mujeres a ser más activas físicamente puede ser simplemente animarlas a incorporar más AF no estructurada en la vida diaria, tanto antes como durante el embarazo, en ausencia de contraindicaciones. Esto se consideraría como un punto de partida para avanzar hacia la prescripción del entrenamiento físico, si no existen otras contraindicaciones. Se discute no sólo sobre el tipo y la intensidad, sino también sobre la frecuencia, la duración y la progresión. En cuanto al tipo, se pueden realizar con seguridad ejercicios aeróbicos y de fuerza. Los ejercicios de resistencia son seguros y eficaces para adaptar la dosis de insulina (cuando sea necesario) y comprobar la hiperglucemia. En cuanto a la intensidad, se proponen tres métodos sencillos para evaluar la intensidad del ejercicio aeróbico: las zonas de frecuencia cardíaca objetivo, la escala de Borg y el test del habla. La frecuencia cardíaca es una forma relativamente simple de prescribir ejercicio aeróbico de una manera que se corresponda con el esfuerzo percibido y, por lo tanto, con la intensidad. La escala de Borg se usa para evaluar la intensidad de las diferentes sesiones de entrenamiento, y representa el índice de evaluación subjetiva y la percepción de fatiga y se recomienda en el embarazo. Para la mayoría de las mujeres sanas que aún no son muy activas o que no realizan una actividad de intensidad vigorosa, se recomienda la actividad aeróbica de intensidad moderada durante el embarazo y en el período posparto. Una mujer en mala forma física puede comenzar con intensidad baja y luego progresar a niveles moderados. Las mujeres que ya son muy activas o que realizan una actividad vigorosa regular pueden continuar con estas actividades durante el embarazo. En cuanto a la frecuencia, se sugiere que la recomendada para cualquier tipo de AF en mujeres que padecen DMG sea de 3 a 7 días a la semana. En cuanto a la duración, las mujeres embarazadas sin complicaciones médicas y/u obstétricas deben recibir al menos 150 minutos por semana de AF. Para las mujeres inactivas, aumente la duración del ejercicio moderado lentamente; si ya están más activos, mantenga o baje la intensidad durante el embarazo y aumente la frecuencia o duración.
Conclusiones del estudio	• Antes del embarazo, el ejercicio físico mejora la sensibilidad a la insulina y reduce los niveles plasmáticos de glucosa a través de varios mecanismos mediados y no mediados por insulina (nivel IA). • La intervención combinada de ejercicio y dieta en la diabetes mellitus gestacional limita el aumento de peso materno y el sobrecrecimiento fetal (nivel IB).

	• La actividad física previene la diabetes mellitus gestacional en mujeres obesas pertenecientes a determinadas etnias o características genéticas (nivel IA). • El ejercicio aeróbico y de fuerza puede determinar el inicio tardío de la terapia con insulina, la reducción de la necesidad de insulina y una mejor salud cardiorrespiratoria (nivel IIIB). • Animar a las mujeres a realizar actividad física a lo largo del día, antes y durante el embarazo, es una condición previa para una prescripción de ejercicio personalizada en ausencia de contraindicaciones (nivel IA). • El ejercicio físico durante el embarazo es útil en mujeres diabéticas (nivel IIIB). • La monitorización continua de la glucemia en pacientes con diabetes mellitus tipo 1 durante el ejercicio es un método útil (nivel IIA). • El ejercicio físico está contraindicado en mujeres diabéticas con complicaciones graves de la enfermedad (nivel IA). • Cualquier prescripción de ejercicio debe considerar el tipo, intensidad, frecuencia, duración y progresión. • La actividad física mejora la salud cardiorrespiratoria y el estado de ánimo sin tener efectos negativos sobre el volumen y la composición de la leche materna (nivel IA). • La actividad física ayuda a las mujeres a alcanzar y mantener el peso ideal después del parto y promueve la pérdida de peso cuando se combina con una restricción calórica adecuada (nivel IA). • La actividad física combinada con una nutrición adecuada puede prevenir y/o retrasar la aparición de diabetes en mujeres que previamente padecían diabetes mellitus gestacional (nivel IB).
Valoración (Escala Liker)	Liker 1 | | Poco relevante para el objetivo de nuestro estudio (valorar su exclusión) Liker 2 | | Relevante para el marco teórico de justificación del estudio pero de poca calidad metodológica Liker 3 | | Relevante por la metodología de investigación pero con resultados poco interesantes para nuestro estudio Liker 4 | x | Relevante por la metodología, resultados, conclusiones y marco teórico
Otros aspectos u observaciones	

FICHA REVISIÓN BIBLIOGRÁFICA

Nº Ficha (por orden)	Código de Referencia interna
14	Zheng

Cita Bibliográfica (Según Vancouver)	Zheng J, Wang H, Ren M. Influence of exercise intervention on gestational diabetes mellitus: a systematic review and meta-analysis. J Endocrinol Invest. 2017 Oct;40(10):1027-1033. doi: 10.1007/s40618-017-0673-3. Epub 2017 Apr 12. PMID: 28401529.	
Introducción	***Justificación del artículo***	Demostrar la eficacia del ejercicio físico para el tratamiento de la diabetes gestacional en mujeres embarazadas.
	Objetivo del estudio	Estudiar el efecto de la intervención con ejercicios sobre la diabetes mellitus gestacional.
Metodología	***Tipo de estudio***	Revisión bibliográfica: – ; Revisión Sistemática: x ; Meta-análisis: x ; Marco Teórico: – ; Revisión histórica: – ; Ensayo Clínico: – ; Casos controles: – ; Cohortes: – ; Descriptivo: – ; Cualitativa: –
	Año de realización	2017
	Técnica recogida de datos	Encuesta/Cuestionario validado: (especificar) ; Encuesta/cuestionario de elaboración propia: (especificar) ; Escala (Validada/No validada): (especificar) ; Registros: (especificar) ; Técnicas cualitativas: (especificar) ; Otras: No se especifica la técnica de recogida de datos al tratarse de un metaanálisis que revisa estudios anteriores. En todo caso, se menciona que ante la falta de datos, se contactaría con el autor de cada estudio.
	Población y muestra	Cinco ensayos clínicos aleatorizados con 1872 mujeres embarazadas.

Resultados relevantes	En general, en comparación con la intervención de control, se encontró que la intervención con ejercicios reduce significativamente el riesgo de diabetes mellitus gestacional (diferencia de medias estándar 0,62; IC del 95%: 0,43 a 0,89; P = 0,01), pero no demostró influencia sobre el parto prematuro (OR 0,93; IC del 95% 0,44–1,99; P = 0,86), edad gestacional al nacer (diferencia media estándar - 0,03; IC del 95% - 0,12 a 0,07; P = 0,60), glucosa 2 horas después de la OGTT (diferencia media estándar - 1,02; IC del 95% - 2,75 a 0,71; P = 0,25), peso al nacer (diferencia media estándar - 0,10; IC del 95% - 0,25 a 0,04; P = 0,16), puntuación de Apgar inferior a 7 (OR 0,78; IC del 95%: 0,21 a 2,91; P = 0,71) y preeclampsia (OR 1,05; IC del 95%: 0,53 a 2,07; P = 0,88). En comparación con la intervención de control, se encontró que la intervención con ejercicios redujo significativamente la incidencia de diabetes mellitus gestacional, pero no tuvo una influencia significativa en el parto prematuro, la edad gestacional al nacer, la glucosa 2 h después de la OGTT, el peso al nacer, la puntuación de Apgar menor de 7, y preeclampsia.
Discusión planteada	Este metaanálisis sugirió claramente que, en comparación con la intervención de control, la intervención con ejercicios se asoció con una incidencia significativamente reducida de diabetes mellitus gestacional, pero no mostró ningún efecto significativo sobre el parto prematuro, la edad gestacional al nacer, la glucosa 2 horas después de la prueba de embarazo y la lactancia materna, el peso al nacer, la puntuación Apgar inferior a 7 y preeclampsia. Además, también se encontró que la intervención con ejercicios mejora la aptitud cardiovascular materna, la automaticidad del ejercicio y reduce el malestar psicológico general indicado por la escala de estrés, ansiedad y depresión de 21 ítems. La ingesta nutricional es fundamental para la incidencia de diabetes mellitus gestacional. Para evitar la influencia de la ingesta nutricional, los participantes en el grupo de intervención y el grupo de control obtuvieron una ingesta nutricional similar. Un estudio incluido informó que cada mujer elegible recibió una ingesta nutricional diaria media (energía total, carbohidratos, grasas, proteínas, azúcar y fibra) después de completar un diario de alimentos de 7 días antes y después de la intervención. Además, se descubrió que el ejercicio mejora la salud y reduce la incidencia de obesidad y diabetes mellitus en personas no embarazadas. Pero no hubo evidencia efectiva de la eficacia del ejercicio en mujeres embarazadas. Este metaanálisis indicó claramente que la intervención con ejercicios podría prevenir significativamente la diabetes mellitus gestacional y se centró en otras medidas que incluyen el parto prematuro, la edad gestacional al nacer, la glucosa 2 horas después del TOGT, el peso al nacer, la puntuación de Apgar menor de 7 y la preeclampsia, pero sin diferencias significativas entre la intervención con ejercicios y la intervención de control. Un efecto beneficioso del ejercicio sobre la prevención de la diabetes mellitus gestacional puede ocurrir en mujeres que participaron en una actividad de intensidad vigorosa antes del embarazo y continuaron alguna actividad al principio del embarazo. Deben tenerse en cuenta varias limitaciones. En primer lugar, nuestro análisis se basó en solo cinco ECA y se necesitaron más ensayos clínicos con una muestra grande para explorar este tema. El tiempo de duración y la intensidad del ejercicio en los estudios incluidos fueron diferentes y pueden influir en los resultados de la combinación. A continuación, la intervención con ejercicio basada en las pautas del ACOG puede no cumplir con el requisito de prevenir la diabetes gestacional, y los estudios futuros deben centrarse en una mayor intensidad del ejercicio para las mujeres embarazadas. Por último, algunos datos no publicados y faltantes pueden generar sesgo en el efecto agrupado. La intervención con ejercicios mostró una capacidad importante para reducir el riesgo de diabetes mellitus gestacional. Se recomendó que la intervención con ejercicios se administrara en mujeres embarazadas, pero más estudios deberían investigar la duración óptima y la intensidad del ejercicio.

<table>
<tr><td>Conclusiones del estudio</td><td>En comparación con la intervención de control, se encontró que la intervención con ejercicios redujo significativamente la incidencia de diabetes mellitus gestacional, pero no tuvo una influencia significativa en el parto prematuro, la edad gestacional al nacer, la glucosa 2 horas después de la OGTT, el peso al nacer, la puntuación de Apgar menor de 7, y preeclampsia.</td></tr>
<tr><td>Valoración (Escala Liker)</td><td><table>
<tr><td>Liker 1</td><td></td><td>Poco relevante para el objetivo de nuestro estudio (valorar su exclusión)</td></tr>
<tr><td>Liker 2</td><td></td><td>Relevante para el marco teórico de justificación del estudio pero de poca calidad metodológica</td></tr>
<tr><td>Liker 3</td><td></td><td>Relevante por la metodología de investigación pero con resultados poco interesantes para nuestro estudio</td></tr>
<tr><td>Liker 4</td><td>x</td><td>Relevante por la metodología, resultados, conclusiones y marco teórico</td></tr>
</table></td></tr>
<tr><td>Otros aspectos u observaciones</td><td></td></tr>
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FICHA REVISIÓN BIBLIOGRÁFICA

Nº Ficha (por orden)	Código de Referencia interna
15	Nasiri

Cita Bibliográfica (Según Vancouver)	Nasiri-Amiri F, Sepidarkish M, Shirvani MA, Habibipour P, Tabari NSM. The effect of exercise on the prevention of gestational diabetes in obese and overweight pregnant women: a systematic review and meta-analysis. Diabetol Metab Syndr. 2019 Aug 27;11:72. doi: 10.1186/s13098-019-0470-6. PMID: 31467594; PMCID: PMC6712661.	
Introducción	***Justificación del artículo***	Análisis de la relación entre el ejercicio físico y la prevención de la diabetes gestacional.
	Objetivo del estudio	Revisar sistemáticamente los artículos sobre el efecto del ejercicio en la prevención de la diabetis gestacional en mujeres embarazadas obesas y con sobrepeso.
Metodología	***Tipo de estudio***	Revisión bibliográfica: – ; Ensayo Clínico: – ; Revisión Sistemática: x ; Casos controles: – ; Meta-análisis: x ; Cohortes: – ; Marco Teórico: – ; Descriptivo: – ; Revisión histórica: – ; Cualitativa: –
	Año de realización	2019
	Técnica recogida de datos	Encuesta/Cuestionario validado: Cuestionario de actividad física durante el embarazo (PPAQ). Encuesta/cuestionario de elaboración propia: (especificar). Escala (Validada/No validada): (especificar). Registros: (especificar). Técnicas cualitativas: (especificar). Otras: (especificar)
	Población y muestra	Se incluyeron un total de ocho publicaciones con un tamaño de muestra de 1441 mujeres embarazadas.
Resultados relevantes	El resultado principal del estudio reciente fue comparar la incidencia de diabetes gestacional en el grupo de intervención (entrenamiento con ejercicios durante el embarazo) y el grupo de control. En el caso de la incidencia de diabetes, se ingresaron ocho ensayos clínicos con un tamaño de muestra de 1441 en el metaanálisis. En consecuencia, 143 (19,66%, con IC del 95% 16,83 a 22,74) y 196 (27,45%, con un IC del 95%: 24,20 a 30,88) mujeres	

Tipo de estudio:

Revisión bibliográfica		Ensayo Clínico	
Revisión Sistemática	x	Casos controles	
Meta-análisis	x	Cohortes	
Marco Teórico		Descriptivo	
Revisión histórica		Cualitativa	

Técnica recogida de datos:

Encuesta/Cuestionario validado	Cuestionario de actividad física durante el embarazo (PPAQ).
Encuesta/cuestionario de elaboración propia	(especificar)
Escala (Validada/No validada)	(especificar)
Registros	(especificar)
Técnicas cualitativas	(especificar)
Otras	(especificar)

	embarazadas padecían diabetes en el grupo de intervención y el grupo de control, respectivamente. El RR de DMG fue 0,76 (con IC del 95%: 0,56 a 1,03; P = 0,07). Además, no hubo una relación estadísticamente significativa entre los estudios con intervención en el primer trimestre del embarazo (0,85; IC del 95%: 0,55 a 1,29; I 2 = 66%, P = 0,03) y aquellos con intervención en el segundo trimestre del embarazo (0,64, con IC del 95%: 0,40 a 1.04, yo 2 = 23%, P = 0,27). En los estudios que tuvieron un tiempo de intervención de tres veces a la semana o menos, se observó el efecto de la intervención en la reducción de la incidencia de diabetes (0,59, con IC del 95%: 0,46 a 0,76, I 2 = 0%, P = 0,47). Sin embargo, el efecto de la intervención sobre la reducción de la incidencia de diabetes no se observó en estudios con un tiempo de intervención de más de tres veces por semana (1,03, con IC del 95% 0,78 a 1,35, yo 2 = 0%, P = 0,46). La glucosa plasmática en ayunas (FPG) se evaluó en seis ensayos clínicos con un tamaño de muestra de 819 participantes (423 y 396 en el grupo de intervención y el grupo de control, respectivamente), añadidos en el metaanálisis final. La media de FPG no tuvo diferencias significativas entre los grupos de intervención y control (DME: 0,01, IC del 95% - 0,34 a 0,36, yo 2 = 82%, P <0,001). Además, no se encontraron diferencias significativas entre los estudios con intervención en el primer trimestre del embarazo (SMD: - 0,20, IC del 95% - 52,0 a 0,12, yo 2 = 71%, P = 0,02) y aquellos con intervención en el segundo trimestre del embarazo (DME: 0,45, IC del 95% - 0,20 hasta - 10.1, yo 2 = 79%, P = 0,03). No hubo diferencias significativas entre los grupos de intervención y control en los estudios cuyo tiempo de intervención fue tres veces por semana o menos (DME: 0,13, IC del 95% - 0,60 hasta - 0,86, yo 2 = 92%, P <0,001) frente a estudios con intervención de más de tres veces por semana (SMD: - 0,04, IC del 95% - 0,28 a 0,21, yo 2 = 19%, P = 0,29). La insulina plasmática en ayunas (FPI) se investigó en tres ensayos clínicos con un tamaño de muestra de 235 participantes (119 y 116 en los grupos de intervención y control, respectivamente), ingresados en el metaanálisis final. El FPI medio no tuvo diferencias significativas entre los grupos de intervención y control (DME: - 0,28, IC del 95% - 0,65 hasta 0,08, yo 2 = 49%, P = 0,14).
Discusión planteada	Los resultados del presente estudio mostraron que las actividades de ejercicio, por sí solas, en mujeres embarazadas obesas o con sobrepeso no tuvieron un efecto significativo sobre la incidencia general de DMG, pero considerando el RR, la incidencia de DMG fue un 24% menor en el grupo de intervención que el grupo de control. Esta diferencia es considerable en los dos grupos. Además, el efecto de la intervención sobre la reducción de la incidencia de DMG fue significativo en los estudios cuyo tiempo de intervención fue de tres veces por semana o menos. De modo que el RR de DMG fue hasta un 41% más bajo en el grupo de intervención que en el grupo de atención de rutina. Según el RR, el valor del número necesario a tratar (NNT) fue 4,2 (la confianza varía de 3,0 a 4,4). La inversa de la reducción o aumento del riesgo absoluto y el número de pacientes que necesitan ser tratados para que uno se beneficie en comparación con un control. El NNT ideal es 1, en el que todos han mejorado con el tratamiento y nadie lo ha hecho en el control. Cuanto mayor sea el NNT, menos eficaz es el tratamiento. Pero el valor de un NNT no es solo numérico. Por ejemplo, NNT de 2-5 son indicativos de terapias efectivas. Comenzar a practicar una intervención de ejercicio en el primer o segundo trimestre del embarazo no tuvo una diferencia significativa para disminuir la incidencia de DMG, pero el RR de DMG fue hasta un 36% menor en el grupo de intervención que comenzaron la intervención de ejercicio en el segundo trimestre de embarazo. El estudio de revisión y metaanálisis de Sanabria-Martínez et al. evaluaron el efecto de la actividad física en la prevención de la diabetes gestacional y el aumento de peso materno en 13 estudios con 2873 mujeres embarazadas. Los resultados de su estudio indicaron que el riesgo de desarrollar DMG se puede prevenir en un 31% mediante actividades físicas antes del embarazo. Esta prevención de la DMG fue más evidente cuando

	el ejercicio fue una combinación de ejercicios de resistencia y aeróbicos. Han afirmado que, dado que los ejercicios de resistencia conducen a la captación de glucosa en sangre sin variar la capacidad muscular para responder a la insulina, y los ejercicios aeróbicos provocan la captación de glucosa a través de la insulina; por lo tanto, cuando estos dos tipos de ejercicio se combinan, la probabilidad de prevenir la DMG aumenta. Du y col. en su estudio de revisión evaluó el efecto del ejercicio en 1439 mujeres embarazadas de 13 estudios, y observó que el ejercicio disminuyó el riesgo de DMG en mujeres embarazadas obesas y con sobrepeso. Han et al. revisó los ensayos clínicos (un total de cinco artículos con 1115 participantes) sobre el impacto del ejercicio en la prevención de la DMG y sugirió que no había una diferencia significativa en la incidencia de DMG en las mujeres que recibieron una intervención de ejercicio de intensidad moderada en comparación con las que recibieron atención prenatal de rutina. Un resultado interesante de este estudio de revisión sistemática fue que hacer ejercicio tres veces por semana o menos tuvo mejores resultados que hacerlo más tiempo para prevenir la DMG, y esta diferencia fue estadísticamente significativa. Este fenómeno puede ocurrir a través de dos mecanismos. El estrés ejercido sobre los músculos aumenta la secreción de cortisol y el cortisol también mejora los niveles de glucosa en sangre al aumentar la gluconeogénesis hepática y estimular la degradación de proteínas; por otro lado, el metabolismo del cuerpo pasa a una ingesta de grasas y la energía necesaria para hacer ejercicio se obtiene quemando grasas en las personas que realizan ejercicios diarios. Como resultado, los niveles de glucosa en sangre de estas personas pueden permanecer sin cambios o incluso más altos, mientras que cuando el período de ejercicio es de 3 días a la semana, el metabolismo del cuerpo se mueve hacia las fuentes disponibles, como la glucosa en sangre, que reduce la glucosa en sangre. Se examinó la relación entre la cantidad de actividad física en las primeras 20 semanas de embarazo y el riesgo de desarrollar DMG en un estudio de casos y controles. Determinaron que las mujeres con baja actividad física en las primeras 20 semanas de embarazo, según el cuestionario PPAQ, tenían un alto riesgo de desarrollar DMG en comparación con las que tenían más actividad física. Además, después de ajustar por edad, IMC, gravidez y antecedentes familiares de diabetes, las mujeres con menor actividad física (PPAQ) en el dominio de la actividad de transporte durante las primeras 20 semanas de embarazo tenían un riesgo significativamente mayor de desarrollar DMG. Los resultados contradictorios indican que se necesitan más y más ensayos precisos para llegar a una buena conclusión.
Conclusiones del estudio	Las actividades de ejercicio, solas, en mujeres embarazadas obesas o con sobrepeso no tuvieron un efecto significativo sobre la incidencia general de DMG, pero considerando la medida del efecto, la incidencia de DMG fue un 24% menor en el grupo de intervención que en el grupo de control. Esta diferencia es considerable en los dos grupos. Dado que las publicaciones de la revisión sistemática representan la brecha de información sobre el tema de investigación y allanan el camino para estudios adicionales, parece que se necesitan más ensayos controlados aleatorios para que podamos llegar a una conclusión completa sobre el tipo, la intensidad y duración del ejercicio para prevenir la DMG.
Valoración (Escala Liker)	

Liker 1		Poco relevante para el objetivo de nuestro estudio (valorar su exclusión)
Liker 2		Relevante para el marco teórico de justificación del estudio pero de poca calidad metodológica

	Liker 3		Relevante por la metodología de investigación pero con resultados poco interesantes para nuestro estudio
	Liker 4	x	Relevante por la metodología, resultados, conclusiones y marco teórico
Otros aspectos u observaciones			

FICHA REVISIÓN BIBLIOGRÁFICA

Nº Ficha (por orden)	Código de Referencia interna
16	Bgeginski

Cita Bibliográfica (Según Vancouver)	Bgeginski R, Ribeiro PAB, Mottola MF, Ramos JGL. Effects of weekly supervised exercise or physical activity counseling on fasting blood glucose in women diagnosed with gestational diabetes mellitus: A systematic review and meta-analysis of randomized trials. J Diabetes. 2017 Nov;9(11):1023-1032. doi: 10.1111/1753-0407.12519. Epub 2017 Feb 28. PMID: 28032459.	
Introducción	***Justificación del artículo***	Justificar el ejercicio físico como método de control de la glucemia en ayunas en mujeres embarazadas con diabetes gestacional.
	Objetivo del estudio	Evaluar el efecto del ejercicio supervisado semanalmente (grupo EXE) o el asesoramiento sobre actividad física (grupo AF) en mujeres con DMG en comparación con la atención prenatal habitual (grupo UPN) sobre el control glucémico.
Metodología	***Tipo de estudio***	Revisión bibliográfica [ ] / Ensayo Clínico [ ]; Revisión Sistemática [x] / Casos controles [ ]; Meta-análisis [x] / Cohortes [ ]; Marco Teórico [ ] / Descriptivo [ ]; Revisión histórica [ ] / Cualitativa [ ]
	Año de realización	2017
	Técnica recogida de datos	Encuesta/Cuestionario validado: (especificar); Encuesta/cuestionario de elaboración propia: (especificar); Escala (Validada/No validada): (especificar); Registros: (especificar); Técnicas cualitativas: (especificar); Otras: No se especifican técnicas de recogida de datos al tratarse de una revisión sistemática.
	Población y muestra	Los ocho ECA incluidos en este análisis totalizaron 469 mujeres embarazadas, de las cuales 91 mujeres con DMG participaron en EXE y 143 mujeres con DMG recibieron asesoramiento sobre AF.

Resultados relevantes	El efecto general del ejercicio, supervisado o asesorado, no fue significativamente diferente (P = 0,11) en comparación con las intervenciones de UPN sobre las concentraciones de glucosa en sangre en ayunas (DMP = -2,76 mg / dl, IC del 95%: -6,13 a 0,61; I 2, 87%; PAG para heterogeneidad <0,00001). Sin embargo, cuando se probaron las diferentes intervenciones de ejercicio, el asesoramiento sobre AF mostró una disminución significativa en las concentraciones de glucosa en sangre en ayunas de: 3,88 mg / dl versus control (DMP = -3,88; IC del 95%: -7,33 a -0,42; I 2, 48%; PAG para heterogeneidad <0'15). El efecto de las intervenciones de EXE frente a UPN no fue significativamente diferente (DMP = -1,92 mg / dL, IC del 95%: -7,50 a 3,65; I 2, 91%; PAG para heterogeneidad <0,00001). El efecto general del ejercicio, supervisado o asesorado, no fue significativamente diferente (P = 0,08) en comparación con los controles sobre las concentraciones de glucosa en sangre en ayunas. Sin embargo, cuando se probaron las diferentes intervenciones de ejercicio, el asesoramiento sobre AF mostró una disminución significativa en las concentraciones de glucosa en sangre en ayunas de 3,88 mg/dL frente al control. El efecto de una intervención de EXE frente a UPN sobre las concentraciones de glucosa en sangre en ayunas no fue significativamente diferente. Se examinó el tipo de intervención (modalidad de ejercicio) en los cambios absolutos de la glucemia en ayunas. El ejercicio aeróbico solo se eligió para la mayoría de los estudios, y el efecto general, no fue significativamente diferente (5 intervenciones, 219 pacientes; P = 0,30) en comparación con el control de las concentraciones de glucosa en sangre en ayunas. Los análisis de sensibilidad de los datos según la cantidad de ejercicio semanal (duración de las sesiones x frecuencia = volumen de entrenamiento) se realizaron de acuerdo con las pautas del American College of Obstetricians and Gynecologists que recomiendan ejercicio de intensidad moderada durante al menos 20-30 min/día la mayoría de los días de la semana para embarazadas. Esta recomendación conduce a un rango de 100 a 150 min/semana de ejercicio (20-30 min/día x 5 días/semana). Sin embargo, los participantes alcanzaron los 150 min/semana de ejercicio en un solo estudio. Luego estratificamos por el límite inferior de 100 min/semana de ejercicio, nuestros resultados mostraron que el efecto general de la cantidad de ejercicio semanal (5 intervenciones, 182 pacientes), supervisado o con asesoramiento, no fue significativamente diferente (P = 0.46) en comparación con la atención habitual. Los resultados secundarios se analizaron solo para las pruebas de ejercicio supervisadas semanalmente, ya que las pruebas de asesoramiento sobre actividad física no informaron estos datos. En general, la EXE no tuvo ningún efecto sobre la edad gestacional del parto (DMP = 0,01 semanas, IC del 95%: -0,33 a 0,36; I 2, 0,0%; PAG para heterogeneidad = 0,75) y peso al nacer en el momento del parto (DMP = -69,41 g, IC del 95% - 202,05 a 63,22; I 2, 0,0%; PAG para heterogeneidad = 0,52). Las probabilidades de tener un recién nacido macrosómico (peso al nacer superior a 4000 g) tampoco fueron significativas (OR 0,79; IC del 95%: 0,24 a 2,62; I 2, 20,0%; PAG para heterogeneidad = 0,57), así como un parto prematuro (<37 semanas de gestación) (OR 1,16; IC del 95%: 0,39 a 3,41; I 2, 20,0%; PAG por heterogeneidad = 0,93) o un parto por cesárea (OR 0,75; IC del 95%: 0,37 a 1,55; I 2, 20,0%; PAG para heterogeneidad = 0,95). Solo dos pruebas de ejercicio supervisadas por semana informaron datos sobre el índice de masa corporal antes del embarazo y el aumento de peso durante el embarazo; no se realizaron análisis de estos resultados secundarios.
Discusión planteada	La presente revisión sistemática proporciona el efecto resumido de ocho ECA, con 469 participantes embarazadas. El efecto general del asesoramiento sobre EXE y PA no fue significativamente diferente en comparación con el UPN sobre las concentraciones de glucosa en sangre en ayunas. Dado que la UPN para mujeres con DMG incluye algún tipo

<table>
<tr><td></td><td>de recomendación de actividad física, estos resultados no son sorprendentes. Sin embargo, cuando se probaron las diferentes intervenciones de ejercicio, el asesoramiento sobre AF mostró una disminución significativa en las concentraciones absolutas de glucosa en sangre en ayunas de 3,88 mg / dL en comparación con el control. Aunque la reducción de las concentraciones de glucosa en sangre en ayunas puede ser un indicador importante de la eficacia del programa de intervención para las mujeres con DMG, especialmente si estos valores se reducen por debajo del objetivo sugerido para las concentraciones de FBG, el objetivo exacto sigue siendo un tema controvertido a nivel mundial. Se analizó el efecto de diferentes intervenciones con ejercicios sobre los resultados maternos y perinatales que consistieron en ocho ensayos. La mayoría de las comparaciones de metaanálisis de la revisión anterior se realizaron incluyendo un solo estudio, disminuyendo el poder de sus resultados. La hiperglucemia persistente durante el embarazo se asocia con un mayor riesgo de malformaciones fetales, macrosomía e hipoglucemia neonatal en el momento del parto. La literatura informa que el ejercicio afecta la composición corporal, el metabolismo de carbohidratos y lípidos y estimula la absorción de glucosa, lo que reduce las concentraciones de glucosa en sangre. El ejercicio aumenta la tasa de captación de glucosa en el músculo esquelético, un proceso que está regulado por la translocación de la proteína transportadora de glucosa GLUT-4. Por tanto, sería lógico introducir ejercicio para neutralizar los efectos negativos de la DMG, mejorando así la salud durante el embarazo.</td></tr>
<tr><td>Conclusiones del estudio</td><td>El asesoramiento sobre AF en mujeres con DMG mostró un efecto significativo en comparación con UPN sobre las concentraciones de FBG, posiblemente debido a un mayor tiempo de seguimiento en comparación con los grupos de EXE. Este resultado destaca la importancia de una intervención temprana que dure hasta el parto para una mejor gestión de la DMG. El efecto general del ejercicio en mujeres diagnosticadas con DMG, supervisadas o mediante asesoramiento, no fue significativamente diferente en comparación con las intervenciones de control sobre las concentraciones de glucosa en sangre en ayunas. Cuando se probaron las diferentes intervenciones de ejercicio, el asesoramiento sobre actividad física mostró una disminución significativa en las concentraciones absolutas de glucosa en sangre en ayunas. No hay pruebas suficientes para recomendar o desaconsejar a las mujeres con DMG que se inscriban en programas de ejercicio. Las sesiones de asesoramiento sobre actividad física, además de la atención estándar, pueden ayudar a motivar a las mujeres con DMG para que sean más activas, mientras que el ejercicio estructurado puede ser más difícil de lograr. Para estudios futuros, se sugiere que se diseñen ECA más grandes para comparar la intervención temprana del ejercicio supervisado con el asesoramiento sobre actividad física (o al menos tener una duración similar), con un tiempo de seguimiento más largo hasta la entrega para las mejores prácticas de manejo de la DMG con el fin de evaluar directamente evaluar los diferentes efectos de este tipo de intervenciones sobre el control glucémico en mujeres con DMG.</td></tr>
<tr><td>Valoración (Escala Liker)</td><td><table>
<tr><td>Liker 1</td><td></td><td>Poco relevante para el objetivo de nuestro estudio (valorar su exclusión)</td></tr>
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<tr><td>Otros aspectos u observaciones</td><td></td></tr>
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FICHA REVISIÓN BIBLIOGRÁFICA

Nº Ficha (por orden)	Código de Referencia interna
17	Laredo

Cita Bibliográfica (Según Vancouver)	Laredo-Aguilera JA, Gallardo-Bravo M, Rabanales-Sotos JA, Cobo-Cuenca AI, Carmona-Torres JM. Physical Activity Programs during Pregnancy Are Effective for the Control of Gestational Diabetes Mellitus. Int J Environ Res Public Health. 2020 Aug 24;17(17):6151. doi: 10.3390/ijerph17176151. PMID: 32847106; PMCID: PMC7503359.	
Introducción	***Justificación del artículo***	Justificar los efectos del ejercicio físico para el control de la glucosa y, por tanto, el control de la diabetes gestacional en mujeres embarazadas.
	Objetivo del estudio	Conocer cómo la actividad física influye en las gestantes con diabetes gestacional y analizar qué beneficios aporta el ejercicio o la actividad física sobre el control de GDM.
Metodología	***Tipo de estudio***	Revisión bibliográfica [ ] · Ensayo Clínico [ ] Revisión Sistemática [x] · Casos controles [ ] Meta-análisis [ ] · Cohortes [ ] Marco Teórico [ ] · Descriptivo [ ] Revisión histórica [ ] · Cualitativa [ ]
	Año de realización	2020
	Técnica recogida de datos	Encuesta/Cuestionario validado: (especificar) Encuesta/cuestionario de elaboración propia: (especificar) Escala (Validada/No validada): (especificar) Registros: (especificar) Técnicas cualitativas: (especificar) Otras: Al tratarse de una revisión sistemática, no se especifica.
	Población y muestra	Se seleccionaron seis estudios controlados aleatorios y un estudio observacional de casos y controles de alta calidad. La población estudiada proviene de Italia, Croacia, Brasil, Tailandia, Australia, Nigeria y Reino Unido. Las participantes de los siete artículos son mujeres embarazadas con DMG diagnosticada durante el embarazo cuyas edades oscilan entre los 18 y los 50 años. La muestra total de participantes es de 782 mujeres. La edad gestacional de las mujeres en el momento de la intervención es entre la semana 24 y el final del embarazo (aproximadamente la semana 40).

Resultados relevantes	La duración de las intervenciones varía entre 6 y 16 semanas; por lo tanto, no se puede establecer una duración específica. En cuanto al ejercicio, existen dos tipos de modalidades: actividad aeróbica (AA) y ejercicio de fuerza (RE) o una combinación de ambos, como en el estudio de Sklempe et al. Tres de las siete intervenciones mencionan la actividad aeróbica como una medida de intervención en el control de la DMG. La actividad aeróbica del estudio de Halse et al. consiste en utilizar una bicicleta estática con intervalos de mayor intensidad con una duración final de entrenamiento de 45 min en el último trimestre. Sin embargo, la actividad de Davenport et al. consiste en caminar de 3 a 4 veces por semana durante unos 40 min. En otro estudio, se analiza el efecto de una banda elástica utilizada para realizar un circuito de 8 ejercicios de resistencia, donde la duración del entrenamiento aumenta a medida que avanza el embarazo. Sklempe y col. combinan ambas modalidades (AA y RE) y también incluyen ejercicios pélvicos y de estiramiento con la correspondiente relajación. Este estudio incluye la mayoría de los ejercicios sobre el tipo de intervención y refleja que al final del embarazo no hay diferencias significativas entre los grupos en los niveles de glucosa en ayunas, pero hay una diferencia significativa en los niveles de glucosa posprandial en el GE. Cabe señalar que la intensidad del ejercicio fue moderada. El tipo de actividad de estudio que se realiza en Tailandia es el yoga. Esta forma de ejercicio se ha incluido dentro de la modalidad de ejercicios de resistencia. Durante ocho semanas, la población estudiada realizó este ejercicio dos veces por semana durante 50 min. Las variables analizadas son el ayuno, la glucosa posprandial y la hemoglobina glucosilada (HbA1c). Estas tres variables son menores en el grupo de intervención, con una diferencia significativa ($p = 0{,}012$; $p = 0{,}001$; $p = 0{,}038$, respectivamente). Por lo tanto, se puede afirmar que el yoga es un ejercicio efectivo para controlar estas variables. El ejercicio de Bo et al. consiste en caminar todos los días durante 20 minutos, y los resultados del ayuno, la glucosa posprandial y la HbAc1 son más bajos en los grupos de ejercicio, pero también con una diferencia significativa ($p < 0{,}001$). Finalmente, el estudio controlado aleatorizado de Daniel et al. analiza dos grupos elegidos al azar, experimental y control. El grupo experimental realiza el ejercicio aeróbico, en este caso danza, durante ocho semanas. En comparación con el grupo de control que no realiza actividad física durante este período los resultados son mejores para el grupo experimental para los niveles de glucosa en ayunas a la cuarta y octava semana de actividad física, sin embargo, no hay diferencias entre grupos al principio. Así, realizar este tipo de ejercicio 40-60 min semanales a una intensidad moderada reduce considerablemente la glucosa en ayunas en mujeres embarazadas con DMG.
Discusión planteada	Esta revisión sistemática confirma los beneficios de la actividad física sobre el ayuno, la glucosa posprandial y el control de HbAc1 en mujeres embarazadas con DMG durante el embarazo. Sin embargo, no podemos recomendar un tipo específico de ejercicio, ya que los resultados de todos los estudios muestran beneficios similares de la actividad física durante el embarazo en mujeres con DMG. Solo dos estudios analizan la cantidad de insulina necesaria para controlar la DMG. Ambos estudios coinciden en que la cantidad de insulina es menor en el grupo que realiza la actividad física. Sin embargo, este requisito sigue siendo controvertido ya que Davenport et al. muestran que tanto el grupo que camina como el que no camina aún requieren insulina. Al mismo tiempo, el estudio de De Barros et al. indica que el requerimiento de insulina es menor en el grupo de ejercicio que tiene una actividad física más intensa. Sin embargo, los dos autores están de acuerdo en que la actividad física aeróbica y de resistencia o una combinación de ambas son beneficiosas para controlar los valores de DMG. Además de los beneficios de la actividad física en la DMG, se han encontrado otros beneficios de la actividad física en mujeres embarazadas, por ejemplo, los beneficios

	psicológicos. En uno de los estudios de las 50 mujeres embarazadas que hacían ejercicio, 35 indicaron que su percepción de la salud era excelente, y sólo 5 de las 51 mujeres que no hacían ejercicio percibían que su salud era muy buena. Además, Nakamura afirma que el ejercicio reduce la aparición de síntomas depresivos en mujeres embarazadas y ayuda a mejorar el estado de ánimo. La actividad física ayuda a prevenir la diabetes gestacional al mejorar el control glucémico, la resistencia a la insulina y el aumento de peso antes del embarazo. Un estudio indica que un aumento de 100 minutos de actividad física moderada a vigorosa por semana podría reducir el riesgo de DMG en un 9%. Sin embargo, la mayor probabilidad de prevenir la DMG mediante el ejercicio físico es para las mujeres embarazadas con obesidad mórbida. Además, el último estudio afirma que la prevención depende de la intensidad de la actividad física. Esta intensidad debe ser moderada para reducir el riesgo de DMG y para mejorar la absorción de glucosa. Aun así, otro estudio confirma que los niveles de actividad entre las mujeres embarazadas son bajos por varias razones, por ejemplo, falta de tiempo, miedo a lesionarse o fuerza de voluntad. Además, el ejercicio físico depende del nivel educativo, por lo que tener un nivel socioeconómico bajo contribuye a estar inactivo durante el embarazo. Los protocolos de actividad física podrían mejorar las consultas de enfermería y partería como medida de apoyo a las pacientes embarazadas. Estos protocolos pueden prevenir diferentes problemas asociados con un estilo de vida sedentario en mujeres embarazadas, por ejemplo, aumento de peso excesivo durante el embarazo, GDM, hipertensión arterial, síndrome de dificultad respiratoria e hipocalcemia. Estos protocolos también pueden prevenir complicaciones relacionadas con el feto, por ejemplo, macrosomía, deterioro del crecimiento intrauterino, trauma obstétrico, hiperbilirrubinemia, hipoglucemia, infección y duración de la estadía en la unidad de cuidados intensivos. El seguimiento del embarazo mejoraría, las complicaciones podrían minimizarse y los costos de salud asociados con estas complicaciones se reducirían. Actualmente, estos programas no se ofrecen en el sistema de salud.
Conclusiones del estudio	Ejercicios aeróbicos, de resistencia o una combinación de ambos son eficaces en el control de glucosa, HbcA1 e insulina. Debido a la variabilidad de los ejercicios de los estudios analizados y la variabilidad de la forma de las diferentes mujeres embarazadas, no permite recomendar un tipo de ejercicio en particular. Sin embargo, cualquier tipo de actividad física de intensidad y duración adecuadas pueden beneficiar a las mujeres embarazadas con DMG. Las mujeres embarazadas con DMG deben hacer ejercicio al menos de 20 a 50 minutos como mínimo dos veces por semana. La intensidad de la actividad debe ser al menos moderada. Si bien el ejercicio proporciona el mayor beneficio según los estudios analizados, la dieta también es importante para controlar los valores de glucosa, HbcA1 y la cantidad requerida de insulina. Debido a la escasez de artículos encontrados sobre el tema investigado, la influencia de la actividad física para el control de la DMG requiere una mayor investigación por parte de diferentes profesionales para un mejor control de la GDM.
Valoración (Escala Liker)	

Liker 1		Poco relevante para el objetivo de nuestro estudio (valorar su exclusión)
Liker 2		Relevante para el marco teórico de justificación del estudio pero de poca calidad metodológica
Liker 3		Relevante por la metodología de investigación pero con resultados poco interesantes para nuestro estudio

	Liker 4	x	Relevante por la metodología, resultados, conclusiones y marco teórico
Otros aspectos u observaciones			

FICHA REVISIÓN BIBLIOGRÁFICA

Nº Ficha (por orden)	Código de Referencia interna
18	Guelfi

Cita Bibliográfica (Según Vancouver)	Guelfi KJ, Ong MJ, Crisp NA, Fournier PA, Wallman KE, Grove JR, Doherty DA, Newnham JP. Regular Exercise to Prevent the Recurrence of Gestational Diabetes Mellitus: A Randomized Controlled Trial. Obstet Gynecol. 2016 Oct;128(4):819-827. doi: 10.1097/AOG.0000000000001632. PMID: 27607876.	
Introducción	***Justificación del artículo***	Evaluar los efectos del ejercicio físico sobre la prevención de diabetes gestacional y los resultados maternos y fetales.
	Objetivo del estudio	Investigar el efecto de un programa de ejercicio domiciliario supervisado sobre la recurrencia y la gravedad de la diabetes mellitus gestacional (DMG) junto con otros aspectos de la salud materna y los resultados obstétricos y neonatales.
Metodología	***Tipo de estudio***	(see table below)
	Año de realización	2016
	Técnica recogida de datos	(see table below)

Tipo de estudio:

Revisión bibliográfica		Ensayo Clínico	x
Revisión Sistemática		Casos controles	
Meta-análisis		Cohortes	
Marco Teórico		Descriptivo	
Revisión histórica		Cualitativa	

Técnica recogida de datos:

Encuesta/Cuestionario validado	Cuestionario de fuerza del hábito de ejercicio.
Encuesta/cuestionario de elaboración propia	(especificar)
Escala (Validada/No validada)	Escala de Borg para evaluar el esfuerzo percibido, escala de Depresión Postnatal de Edimburgo, escala de estrés, ansiedad y depresión de 21 ítems, escala de ansiedad físico-social.
Registros	Registros de frecuencia cardíaca, registros de alimentación de 7 días y de actividad física (acelerómetro), registros hospitalarios.
Técnicas cualitativas	(especificar)
Otras	(especificar)

	Población y muestra	Un total de 169 mujeres embarazadas completaron el estudio. 85 mujeres formaron el grupo control y 84 el grupo experimental (ejercicio físico).
Resultados relevantes	El cumplimiento de la intervención de ejercicio fue alto (mediana del 86% de sesiones completadas). La frecuencia cardíaca media durante el ejercicio fue de 130 ± 10 latidos por minuto (70 ± 5% máximo previsto por edad). Los participantes informaron una calificación media de sesión de esfuerzo percibido de 13 ± 1, lo que indica que la intensidad del ejercicio se percibió como " algo duro. " La duración del ejercicio aumentó de 28 ± 4 minutos por sesión en la primera semana a 47 ± 11 minutos en la última semana de la intervención. La tasa de recurrencia de DMG fue similar entre los grupos (control 40% [n=34]; ejercicio 40,5% [n=34]; P=0.95) y la gravedad de la DMG en el momento del diagnóstico no se vio afectada por el programa de ejercicio con respuestas similares de glucosa e insulina a la OGTT (glucosa 2 horas post-OGTT 7.7 ± 1.5 en comparación con 7.6 ± 1.6 mmol/L; P>0.05). El modelo homeostático de evaluación, el índice de sensibilidad a la insulina, la hemoglobina glicosilada y el péptido C sérico también fueron similares entre grupos post-intervención. El avance del embarazo se asoció con un aumento en la frecuencia cardíaca en reposo, los triglicéridos en sangre, las lipoproteínas de baja densidad y el colesterol de las lipoproteínas de alta densidad, y una disminución en presión arterial sistólica y diastólica (P< 0,001); sin embargo, no hubo diferencias entre los grupos. De manera similar, la masa corporal, la suma de los pliegues cutáneos y la circunferencia aumentaron a medida que avanzaba el embarazo sin diferencia entre grupos. La aptitud cardiovascular materna, basada en la producción de potencia al 75% de la frecuencia cardíaca máxima, se incrementó en respuesta al ejercicio, lo que resulta en una mayor aptitud física en el grupo de ejercicio en comparación con las mujeres en el grupo de control después de la intervención. El consumo de oxígeno al 75% de la frecuencia cardíaca máxima también tendió a aumentar después de la intervención de ejercicio. No hubo cambios en las puntuaciones de la Escala de Depresión Postnatal de Edimburgo a lo largo del tiempo y no hubo diferencias entre los grupos. De manera similar, el número de participantes con puntajes de 12 o más en la Escala de Depresión Postnatal de Edimburgo (que indica un mayor riesgo de depresión durante el embarazo) fue similar entre los grupos. En contraste, se observó una diferencia significativa en las puntuaciones de angustia psicológica de la Escala de estrés, ansiedad y depresión de 21 ítems entre los grupos después de la intervención con una reducción en la respuesta al ejercicio, pero sin cambios en el grupo de control. La ansiedad del físico social no cambió con el tiempo y fue similar entre los grupos. La ingesta nutricional diaria se mantuvo inalterada con el tiempo y fue similar entre los grupos pre-intervención y post-intervención. Con respecto a los niveles de actividad física diaria, el número medio de pasos dados disminuyó y el tiempo de sedentarismo aumentó a medida que avanzaba el embarazo, pero no hubo diferencias pre-intervención o post-intervención entre los grupos. El tiempo dedicado a una actividad moderada fuera de la intervención fue similar a lo largo del tiempo y entre los grupos. Es de destacar que las mujeres que realizaban más de 20 minutos de ejercicio físico de intensidad moderada al ingresar al estudio tuvieron una incidencia reducida de DMG independientemente de su asignación de grupo en comparación con las mujeres que realizaban menos de 20 minutos de actividad moderada diaria. El Cuestionario de Fortaleza del Hábito reveló un aumento en el patrón de la acción y la automaticidad del ejercicio desde la pre-intervención hasta la post-intervención en el grupo de ejercicio, pero ningún cambio en las mujeres del grupo de control. No hubo diferencias en los resultados	

	obstétricos o neonatales entre los grupos, excepto que hubo más neonatos varones nacidos de participantes en el grupo de ejercicio en comparación con las mujeres en el grupo de control.
Discusión planteada	Un programa de ejercicio domiciliario supervisado de 14 semanas que comenzó a las 14 semanas de gestación no redujo la recurrencia de DMG ni alteró el grado general de intolerancia a la glucosa o sensibilidad a la insulina. Sin embargo, la intervención se asoció con mejoras en la aptitud cardiovascular materna, aumentos en la automaticidad del ejercicio y una reducción en la angustia psicológica general indicada por la escala de ansiedad, estrés y depresión de 21 ítems. Se identificó un deterioro de la tolerancia a la glucosa antes de las 14 semanas de gestación en el 16% de las mujeres que dieron su consentimiento para el estudio, lo que sugiere que la detección de DMG en mujeres con antecedentes de la afección puede necesitar comenzar antes de lo que se practica actualmente. La falta de efecto de la intervención sobre la recurrencia de DMG es sorprendente dados los datos epidemiológicos que apoyan una reducción del riesgo de DMG con el aumento de la actividad física junto con estudios experimentales que informan sobre los beneficios del ejercicio regular durante el embarazo para la tolerancia a la glucosa. Sin embargo, los pocos ensayos controlados aleatorios que investigan el efecto del ejercicio para la prevención de la DMG han informado resultados contradictorios, y algunos ensayos no observaron ningún efecto del ejercicio prenatal (ejercicios aeróbicos de intensidad moderada, de fuerza y flexibilidad realizados tres veces por semana durante 45- 60 minutos) sobre la incidencia de DMG, mientras que Cordero et al informaron una menor prevalencia de DMG con un programa de ejercicios aeróbicos, de fuerza y flexibilidad realizados tres veces por semana a partir de las 10 a 14 semanas de gestación. La falta de beneficio de nuestra intervención para disminuir la recurrencia de DMG fue poco probable como resultado del bajo cumplimiento dado el diseño domiciliario totalmente supervisado. La prescripción de ejercicio se basó en trabajos previos en mujeres con y sin GDM; sin embargo, es posible que el aumento de la frecuencia del ejercicio haya alterado los resultados, y se desconoce la duración e intensidad óptimas del ejercicio para la prevención de la DMG. También es poco probable que la falta de efecto del ejercicio sobre la DMG sea el resultado de cambios compensatorios en la ingesta nutricional diaria o los niveles de actividad física fuera de la intervención dada la falta de diferencia entre los grupos, aunque se debe reconocer que estas medidas se tomaron antes y después de la intervención solamente, y que los registros diarios de alimentación son susceptibles de subinformar, lo que probablemente se debe a la ingesta de energía más baja de la esperada que se observa aquí. También debe tenerse en cuenta que el grupo de ejercicio dio a luz a un número significativamente mayor de neonatos varones. La presente intervención se inició a las 14 semanas de gestación. Aunque inicialmente esto se consideró una fortaleza del ensayo, recientemente se ha sugerido que la función placentaria y la expresión génica están programadas durante el primer trimestre. En consecuencia, la investigación futura podría centrarse en superar los desafíos de la contratación en una etapa temprana del embarazo e incluso antes de la concepción. En apoyo de esta noción, las mujeres que realizaban más de 20 minutos de actividad física de intensidad moderada al ingresar al estudio tuvieron una incidencia reducida de DMG independientemente de la asignación de grupo. La consideración de los niveles de actividad física de referencia de esta muestra también destaca que las mujeres estudiadas aquí pueden no ser representativas de la población general de mujeres embarazadas en riesgo de DMG. Al ingresar al estudio, la muestra actual acumuló una media de 24 minutos diarios de actividad física de intensidad moderada, que es mayor que la reportada en la población general de mujeres embarazadas en Australia. A pesar de la falta de efecto de la

	intervención del ejercicio sobre la recurrencia o la gravedad de la DMG, la mejora en la aptitud cardiovascular es de gran importancia dada la relación beneficiosa entre el ejercicio durante el embarazo y una mejor forma física y factores de riesgo cardiovascular reducidos más adelante en la vida. Mientras tanto, la reducción en la angustia psicológica general indicada por la escala de estrés, ansiedad y depresión de 21 ítems en el grupo de ejercicio es de interés dados los efectos adversos de la angustia materna en el desarrollo en el útero. Independientemente de estos beneficios, no hubo diferencias en los resultados obstétricos y neonatales entre los grupos, aunque el presente estudio no tuvo el poder estadístico para estos resultados. La presente intervención cesó a las 28 semanas de gestación para coincidir con la evaluación de la medida de resultado primaria; sin embargo, queda por determinar el efecto de continuar una intervención de esta naturaleza hasta el parto.
Conclusiones del estudio	El ejercicio domiciliario supervisado que se inicia después del primer trimestre del embarazo no reduce la recurrencia de DMG ni el grado de disminución de la tolerancia a la glucosa en mujeres con antecedentes de la afección a las 28 semanas de gestación; sin embargo, beneficia la salud materna y el bienestar psicológico. Los estudios futuros deben buscar implementar intervenciones de ejercicio antes de la concepción, extenderse hasta el parto y centrarse en las mujeres con la salud, el nivel socioeconómico y los niveles de actividad física más bajos. Independientemente de la falta de beneficio observado aquí para la prevención de DMG, los beneficios del ejercicio regular para el tratamiento de la diabetes gestacional después del diagnóstico están bien establecidos.
Valoración (Escala Liker)	
Otros aspectos u observaciones	

Liker 1		Poco relevante para el objetivo de nuestro estudio (valorar su exclusión)
Liker 2		Relevante para el marco teórico de justificación del estudio pero de poca calidad metodológica
Liker 3	x	Relevante por la metodología de investigación pero con resultados poco interesantes para nuestro estudio
Liker 4		Relevante por la metodología, resultados, conclusiones y marco teórico

FICHA REVISIÓN BIBLIOGRÁFICA

Nº Ficha (por orden)	Código de Referencia interna
19	Halvatsiotis

Cita Bibliográfica (Según Vancouver)	Halvatsiotis P, Panagiotou O, Koulouvaris P, Raptis A, Bamias A, Kalantaridou S, Valsamakis G. Benefits of exercise in pregnancies with gestational diabetes. J Matern Fetal Neonatal Med. 2020 Jul 7:1-6. doi: 10.1080/14767058.2020.1786515. Epub ahead of print. PMID: 32631105.	
Introducción	***Justificación del artículo***	Justificar la realización de ejercicio físico durante el embarazo para el tratamiento de la diabetes gestacional.
	Objetivo del estudio	Demostrar los beneficios del ejercicio físico en embarazos con diabetes gestacional.
Metodología	***Tipo de estudio***	Revisión bibliográfica [ ] · Ensayo Clínico [ ] Revisión Sistemática [x] · Casos controles [ ] Meta-análisis [ ] · Cohortes [ ] Marco Teórico [ ] · Descriptivo [ ] Revisión histórica [ ] · Cualitativa [ ]
	Año de realización	2020
	Técnica recogida de datos	Encuesta/Cuestionario validado: (especificar) Encuesta/cuestionario de elaboración propia: (especificar) Escala (Validada/No validada): (especificar) Registros: (especificar) Técnicas cualitativas: (especificar) Otras: No se especifica la técnica de recogida de datos.
	Población y muestra	En este artículo no se especifica la muestra. La población son mujeres embarazadas con diabetes gestacional o en prevención de esta.
Resultados relevantes	Parece que los beneficios son más intensos cuando el programa de ejercicios ocurre durante todo el embarazo e incluye una combinación de ejercicios aeróbicos, tonificantes, de resistencia, de fuerza y de flexibilidad. Se recomienda que la actividad física, aunque se fomente a diario, se realice al menos tres días a la semana y se debe hacer al menos 150 minutos de ejercicio aeróbico de intensidad moderada (aumenta la frecuencia cardíaca y comienza a sudar) cada semana (que involucre los músculos grandes del cuerpo). En particular, es preferible realizar ejercicio aeróbico 3-5 veces a la semana. El ejercicio	

	aeróbico favorece el control del peso, mantenimiento del acondicionamiento físico, y también parece reducir los riesgos de diabetes mellitus gestacional (DMG) en grupos específicos. El tiempo puede oscilar entre 150 min/semana de ejercicio de intensidad moderada o 75 min/semana de ejercicio aeróbico intenso, distribuidos en diferentes días. Los 150 minutos se pueden dividir en ejercicios de 30 minutos 5 días a la semana o en ejercicios más pequeños de 10 minutos cada día. En cuanto a los ejercicios de resistencia de intensidad ligera a moderada, pueden mejorar la resistencia muscular y la flexibilidad sin complicaciones para el embarazo. En cuanto a la participación de la gestante en programas de entrenamiento de resistencia (pesas libres, máquinas o peso corporal) es preferible que se realice 2 - 3 veces por semana en días no consecutivos. Los resultados de la investigación describen una relación inversa entre actividad vigorosa, niveles semanales más altos de actividad física y apariencia de DMG. Los resultados estadísticos de muchos más estudios revelan que el ejercicio, como complemento de la atención de rutina, mejora significativamente el control glucémico posprandial, reduce la glucosa en sangre en ayunas para las mujeres embarazadas con DMG e incluso puede retrasar la necesidad de usar insulina.
Discusión planteada	Según lo presentado en un metaanálisis de ensayos controlados aleatorios, los programas estructurados de ejercicio moderado durante el embarazo parecen reducir el aumento excesivo del peso materno, uno de los factores de riesgo más importantes para desarrollar DMG, reduciendo así las tasas de su aparición. Además, los datos basados en la evidencia sugieren que la actividad física de intensidad moderada reduce el riesgo de aumento de peso excesivo durante el embarazo, que es un factor de riesgo tanto para la madre como para el feto, relacionado con la aparición de DMG y complicaciones graves. De hecho, la participación en programas de ejercicio incluso antes del embarazo parece particularmente eficaz para la prevención de la diabetes gestacional, la hipertensión y la preeclampsia. Más específicamente, se demostró que los programas de ejercicio de intensidad moderada de al menos 600 MET-min / semana (por ejemplo, 140 minutos de caminata, aeróbicos acuáticos, ciclismo o entrenamiento de resistencia) contribuyen a una disminución del 25% en el desarrollo de DMG, hipertensión y preeclampsia. Además, se ha registrado suficiente información a favor de una relación inversa entre la actividad física y el riesgo de hipertensión gestacional y preeclampsia. Dado que la aparición de DMG en una mujer está directamente relacionada con la aparición posterior de DM tipo 2, el papel beneficioso del ejercicio en combinación con una dieta saludable en el embarazo diabético es de particular importancia. El ejercicio facilita un mayor ritmo de flujo de glucosa intracelular hacia las células musculares, incluso cuando los niveles de insulina están alterados. Las contracciones musculares durante el ejercicio estimulan el movimiento de los transportadores de glucosa GLUT4 desde el compartimento intracelular a la superficie de la célula muscular mediante la activación de la quinasa AMP, aumentando el NO - óxido nítrico y aumentando los radicales libres de oxígeno (ROS - especies de oxígeno reactivas). También hay evidencia de que el ejercicio puede aumentar tanto la actividad como el número de GLUT4 estimulando su expresión genética. La acción de la insulina es bastante similar ya que también estimula el movimiento de los transportadores de glucosa GLUT4 a la superficie de las células musculares. Sin embargo, la transferencia de la señal de insulina a las células musculares sigue una ruta metabólica diferente, al menos en sus etapas iniciales, a la de la señal de contracción muscular. Por supuesto, existe un criterio de valoración común en las dos vías metabólicas implicadas en la activación de dos proteínas intracelulares, TBC1D1/TBC1D4. Por lo tanto, el ejercicio tiene un efecto beneficioso en la reducción de los niveles elevados de HbA1c y las necesidades de insulina en pacientes con DM tipo 2 y los datos del metaanálisis describen una correlación lineal entre la intensidad del ejercicio y el control

	glucémico. Además, el ejercicio tiene un efecto positivo sobre el control glucémico en mujeres embarazadas con diabetes mellitus. Los resultados de un ensayo clínico aleatorizado mostraron que un programa de ejercicio estructurado que incluía ejercicios aeróbicos y de resistencia tenía un efecto beneficioso sobre los niveles de glucosa posprandial de las mujeres embarazadas. El ejercicio regular durante el embarazo se ha asociado con una menor probabilidad de dar a luz a un bebé con macrosomía. Los bebés mostraron una sensibilidad mejorada a la insulina, una disminución de la grasa corporal con un aumento de la masa magra, un mayor desarrollo del sistema nervioso autónomo y una mejor función del endotelio vascular y del músculo liso. Blaize y col. sugieren que el ejercicio materno durante el embarazo mejora la salud cardiovascular de la descendencia al tiempo que reduce el riesgo de diabetes tipo 2 y enfermedad cardiovascular en la descendencia en el futuro.
Conclusiones del estudio	Combinado con intervenciones dietéticas y medicación si es necesario, el ejercicio como medio esencial para prevenir y controlar la diabetes en un embarazo, demuestra ser necesario para el buen desarrollo y mejores resultados del embarazo, asegurando la salud de la madre y el recién nacido. Además, hay un número creciente de estudios que revelan el papel extremadamente beneficioso del ejercicio en los seres humanos, ya que puede prevenir e incluso revertir el curso del desarrollo de la enfermedad o simplemente tener un efecto en los cambios corporales que pueden haberse "escrito" en nuestro ADN.
Valoración (Escala Liker)	
Otros aspectos u observaciones	

Liker 1		Poco relevante para el objetivo de nuestro estudio (valorar su exclusión)
Liker 2		Relevante para el marco teórico de justificación del estudio pero de poca calidad metodológica
Liker 3		Relevante por la metodología de investigación pero con resultados poco interesantes para nuestro estudio
Liker 4	x	Relevante por la metodología, resultados, conclusiones y marco teórico

FICHA REVISIÓN BIBLIOGRÁFICA

Nº Ficha (por orden)	Código de Referencia interna
20	Awad

<table>
<tr><td>Cita Bibliográfica (Según Vancouver)</td><td colspan="2">Awad E, Ahmed H, Yousef A, Saab IM. Effect of antenatal exercise on mode of delivery in gestational diabetic females: A single-blind randomized controlled trial. Physiother Q. 2019;27(2):1–5.</td></tr>
<tr><td rowspan="2">Introducción</td><td>Justificación del artículo</td><td>Evaluar los resultados de la realización de ejercicio físico sobre la madre y el feto en mujeres con diabetes gestacional.</td></tr>
<tr><td>Objetivo del estudio</td><td>Determinar el efecto de un programa de ejercicio sobre el modo de parto en mujeres embarazadas con diabetes gestacional.</td></tr>
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<tr><td>Meta-análisis</td><td></td><td>Cohortes</td><td></td></tr>
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<tr><td>Técnica recogida de datos</td><td><table>
<tr><td>Encuesta/Cuestionario validado</td><td>(especificar)</td></tr>
<tr><td>Encuesta/cuestionario de elaboración propia</td><td>(especificar)</td></tr>
<tr><td>Escala (Validada/No validada)</td><td>Escala de Borg.</td></tr>
<tr><td>Registros</td><td>Registros de edad, índice de masa corporal, historia clínica, frecuencia cardíaca, puntuación de Apgar.</td></tr>
<tr><td>Técnicas cualitativas</td><td>(especificar)</td></tr>
<tr><td>Otras</td><td>(especificar)</td></tr>
</table></td></tr>
<tr><td>Población y muestra</td><td>Se incluyeron 60 mujeres embarazadas con diabetes gestacional.</td></tr>
<tr><td>Resultados relevantes</td><td colspan="2">No hubo diferencias estadísticamente significativas (p> 0,05) entre los sujetos de ambos grupos en cuanto a edad, IMC o edad gestacional. Sin embargo, la prueba de chi-cuadrado reveló diferencias significativas entre los grupos en el modo de distribución del parto (p < 0,05). El análisis estadístico con ANoVA de diseño mixto analizó a 60 pacientes asignados en 2 grupos iguales y reveló un efecto intrasujeto significativo (F = 306,82, p = 0,0001) y efecto entre sujetos (F = 50,129, p = 0,0001). Sin embargo, no hubo un efecto significativo del tratamiento * tiempo (F = 0,58, p = 0,449). Las pruebas de comparación múltiple por pares revelaron que hubo un aumento significativo (p < 0,05) en la puntuación de Apgar después de 5 minutos en comparación con el de 1 minuto en los recién nacidos de ambos</td></tr>
</table>

	grupos. En cuanto a los efectos entre sujetos, múltiples comparaciones por pares mostraron un aumento significativo a favor del grupo A en comparación con el grupo B en 1 minuto y 5 minutos ($p < 0{,}05$).
Discusión planteada	Un número significativo de mujeres embarazadas se ven afectadas por GDM cada año. Su creciente prevalencia y su relación establecida con numerosas complicaciones y trastornos durante y después del embarazo exigen la identificación de factores que pueden prevenir la incidencia e influir en su curso. Por lo tanto, este estudio se realizó para determinar el efecto de un programa especializado de ejercicio prenatal sobre el modo de parto y la condición neonatal entre 60 mujeres que padecían GDM. Los resultados revelaron una diferencia estadísticamente significativa en el modo de distribución del parto, con una disminución significativa en el número de partos por cesárea en el grupo de estudio en comparación con el grupo de control. Además, hubo un aumento estadísticamente significativo en las puntuaciones de Apgar de los recién nacidos en el nivel crítico 1 y 5 minutos después del parto, lo que favoreció a los neonatos del grupo A. Estas observaciones concuerdan con otros informes que afirman que el ejercicio físico es muy recomendable para la población en general antes y durante el embarazo, y para las mujeres que padecen o están en riesgo de presentar GDM. Las mujeres que padecen diabetes durante el embarazo son más propensas a desarrollar trastornos hipertensivos y preeclampsia y tienen un mayor riesgo de inducción del trabajo de parto o parto por cesárea. Estos hallazgos también están respaldados por quienes presentaron una reducción de 1/3 en el riesgo de sufrir una cesárea aguda o electiva entre las mujeres que desarrollaron GDM y se ajustaron a un programa regular de ejercicio prenatal de intensidad moderada. La GDM se asocia con un riesgo elevado de dar a luz a un bebé macrosómico o grande para la edad gestacional. Como consecuencia de su tamaño, la descendencia de las madres GDM tiene más probabilidades de sufrir un traumatismo de nacimiento significativo, como distocia de hombros, asfixia perinatal, fracturas óseas y parálisis nerviosa. También se ha afirmado que el alto peso fetal al nacer impone riesgos adicionales de cesárea y desproporción cefalopélvica. Estos hallazgos también están respaldados por Lawani et al., quienes informaron un fuerte efecto positivo de agregar ejercicios prenatales aeróbicos y de resistencia a los programas clásicos de ejercicio prenatal sobre los comportamientos de salud y un parto vaginal de bajo riesgo en mujeres diagnosticadas con GDM. El ejercicio prenatal es un método de preparación para el parto no farmacológico. Se considera un método de entrenamiento tanto físico como psicológico de acuerdo con los mecanismos naturales del parto. Los ejercicios prenatales llevaron a una tasa más baja de prolongación de la primera etapa del trabajo de parto en comparación con las mujeres que no recibieron entrenamiento y también resultaron en menos complicaciones en el parto, ya que un tono muscular deficiente puede causar incontinencia, dolor inusual durante el parto, primera y segunda etapas prolongadas del trabajo de parto. Sin embargo, los resultados de este estudio no concuerdan con otros que informan que no hay efectos de las intervenciones de ejercicio o estilo de vida (que combinan dieta y ejercicio) durante el embarazo sobre la puntuación de Apgar o la circunferencia de la cabeza. En un ensayo controlado aleatorio de 105 mujeres, se observaron puntuaciones de Apgar medias más altas en el primer minuto, pero no en el quinto minuto, entre los recién nacidos de mujeres destinadas a la formación. Esto se observó en un análisis por protocolo y no en un análisis por intención de tratar, y la puntuación de Apgar en el quinto minuto se considera una mejor señal de bienestar del recién nacido que el primer minuto. Los resultados de este estudio proporcionan una base para brindar asesoramiento, así como para organizar grupos de entrenamiento físico para mujeres diagnosticadas con GDM y enfatizar la importancia de una dieta saludable y ser

	físicamente activa para ganar el peso recomendado durante el embarazo y después del parto y para prevenir complicaciones del parto en países con recursos limitados.		
Conclusiones del estudio	Se puede concluir que mantener un estilo de vida físicamente activo durante el embarazo protege a las pacientes contra las complicaciones de la GDM. Muchos informes científicos y profesionales enfatizan la importancia del ejercicio como terapia complementaria para las mujeres GDM. Se ha demostrado que los ejercicios prenatales son efectivos para disminuir las complicaciones del trabajo de parto y cambiar el modo de parto hacia un parto normal y sin complicaciones en mujeres diagnosticadas con GDM y su descendencia.		
Valoración (Escala Liker)	Liker 1		Poco relevante para el objetivo de nuestro estudio (valorar su exclusión)
	Liker 2		Relevante para el marco teórico de justificación del estudio pero de poca calidad metodológica
	Liker 3		Relevante por la metodología de investigación pero con resultados poco interesantes para nuestro estudio
	Liker 4	x	Relevante por la metodología, resultados, conclusiones y marco teórico
Otros aspectos u observaciones			

PROGRAMA DE LECTURA CRÍTICA CASPe
Leyendo críticamente la evidencia clínica

10 preguntas para ayudarte a entender una revisión

Comentarios generales

- Hay tres aspectos generales a tener en cuenta cuando se hace la lectura crítica de una revisión:

  ¿Son válidos esos resultados?

  ¿Cuáles son los resultados?

  ¿Son aplicables en tu medio?

- Las 10 preguntas de las próximas páginas están diseñadas para ayudarte a pensar sistemáticamente sobre estos aspectos. Las dos primeras preguntas son preguntas "de eliminación" y se pueden responder rápidamente. Sólo si la respuesta es "sí" en ambas, entonces merece la pena continuar con las preguntas restantes.
- Puede haber cierto grado de solapamiento entre algunas de las preguntas.
- En itálica y debajo de las preguntas encontrarás una serie de pistas para contestar a las preguntas. Están pensadas para recordarte por que la pregunta es importante. ¡En los pequeños grupos no suele haber tiempo para responder a todo con detalle!
- Estas 10 preguntas están adaptadas de: Oxman AD, Guyatt GH et al, Users' Guides to The Medical Literature, VI How to use an overview. (JAMA 1994; 272 (17): 1367-1371)

El marco conceptual necesario para la interpretación y el uso de estos instrumentos puede encontrarse en la referencia de abajo o/y puede aprenderse en los talleres de CASPe:

Juan B Cabello por CASPe. Lectura crítica de la evidencia clínica. Barcelona: Elsevier; 2015. (ISBN 978-84-9022-447-2)

Esta plantilla debería citarse como:
Cabello, J.B. por CASPe. Plantilla para ayudarte a entender una Revisión Sistemática. En: CASPe. Guías CASPe de Lectura Crítica de la Literatura Médica. Alicante: CASPe; 2005. Cuaderno I. p.13-17.

A/ ¿Los resultados de la revisión son válidos?

Preguntas "de eliminación"

1 ¿Se hizo la revisión sobre un tema claramente definido? *PISTA: Un tema debe ser definido en términos de* - *La población de estudio.* - *La intervención realizada.* - *Los resultados ("outcomes") considerados.*	□ SÍ □ NO SÉ □ NO
2 ¿Buscaron los autores el tipo de artículos adecuado? *PISTA: El mejor "tipo de estudio" es el que* - *Se dirige a la pregunta objeto de la revisión.* - *Tiene un diseño apropiado para la pregunta.*	□ SÍ □ NO SÉ □ NO

¿Merece la pena continuar?

Preguntas detalladas

3 ¿Crees que estaban incluidos los estudios importantes y pertinentes? *PISTA: Busca* - *Qué bases de datos bibliográficas se han usado.* - *Seguimiento de las referencias.* - *Contacto personal con expertos.* - *Búsqueda de estudios no publicados.* - *Búsqueda de estudios en idiomas distintos del inglés.*	□ SÍ □ NO SÉ □ NO
4 ¿Crees que los autores de la revisión han hecho suficiente esfuerzo para valorar la calidad de los estudios incluidos? *PISTA: Los autores necesitan considerar el rigor de los estudios que han identificado. La falta de rigor puede afectar al resultado de los estudios ("No es oro todo lo que reluce" El Mercader de Venecia. Acto II)*	□ SÍ □ NO SÉ □ NO
5 Si los resultados de los diferentes estudios han sido mezclados para obtener un resultado "combinado", ¿era razonable hacer eso? *PISTA: Considera si* - *Los resultados de los estudios eran similares entre sí.* - *Los resultados de todos los estudios incluidos están claramente presentados.* - *Están discutidos los motivos de cualquier variación de los resultados.*	□ SÍ □ NO SÉ □ NO

B/ ¿Cuáles son los resultados?

6 ¿Cuál es el resultado global de la revisión? *PISTA: Considera* - *Si tienes claro los resultados últimos de la revisión.* - *¿Cuáles son? (numéricamente, si es apropiado).* - *¿Cómo están expresados los resultados? (NNT, odds ratio, etc.).*	
7 ¿Cuál es la precisión del resultado/s? *PISTA:* *Busca los intervalos de confianza de los estimadores.*	

C/¿Son los resultados aplicables en tu medio?

8 ¿Se pueden aplicar los resultados en tu medio? *PISTA: Considera si* - *Los pacientes cubiertos por la revisión pueden ser suficientemente diferentes de los de tu área.* - *Tu medio parece ser muy diferente al del estudio.*	□ SÍ □ NO SÉ □ NO
9 ¿Se han considerado todos los resultados importantes para tomar la decisión?	□ SÍ □ NO SÉ □ NO
10 ¿Los beneficios merecen la pena frente a los perjuicios y costes? *Aunque no esté planteado explícitamente en la revisión, ¿qué opinas?*	□ SÍ □ NO

11 preguntas para entender un ensayo clínico

Comentarios generales

- Para valorar un ensayo hay que considerar tres grandes epígrafes:

  ¿Son válidos los resultados del ensayo?

  ¿Cuáles son los resultados?

  ¿Pueden ayudarnos estos resultados?

  Las 11 preguntas de las siguientes páginas están diseñadas para ayudarte a centrarte en esos aspectos de modo sistemático.

- Las primeras tres preguntas son de eliminación y pueden ser respondidas rápidamente. Si la respuesta a las tres es "sí", entonces vale la pena continuar con las preguntas restantes.
- Puede haber cierto grado de solapamiento entre algunas de las preguntas.
- En itálica y debajo de las preguntas encontrarás una serie de pistas para contestar a las mismas. Están pensadas para recordarte por qué la pregunta es importante. ¡En los pequeños grupos no suele haber tiempo para responder a todo con detalle!

El marco conceptual necesario para la interpretación y el uso de estos instrumentos puede encontrarse en la referencia de abajo o/y puede aprenderse en los talleres de CASPe:

Juan B Cabello por CASPe. Lectura crítica de la evidencia clínica. Barcelona: Elsevier; 2015. (ISBN 978-84-9022-447-2)

Esta plantilla debería citarse como:

Cabello, J.B. por CASPe. Plantilla para ayudarte a entender un Ensayo Clínico. En: CASPe. Guías CASPe de Lectura Crítica de la Literatura Médica. Alicante: CASPe; 2005. Cuaderno I. p.5-8.

A/¿Son válidos los resultados del ensayo?

<u>Preguntas "de eliminación"</u>

1 ¿Se orienta el ensayo a una pregunta claramente definida? *Una pregunta debe definirse en términos de:* *- La población de estudio.* *- La intervención realizada.* *- Los resultados considerados.*	☐ SÍ	☐ NO SÉ	☐ NO
2 ¿Fue aleatoria la asignación de los pacientes a los tratamientos? *- ¿Se mantuvo oculta la secuencia de aleatorización?*	☐ SÍ	☐ NO SÉ	☐ NO
3 ¿Fueron adecuadamente considerados hasta el final del estudio todos los pacientes que entraron en él? *- ¿El seguimiento fue completo?* *- ¿Se interrumpió precozmente el estudio?* *- ¿Se analizaron los pacientes en el grupo al que fueron aleatoriamente asignados?*	☐ SÍ	☐ NO SÉ	☐ NO

Preguntas de detalle

4 ¿Se mantuvo el cegamiento a: *- Los pacientes.* *- Los clínicos.* *- El personal del estudio.*	☐ SÍ ☐ NO SÉ ☐ NO
5 ¿Fueron similares los grupos al comienzo del ensayo? *En términos de otros factores que pudieran tener efecto sobre el resultado: edad, sexo, etc.*	☐ SÍ ☐ NO SÉ ☐ NO
6 ¿Al margen de la intervención en estudio los grupos fueron tratados de igual modo?	☐ SÍ ☐ NO SÉ ☐ NO

B/ ¿Cuáles son los resultados?

7 ¿Es muy grande el efecto del tratamiento? *¿Qué desenlaces se midieron?* *¿Los desenlaces medidos son los del protocolo?*	
8 ¿Cuál es la precisión de este efecto? *¿Cuáles son sus intervalos de confianza?*	

C/¿Pueden ayudarnos estos resultados?

9 ¿Puede aplicarse estos resultados en tu medio o población local? *¿Crees que los pacientes incluidos en el ensayo son suficientemente parecidos a tus pacientes?*	☐ SÍ ☐ NO SÉ ☐ NO
10 ¿Se tuvieron en cuenta todos los resultados de importancia clínica? *En caso negativo, ¿en qué afecta eso a la decisión a tomar?*	☐ SÍ ☐ NO SÉ ☐ NO
11 ¿Los beneficios a obtener justifican los riesgos y los costes? *Es improbable que pueda deducirse del ensayo pero, ¿qué piensas tú al respecto?*	☐ SÍ ☐ NO

11 preguntas para ayudarte a entender un estudio de Casos y Controles

Comentarios generales

- Hay tres aspectos generales a tener en cuenta cuando se hace lectura crítica de un estudio de Casos y Controles:

  ¿Son válidos los resultados del estudio?

  ¿Cuáles son los resultados?

  ¿Pueden aplicarse en tu medio?

  Las 11 preguntas contenidas en las siguientes páginas están diseñadas para ayudarte a pensar sistemáticamente sobre estos temas.

- Las dos primeras preguntas son "de eliminación" y pueden contestarse rápidamente. Sólo si la respuesta a estas dos preguntas es afirmativa, merece la pena continuar con las restantes.
- Hay un cierto grado de solapamiento entre algunas de las preguntas.
- En la mayoría de las preguntas se te pide que respondas "sí", "no" o "no sé".
- En itálica y debajo de las preguntas encontrarás una serie de pistas para contestar a las preguntas. Están pensadas para recordarte por qué la pregunta es importante. ¡En los pequeños grupos no suele haber tiempo para responder a todo con detalle!

Esta plantilla debería citarse como:
Cabello, J.B. por CASPe. Plantilla para ayudarte a entender un Estudio de Casos y Controles. En: CASPe. Guías CASPe de Lectura Crítica de la Literatura Médica. Alicante: CASPe; 2005. Cuaderno II. p.13-19.

A/ ¿Son los resultados del estudio válidos?

Preguntas de eliminación

1 **¿El estudio se centra en un tema claramente definido?** *PISTA: Una pregunta se puede definir en términos de* - *La población estudiada.* - *Los factores de riesgo estudiados.* - *Si el estudio intentó detectar un efecto beneficioso o perjudicial.*	☐ SÍ ☐ NO SÉ ☐ NO
2 ¿Los autores han utilizado un método apropiado para responder a la pregunta? *PISTA: Considerar* - *¿Es el estudio de Casos y Controles una forma adecuada para contestar la pregunta en estas circunstancias? (¿Es el resultado a estudio raro o prejudicial?).* - *¿El estudio está dirigido a contestar la pregunta?*	☐ SÍ ☐ NO SÉ ☐ NO

¿Merece la pena continuar?

Preguntas de detalle

3 ¿Los casos se reclutaron/incluyeron de una forma aceptable? *PISTA: Se trata de buscar sesgo de selección que pueda comprometer la validez de los hallazgos* - *¿Los casos se han definido de forma precisa?* - *¿Los casos son representativos de una población definida (geográfica y/o temporalmente)?* - *¿Se estableció un sistema fiable para la selección de todos los casos?* - *¿Son incidencia o prevalencia?* - *¿Hay algo "especial" que afecta a los casos?* - *¿El marco temporal del estudio es relevante en relación a la enfermedad/exposición?* - *¿Se seleccionó un número suficiente de casos?* - *¿Tiene potencia estadística?*	☐ SÍ ☐ NO SÉ ☐ NO
4 ¿Los controles se seleccionaron de una manera aceptable? *PISTA: Se trata de buscar sesgo de selección que pueda comprometer la generalizabilidad de los hallazgos.* - *¿Los controles son representativos de una población definida (geográfica y/o temporalmente)?* - *¿Hay algo "especial" que afecta a los controles?* - *¿Hay muchos no respondedores? ¿Podrían ser los no respondedores de alguna manera diferentes al resto?* - *¿Han sido seleccionados de forma aleatorizada, basados en una población?* - *¿Se seleccionó un número suficiente de controles?*	☐ SÍ ☐ NO SÉ ☐ NO

5 ¿La exposición se midió de forma precisa con el fin de minimizar posibles sesgos? *PISTA: Estamos buscando sesgos de medida, retirada o de clasificación:* - *¿Se definió la exposición claramente y se midió ésta de forma precisa?* - *¿Los autores utilizaron variables objetivas o subjetivas?* - *¿Las variables reflejan de forma adecuada aquello que se suponen que tiene que medir? (han sido validadas).* - *¿Los métodos de medida fueron similares tanto en los casos como en los controles?* - *¿Cuando fue posible, se utilizó en el estudio cegamiento?* - *¿La relación temporal es correcta (la exposición de interés precede al resultado/variable de medida)?*	☐ SÍ ☐ NO SÉ ☐ NO
6 **A. ¿Qué factores de confusión han tenido en cuenta los autores?** *Haz una lista de los factores que piensas que son importantes y que los autores han omitido (genéticos, ambientales, socioeconómicos).*	**Lista:**
B. ¿Han tenido en cuenta los autores el potencial de los factores de confusión en el diseño y/o análisis? *PISTA:* *Busca restricciones en el diseño y técnica, por ejemplo, análisis de modelización, estratificación, regresión o de sensibilidad para corregir, controlar o ajustar los factores de confusión.*	☐ SÍ ☐ NO SÉ ☐ NO

B/ ¿Cuáles son los resultados?

7 ¿Cuáles son los resultados de este estudio? *PISTA:* - *¿Cuáles son los resultados netos?* - *¿El análisis es apropiado para su diseño?* - *¿Cuán fuerte es la relación de asociación entre la exposición y el resultado (mira los odds ratio (OR))?* - *¿Los resultados se han ajustado a los posibles factores de confusión y, aun así, podrían estos factores explicar la asociación?* - *¿Los ajustes han modificado de forma sustancial los OR?*	
8 ¿Cuál es la precisión de los resultados? **¿Cuál es la precisión de la estimación del riesgo?** *PISTA:* - *Tamaño del valor de P.* - *Tamaño de los intervalos de confianza.* - *¿Los autores han considerado todas las variables importantes?* - *¿Cuál fue el efecto de los individuos que rechazaron el participar en la evaluación?*	

9 ¿Te crees los resultados? *PISTA*: - *¡Un efecto grande es difícil de ignorar!* - *¿Puede deberse al azar, sesgo o confusión?* - *¿El diseño y los métodos de este estudio son lo suficientemente defectuosos para hacer que los resultados sean poco creíbles?* - *Considera los criterios de Bradford Hills (por ejemplo, secuencia temporal, gradiente dosis-respuesta, fortaleza de asociación, verosimilitud biológica).*	□ SÍ □ NO SÉ □ NO

¿Merece la pena continuar?

C/ ¿Son los resultados aplicables a tu medio?

10 ¿Se pueden aplicar los resultados a tu medio? *PISTA: Considera si* - *Los pacientes cubiertos por el estudio pueden ser suficientemente diferentes de los de tu área.* - *Tu medio parece ser muy diferente al del estudio.* - *¿Puedes estimar los beneficios y perjuicios en tu medio?*	☐ SÍ ☐ NO SÉ ☐ NO
11 ¿Los resultados de este estudio coinciden con otra evidencia disponible? *PISTA*: *Considera toda la evidencia disponible: Ensayos Clínicos aleatorizados, Revisiones Sistemáticas, Estudios de Cohorte y Estudios de Casos y Controles, así como su consistencia.*	☐ SÍ ☐ NO SÉ ☐ NO

Anexo 5: Tabla de resultados de la escala CASPe.

Ítems Escala CASPe	1	2	3	4	5	6	7	8	9	10	11	Total
Peters et al., 2019	Sí	Sí	Sí	No	Sí	Los resultados no están claros, la base de evidencia no es concluyente.	-	Sí	No	Sí	-	6
Brown et al., 2017	Sí	Sí	Sí	Sí	Sí	No hubo evidencia de alta calidad suficiente para poder determinar las diferencias entre los grupos de ejercicio y de control para los resultados de interés.	95%	Sí	Sí	Sí	-	8
Sklempe et al., 2018	Sí	Sí	No	No	Sí	Sí	Sí, la combinación de ejercicios aeróbicos y de resistencia ofrece importantes beneficios para mujeres con diabetes mellitus gestacional.	-	Sí	Sí	Sí	7
Savvaki et al., 2018	Sí	Sí	Sí	Sí	Sí	Bajo la supervisión adecuada, el ejercicio regula los niveles de glucosa, aumenta la sensibilidad a la insulina y es seguro y beneficioso para el tratamiento de la DMG.	-	Sí	Sí	Sí	-	8

Sklempe et al., 2018	Sí	Sí	Sí	No	Sí	Sí	No, no hubo diferencias en las respuestas al ejercicio entre 2º y 3er trimestre, ni entre las que hacen ejercicio antes del embarazo y las que no hacen ejercicio.	95%	Sí	No	Sí	7
Ming et al., 2018	Sí	Sí	Sí	Sí	Sí	El ejercicio durante el embarazo puede disminuir visiblemente la aparición de DMG sin reducir la edad gestacional en el momento del parto y sin aumentar las probabilidades de cesárea en mujeres de peso normal, además de disminuir el aumento de peso gestacional, que se asocia con resultados adversos como hipertensión gestacional, preeclampsia.	95%	Sí	Sí	Sí	-	8
Bianchi et al., 2017	Sí	Sí	Sí	Sí	Sí	Se recomienda a las mujeres embarazadas con diabetes gestacional (o para prevenirla) la realización de ejercicio físico (de tipo aérobico y de resistencia) durante un mínimo de 15 minutos por sesión, 3 veces a la semana (de acuerdo con una frecuencia cardíaca adecuada), aumentándose gradualmente	-	Sí	Sí	Sí	-	8

						durante el segundo trimestre hasta un máximo de aproximadamente 30 minutos por sesión, 4 veces a la semana, y su mantenimiento en su estilo de vida tras el embarazo.						
Barakat et al., 2018	Sí	Sí	No	Sí	Sí	Sí	Sí, los resultados de este ensayo indican que un programa de ejercicio físico supervisado iniciado temprano y mantenido durante el embarazo puede reducir el riesgo de aumento excesivo de peso materno y diabetes mellitus gestacional.	95%	Sí	Sí	Sí	8
Geranmayeh et al., 2019	Sí	Sí	No sé	No sé	No sé	Edad de las pacientes, lenguaje de ellas, factores socioeconómicos. Sí lo han tenido en cuenta.	Este estudio informa del efecto positivo de los ejercicios de relajación sobre la reducción de los niveles de glucosa en sangre en ayunas y la presión arterial sistólica en mujeres con diabetes gestacional.	-	Sí	Sí	Sí	6
Wang et al., 2017	Sí	Sí	Sí	No	Sí	Sí	Sí, el ejercicio aeróbico sobre bicicleta iniciado temprano en el embarazo y realizado al menos 30 minutos, 3 veces por semana, se asocia con una reducción significativa de la frecuencia de diabetes mellitus gestacional en mujeres embarazadas con sobrepeso/obesidad. Y este efecto es muy relevante para	95%	Sí	Sí	Sí	8

							ese tipo de ejercicio al inicio del embarazo ya que disminuye la ganancia de peso gestacional antes de la mitad del segundo trimestre.					
Davenport et al., 2018	Sí	Sí	Sí	Sí	Sí	Las intervenciones de solo ejercicio redujeron las probabilidades de desarrollar diabetes gestacional en un 38%, hipertensión gestacional en un 39% y preeclampsia en un 41%.	95%	Sí	Sí	Sí	-	8
Yu et al., 2017	Sí	Sí	Sí	Sí	Sí	La intervención con ejercicios tiene una capacidad importante para prevenir la diabetes mellitus gestacional y debe recomendarse su administración en mujeres embarazadas.	95%	Sí	Sí	Sí	-	8
Di Biase et al., 2018	Sí	Sí	Sí	Sí	Sí	Las intervenciones con ejercicios pueden ser útiles para ayudar con el control glucémico y pueden mejorar los resultados maternos y fetales. El ejercicio mejora la sensibilidad a la insulina y aumenta la absorción de glucosa.	95%	Sí	Sí	Sí	-	8

Zheng et al., 2017	Sí	Sí	Sí	Sí	Sí	En comparación con la intervención de control, se encontró que la intervención con ejercicios redujo significativamente la incidencia de diabetes mellitus gestacional, pero no tuvo una influencia significativa en el parto prematuro, la edad gestacional al nacer, la glucosa 2 horas después de la OGTT, el peso al nacer, la puntuación de Apgar menor de 7, y preeclampsia	95%	Sí	Sí	Sí	-	8
Nasiri-Amiri et al., 2019	Sí	Sí	No	Sí	Sí	Las actividades de ejercicio, solas, en mujeres embarazadas obesas o con sobrepeso no tuvieron un efecto significativo sobre la incidencia general de DMG, pero considerando la medida del efecto, la incidencia de DMG fue un 24% menor en el grupo de intervención que en el grupo de control.	95%	Sí	No	Sí	-	6
Bgeginski et al., 2017	Sí	Sí	No	Sí	Sí	El efecto general del ejercicio en mujeres diagnosticadas con DMG, supervisadas o mediante asesoramiento, no fue	95%	No	No	Sí	-	5

						significativamente diferente en comparación con las intervenciones de control sobre las concentraciones de glucosa en sangre en ayunas.						
Laredo-Aguilera et al., 2020	Sí	Sí	Sí	Sí	Sí	Ejercicios aeróbicos, de resistencia o una combinación de ambos son eficaces en el control de glucosa, HbcA1 e insulina. Cualquier tipo de actividad física de intensidad y duración adecuadas pueden beneficiar a las mujeres embarazadas con DMG.	-	Sí	Sí	Sí	-	8
Guelfi et al., 2016	Sí	Sí	Sí	No	Sí	Sí	El ejercicio domiciliario supervisado que se inicia después del primer trimestre del embarazo no reduce la recurrencia de DMG ni el grado de disminución de la tolerancia a la glucosa en mujeres con antecedentes de la afección a las 28 semanas de gestación; sin embargo, beneficia la salud materna y el bienestar psicológico.	95%	No	Sí	Sí	7
Halvatsiotis et al., 2020	Sí	Sí	Sí	Sí	Sí	Combinado con intervenciones dietéticas y medicación si es necesario, el ejercicio como medio esencial para prevenir y controlar la	-	Sí	No	Sí	-	7

						diabetes en un embarazo, demuestra ser necesario para el buen desarrollo y mejores resultados del embarazo, asegurando la salud de la madre y el recién nacido.						
Awad et al., 2019	Sí	Sí	Sí	Simple ciego del investigador.	Sí	Sí	Sí, ya que se ha demostrado que los ejercicios prenatales son efectivos para disminuir las complicaciones del trabajo de parto y cambiar el modo de parto hacia un parto normal y sin complicaciones en mujeres diagnosticadas con GDM y su descendencia.	95%	Sí	Sí	Sí	8

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DIABETES AND PREGNANCY (M-F HIVERT AND CE POWE, SECTION EDITORS)

Exercise in Pregnant Women with Diabetes

Tricia M. Peters[1] · Anne-Sophie Brazeau[2]

Abstract

Purpose of Review Diabetes affects an increasing number of pregnancies. Regular exercise is recommended for pregnant women without diabetes, but whether exercise during pregnancy also benefits women with gestational diabetes (GDM) or preexisting (type 1 or type 2) diabetes or if these women have any specific risks is unclear.

Recent Findings Recent evidence suggests that low- to moderate-intensity exercise improves blood glucose and may delay insulin initiation for women with GDM. Exercise is also safe, with no reports of increased maternal or neonatal complications. Few studies evaluated exercise as adjunct therapy for pregnant women with preexisting diabetes, precluding a thorough assessment in this population.

Summary Low- to moderate-intensity exercise during pregnancy safely improves glycemic control among women with GDM. More studies are needed to evaluate the impact of exercise in pregnant women with preexisting diabetes. Whether a specific type, volume, or timing of activity is most effective is not known.

Keywords Diabetes · Pregnancy · Exercise · Physical activity · Gestational

Introduction

Diabetes is increasingly common among women during the reproductive years [1–4], and over 6% of pregnancies in the USA are affected by some form of diabetes, including gestational diabetes mellitus (GDM), type 1 or type 2 diabetes [5]. Importantly, diabetes during pregnancy is associated with increased risks of adverse pregnancy outcomes [6, 7], which can be mitigated by improved glycemic control [8, 9].

Lifestyle modification with diet and exercise is first-line treatment for GDM and is an important adjunct to pharmacotherapy for type 1 and type 2 diabetes during pregnancy. Of note, over 75% of women with GDM are able to meet glycemic targets with lifestyle intervention alone [8, 10]; for those women with GDM and persistent hyperglycemia despite improvements in diet and exercise, treatment with insulin to target fasting and/or postprandial hyperglycemia is typically recommended as the next step in management [11, 12].

Physical activity is a component of a healthy lifestyle during pregnancy, and guidelines recommend that pregnant women achieve 150 min per week of moderate-intensity physical activity [13–15]. However, specific recommendations and precautions for exercise among pregnant women with diabetes must be considered due to differences in physiology as well as the potential for interactions with medical treatment of diabetes in pregnancy. Therefore, pregnant women with diabetes comprise a unique population for whom targeted, evidence-based guidelines should be applied to ensure the safety of exercise and efficacy for improving maternal and offspring health outcomes.

Exercise refers to structured activity performed for maintenance of physical fitness and is a component of overall physical activity, which is a more complex behavior [16, 17]. In non-pregnant individuals with diabetes, exercise improves insulin sensitivity [18], although effects vary according to the type, intensity, and duration of exercise, concurrent treatment modalities (e.g., insulin use), and the type of diabetes. Regular

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moderate-intensity aerobic exercise, and perhaps particularly when combined with resistance training, improves insulin sensitivity and glycemic control in insulin-resistant populations including men and women with type 2 diabetes, independent of weight loss [18, 19]. Furthermore, observational studies have shown that individuals with type 1 diabetes who report higher activity levels have lower hemoglobin A1c, less microvascular disease, and better control of blood pressure and dyslipidemia [20]. Exercise is also beneficial for reducing insulin requirements [21, 22], controlling body weight, and improving fitness among individuals with type 1 diabetes even in the absence of glycemic benefits [23].

However, for individuals with type 1 diabetes and those with insulin-treated type 2 diabetes, exercise also requires careful consideration of the effects of exogenous insulin on the risk of hypoglycemia during and after activity. The management of insulin-treated diabetes during exercise depends on specific aspects of exercise as well as circulating insulin and glucose levels prior to the activity [24–26]. Thus, individuals with insulin-treated diabetes must have knowledge of strategies for managing insulin preceding, during, and after exercise to limit the risks of hyper- and hypoglycemia during and in the 24-h following exercise [27].

Pregnant women with diabetes comprise a population with a similar need to consider potential interactions of exercise with insulin therapy but with unique physiology. Moreover, for women with diabetes in pregnancy, strict glycemic targets mandate frequent blood glucose monitoring and may result in the initiation of insulin and the need for substantial adjustments of insulin doses throughout pregnancy. Furthermore, increasing insulin resistance and fluctuating insulin needs during pregnancy create specific challenges for exercise, as women treated with insulin need to adjust insulin doses and carbohydrate intake to manage glycemic control in the context of exercise [28]. For women with diabetes during pregnancy, potential benefits of exercise must be balanced with these specific risks.

This review examines recent evidence for the effects of exercise during the gestational period among women with diabetes. Although it is conceivable that habitual activity and/or reduced sedentary time may also play a role in modulating health outcomes for pregnant women with diabetes and their offspring, this review will focus on exercise as opposed to overall physical activity or sedentary behaviors, considering that exercise is a primary target of behavior modification. We will evaluate evidence of the effects of exercise in pregnant women with diabetes on glycemic control and insulin use as well as maternal and neonatal outcomes. This review focuses on pregnant women with gestational diabetes (GDM), type 1 or type 2 diabetes, and does not evaluate exercise prior to pregnancy for prevention of GDM or following pregnancy for prevention of type 2 diabetes among women with GDM.

Exercise in Pregnancy

Exercise during pregnancy is safe in the absence of any contraindications and with avoidance of high-risk activities (Table 1), and most obstetrical society guidelines recommend that pregnant women exercise for 20–30 min per day or 150 min per week [14, 15, 29•]. A summary of current guidelines for exercise during pregnancy from eight countries reported a general recommendation that healthy pregnant women engage in 60–150 min per week of aerobic exercise with an upper limit of 30 min per day, and the addition of resistance exercise was recommended by five guidelines [30].

Potential benefits of exercise for all pregnant women include improved fitness, less gestational weight gain (GWG), and reduced risk of GDM and hypertensive disorders of pregnancy [13, 31–33]. Theoretical risks such as preterm birth, small for gestational age, or miscarriage have not been observed for healthy women performing moderate-intensity exercise throughout pregnancy [34, 35•]. However, few pregnant women meet the current activity guidelines; estimates show that only approximately 25% of pregnant women perform sufficient activity during pregnancy [36, 37]. Cited barriers to physical activity during pregnancy include inactivity prior to pregnancy, first trimester symptoms of fatigue or nausea, and/or mechanical limitations as pregnancy progresses [38, 39]. Moreover, pregnant women with insulin-treated diabetes, particularly type 1 diabetes, may avoid exercise due to fear of hypoglycemia [40]. In addition, healthcare providers may not provide specific advice regarding exercise during pregnancy [41] or may give recommendations that are not actually based on guidelines [42, 43].

To identify a specific "dose" of exercise to recommend and to also optimize feasibility, it is important to evaluate components of exercise. Specifically, the type (e.g., aerobic, resistance training), setting (supervised or unsupervised), timing (prepartum, trimester-specific, acute or habitual), frequency and duration (number of sessions per week, minutes per session, and weeks throughout gestation), and intensity (light, moderate, vigorous) of exercise to achieve the greatest benefit without incurring risk should be determined [17, 44]. Although measurement of exercise during pregnancy is complex [45, 46], use of various methods including self-report and objective measures such as pedometers, accelerometers, and heart rate monitors, in combination with measures of exertion such as pregnancy-specific heart rate targets or subjective intensity ratings via the modified Borg's scale [14] can assess adherence and acceptability of exercise interventions.

Evidence for the efficacy of exercise in pregnant women with diabetes has mostly focused on glycemic control, insulin use and/or dose, GWG, and limited safety outcomes such as maternal and neonatal complications. As the effects of exercise in pregnant women likely differ by the type of diabetes, we will address each diabetes type (i.e., GDM, type 1 or type 2 diabetes) separately.

Table 1 Safety precautions for exercise during pregnancy

(a) Contraindications to exercise during pregnancy [14, 29•]	
Absolute	Relative*
Ruptured membranes	Intrauterine growth restriction*
Premature labor	*Uncontrolled type 1 diabetes***, hypertension or thyroid disease*
Placenta previa after 26–28 weeks of gestation	Other serious cardiovascular, respiratory or systemic disorder (e.g., unevaluated maternal cardiac arrhythmia, chronic bronchitis)*
Preeclampsia	Gestational hypertension*
Incompetent cervix	Symptomatic or severe anemia*
High-order multiple pregnancy	Malnutrition or eating disorder or extreme underweight (BMI < 12 kg/m^2)
	Recurrent pregnancy loss
	History of spontaneous premature birth
	Unexplained persistent second or third trimester vaginal bleeding
	Twin pregnancy after week 28
	Heavy smoker
	History of extremely sedentary lifestyle
	Orthopedic limitation
	Poorly controlled seizure disorder
(b) Activities that are safe or should be avoided during pregnancy [14]	
Types of exercise that are safe during pregnancy	Types of exercise to avoid during pregnancy
Walking	Contact sports (e.g., soccer, hockey)
Swimming	High falling risk (e.g., surfing, downhill skiing)
Stationary cycling	Scuba diving
Low-impact aerobics	Sky diving
Yoga, pilates	Hot yoga/pilates
Safe for women who participated prior to pregnancy	
Running or jogging	
Strength training	
Racquet sports	

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*Conditions which may be considered absolute or relative contraindications, depending on society guideline (ACOG 2015 vs Canadian 2019 guidelines)

**Please refer to the text for a detailed discussion of this contraindication

Physiology of Exercise in Pregnant Women with Diabetes

Pregnancy is characterized by myriad metabolic adaptations that affect glucose levels and may also alter the effects of exercise on glycemic control. Glucose is the primary source of fetal energy and is required for optimal fetal growth and development. Accordingly, hormonal changes of pregnancy and effects of the placenta drive preferential feto-placental glucose delivery; maternal glucose production increases and maternal insulin sensitivity is reduced as pregnancy progresses, particularly at the level of skeletal muscle [47], in order to shift glucose to the developing fetus [44, 47].

Among healthy pregnant women, regular exercise during pregnancy reduces insulin resistance and upregulates skeletal muscle glucose transporter GLUT4 [48, 49], and these effects may be more pronounced for overweight and obese pregnant women [50•]. Notably, the gestational timepoint at which a woman exercises is important, as even among low-risk pregnant women, insulin resistance increases during the second and third trimesters.

Effects of Exercise in Pregnant Women with Diabetes on Glycemic Control and Insulin Use

Gestational Diabetes

Many prior studies have focused on exercise interventions for women with GDM, particularly as a means for improving glycemic control (Appendix Table 2). In a systematic review and meta-analysis of randomized controlled trials (RCTs), Brown, et al. [51••] reported that low- to moderate-intensity aerobic and resistance exercise reduced fasting blood glucose (FBG) by a mean difference of 0.59 mmol/L (95% CI − 1.07 to − 0.11) and post-prandial glucose (PPG) by 0.85 mmol/L (95% CI − 1.15 to − 0.55) compared to control conditions. Importantly, there was substantial heterogeneity in the effect of exercise on glycemic control across studies; this may have resulted from differences in the timing or the types of interventions, which included walking, cycling, resistance training, and yoga. A more recent systematic review and meta-analysis of exercise intervention studies during pregnancy included a subgroup analysis of women with GDM and observed that acute exercise decreased post-exercise blood glucose levels (mean difference − 1.42 mmol/L, 95% CI − 1.69 to − 1.16) and chronic exercise lowered FBG (mean difference − 2.76 mmol/L, 95% CI − 3.18 to − 2.34) compared to control conditions [50•]. Prenatal exercise also reduced insulin requirements by 0.08 units/kg (95% CI − 0.16 to − 0.01), although exercise interventions did not limit the need for women with GDM to commence insulin, and no evidence was reported on time to insulin initiation. Another systematic review including 6 studies of women with GDM evaluated the impact of the specific type of exercise during pregnancy [52•]. The authors determined that aerobic exercise interventions lowered capillary blood glucose and may reduce insulin dose and requirement. On the other hand, resistance exercise did not affect glucose levels, although fewer women who participated in resistance training required insulin compared to controls. In addition, one study of combined aerobic and resistance exercise showed lower PPG but not FPG in the exercise group; no participants in this single study required insulin.

More recent exercise intervention studies have also reported an effect of exercise on improved glycemic control for women with GDM. A RCT of a combined exercise intervention including 30 min of brisk walking per day as well as 50 min twice per week of aerobic exercise (20 min), resistance training (20–25 min), and pelvic floor exercises and relaxation (10 min) for 6 weeks reported lower PPG but no difference in FPG in women with GDM, none of whom required insulin, compared with standard GDM care [53•]. Within the exercise group, glucose levels were lower following the exercise session for both women who were active prior to pregnancy and those who did not exercise before pregnancy, and although average blood glucose levels dropped below 4.0 mmol/L, no symptoms or adverse effects of hypoglycemia were observed [54]. Of note, blood glucose levels have been observed to be 20% lower among pregnant women due to glycemic adaptations during pregnancy [60]; therefore, the threshold of hypoglycemia for pregnant women has been defined as < 3.3 mmol/L instead of < 4.0 mmol/L [61]. Furthermore, a pre-post intervention study that included objective measurement of exercise via pedometer and glucose measurement using continuous glucose monitoring (CGM) observed improved PPG following moderate-intensity treadmill walking for 30 min compared with 30 min of sitting for women with GDM, none of whom required insulin [55]. However, this intervention study included only eight women over a 5-day study period. In contrast, a randomized intervention of moderate-intensity, supervised aerobic exercise consisting of two 70 min sessions per week of treadmill walking/jogging, stationary cycling, or aerobics from 20 weeks gestation did not result in any differences in FBG, PPG, or insulin requirements at 32 weeks of gestation [56•], although women in the exercise group had lower PPG at 36 weeks and a trend toward later initiation of insulin.

Taken together, these results show some evidence for a benefit of light- to moderate-intensity aerobic and combined exercise during pregnancy on fasting and post-prandial glycemic control among women with GDM. Moreover, current evidence suggests that the effect of exercise may be more pronounced for PPG than FPG. Additionally, there is weak evidence that progression to insulin requirement may be delayed for pregnant women with GDM who exercise. Furthermore, women with GDM who are treated with insulin appear to also show glycemic benefits without increased risk of hypoglycemia. However, it is not possible to determine the specific type or timing of exercise or whether a threshold of exercise intensity or frequency exists to safely exert an influence on glycemic control for women with GDM.

Type 2 Diabetes

Evidence is strong that exercise reduces insulin resistance and lowers hemoglobin A1c in the general population with type 2 diabetes [19, 62, 63]. Furthermore, the American Diabetes Association (ADA) recommends that women with preexisting diabetes, including type 2 diabetes, engage in regular physical activity during pregnancy (grade C) [64]. However, the specific benefits and risks of exercise for pregnant women with type 2 diabetes are not clear; despite the rising prevalence of pregnancies affected by type 2 diabetes [1–4], only one study has evaluated the effect of exercise in pregnant women with type 2 diabetes [57•], and previous systematic reviews have deemed this study of "very low" quality evidence [65•, 66].

One study (Appendix Table 2) evaluated an exercise intervention among pregnant women with type 2 diabetes, all of whom were obese and required insulin [57•]. Women in the exercise group participated in 30 min of moderate-intensity stationary cycling on three occasions per week at 60% of maximal heart rate starting at 24 weeks of gestation. Compared with women with type 2 diabetes who received usual prenatal care, after 10 weeks of the intervention, women in the exercise group had lower average blood glucose (mean difference − 45.7 mg/dL [− 2.5 mmol/L], $P = 0.001$). However, the authors did not assess differences in insulin doses or episodes of hypoglycemia between groups, and baseline glycemic control, fitness, and activity levels were not reported for the two groups.

Type 1 Diabetes

Although the ADA advises women with type 1 diabetes to engage in regular activity during pregnancy [64], uncontrolled type 1 diabetes is considered a contraindication to exercise during pregnancy by some society guidelines (Table 1a) [14, 29•]. While such a classification was likely made to reduce the potential harms of hyper- or hypoglycemia attributable to exercise among women with labile glucose control, this may create confusion for patients and providers with respect to the safety of exercise during pregnancy for women with well-controlled type 1 diabetes.

Only two previous studies (Appendix Table 2) evaluated the effect of an exercise intervention among pregnant women with type 1 diabetes [58•, 59], one of which included only women with well-controlled diabetes [59]. One RCT showed no difference in glycemic control or insulin requirements following 20 min of unsupervised postprandial walking three times weekly for 30 sessions starting in the late first trimester, compared with usual prenatal care and provision of a pedometer [58•]. However, hemoglobin A1c and average glucose levels were lower following the intervention in women who exercised, and there was no increase in hypoglycemia in the exercise group. Yet, this study did not prescribe a particular intensity of walking, and as both the intervention and control groups were given a pedometer, exercise in the control group may have been affected thereby limiting the ability to detect differences between groups. Furthermore, there was no difference in insulin doses between the exercise and control groups with type 1 diabetes, although current clinical recommendations would suggest reducing at least basal insulin and possibly bolus doses depending on the timing of exercise [27].

A brief pre-post intervention study of pregnant women with type 1 diabetes showed improved average glucose measured by CGM on exercise days (6.0 mmol/L compared with 7.7 mmol/L, $P = 0.028$), which included approximately 2 h of walking (three 20-min post-prandial walks and two 50-min treadmill walks per day, with energy expenditure measured objectively by a combined heart rate monitor and accelerometer) compared with free-living days [59]. This study also reported a slight increase in the time spent in the hypoglycemic range, which was defined as ≤ 3.0 mmol/L with symptoms or ≤ 2.5 mmol/L without symptoms, during the exercise days (4.9% vs 2.4%), although the difference was not statistically significant. Of note, the 2-h exercise sessions in this intervention extend beyond the duration recommended by most clinical guidelines and may not be feasible for many pregnant women.

Effects of Exercise in Pregnant Women with Diabetes on Maternal and Neonatal Outcomes

Gestational Diabetes

Studies of exercise interventions during pregnancy for women with GDM have not observed differences in maternal complications, including rates of preeclampsia, Caesarean section, gestational weight gain, induction of labor, or duration of labor (Appendix Table 2) [35•, 51••, 53•, 54]. Neonatal outcomes including gestational age, preterm birth, neonatal morbidity or mortality, or neonatal hypoglycemia also did not differ for pregnant women with GDM following exercise interventions [34, 51••, 53•, 54]. In addition, whereas no differences in macrosomia or birthweight were observed in the Cochrane review [51••], the systematic review by Davenport et al. [67•] reported that offspring of women with GDM who exercised during pregnancy had lower birthweight compared to women without GDM. While these results suggest that exercise for pregnant women with GDM is safe, few studies reported on a full range of outcomes of interest, and the overall quality of data was low [34, 51••, 53•, 67•].

Type 2 Diabetes

In the single study of exercise in pregnant women with type 2 diabetes (Appendix Table 2), offspring of women who exercised during pregnancy had Apgar scores that were one point higher at 1 min, and there was no difference in Apgar scores at 5 min [57•]. Umbilical artery blood flow measured by Doppler ultrasonography was also improved in the exercise group, with lower resistance and pulsatility indices suggestive of improved placentation, which may confer improved fetal outcomes in high-risk pregnancies [68, 69]. No other maternal or neonatal outcomes were reported.

Type 1 Diabetes

Only one study (Appendix Table 2) reported on maternal and neonatal outcomes in the context of exercise for women with type 1 diabetes during pregnancy [58•]. Following an exercise intervention, there was no difference in gestational weight gain, but women with type 1 diabetes were less likely to have a Caesarean section. While a non-significant increase in preterm labor was observed, this trend was seen for both women with and without type 1 diabetes who exercised, and those women with type 1 diabetes who experienced preterm labor were noted to engage in a greater than recommended volume of exercise, walking > 4 miles per day as opposed to the intervention goal of 20 min daily. Notably, offspring of women with type 1 diabetes in the exercise group experienced less hypoglycemia, hypocalcemia, hyperbilirubinemia, and macrosomia compared to controls, although no differences were observed for neonatal birth weight or body mass index.

Conclusions

Exercise appears to be safe for pregnant women with diabetes, and women with diabetes who are active during pregnancy likely achieve similar benefits in fitness and weight management as pregnant women without diabetes. Moreover, pregnant women with diabetes who exercise gain additional benefits, such as improved glucose control for women with GDM, but also confront additional challenges, namely the potential risk of hypoglycemia in women on insulin. While current evidence is reassuring and does not show that pregnant women with diabetes who exercise experience excess hypoglycemia, this evidence is not conclusive and thus healthcare providers must counsel women regarding specific safety concerns.

There is insufficient evidence of the effect of exercise in pregnant women with preexisting diabetes. Although the absolute number of pregnancies complicated by preexisting diabetes is low, the prevalence is rising [1, 2, 4], particularly as type 2 diabetes is diagnosed more frequently among women of reproductive age [4]. Currently, clinical guidance regarding exercise for these women is extrapolated from non-pregnant individuals with type 1 or type 2 diabetes and women with GDM, although the unique metabolic milieu of preexisting diabetes during pregnancy certainly warrants more targeted investigation and recommendations.

At this time, we cannot recommend a specific "dose" of exercise for women with diabetes during pregnancy that may most effectively improve glycemic control without increasing the risk of hypoglycemia or maternal and neonatal complications. Furthermore, the safety and efficacy of a higher intensity or higher volume of exercise is not established, and whether targeting reductions in sedentary behavior instead of or in combination with structured exercise benefits pregnant women with diabetes has not been studied. In addition, considering the increase in insulin resistance as pregnancy progresses, the timing of exercise during gestation may also influence its effects, and trimester-specific recommendations would help target exercise interventions. Of note, women with GDM are typically diagnosed between weeks 24 to 28 of gestation, offering a limited window of opportunity to intervene. Whether a more intensive exercise intervention at the time of GDM diagnosis could safely help avoid or delay insulin requirements would be of interest. For women with preexisting diabetes, preconception care is exceedingly important [70], although it is not currently known if an earlier increase in physical activity could potentiate the benefits of an exercise intervention.

Finally, proving the feasibility of exercise for women with diabetes during pregnancy is imperative, as several barriers to exercise could limit adherence. Inclusion of objective measurement of exercise using devices validated for pregnancy [71] in combination with assessment of perceived exertion could confirm acceptability of an intervention. Furthermore, several technologies are currently available that could help pregnant women with diabetes to safely engage in exercise and optimize potential benefits in the real-world setting. Activity monitors are useful for enhancing adherence to exercise goals, and these devices may serve as a source of motivation for women to improve physical activity levels [72]. In addition, supervised exercise may be more beneficial than independent exercise for improving glycemic outcomes, as has been observed for exercise interventions in type 2 diabetes [73] and in pregnant women without diabetes [50•]. Moreover, diabetes-specific advances such as CGM, flash glucose monitoring, continuous subcutaneous insulin infusion, and closed-loop insulin delivery systems may have benefits for the maintenance of glycemic excursions and prevention of hypoglycemia among pregnant women with diabetes [74–77], although evidence of the utility of these technologies in combination with exercise for pregnant women with diabetes is lacking.

In conclusion, pregnancy is a challenging time for women with diabetes, but is also a period when motivation for health behavior change is high. It is reasonable for pregnant women with diabetes without contraindications to exercise at similar levels as pregnant women without diabetes. Accordingly, the 2019 Canadian guidelines for physical activity during pregnancy give a weak recommendation that women with GDM engage in exercise during pregnancy [29•]. In addition, the American Diabetes Association recommends that women with GDM exercise 20–30 min on most days for glycemic control and management of GWG and suggests that women with preexisting diabetes participate in "regular physical activity prior to and during pregnancy" [64]. Yet, as described above, the evidence base for these recommendations is limited, particularly for women with preexisting diabetes. Future studies of sufficient size and duration should investigate the effects of well-defined exercise interventions in controlled settings at various gestational timepoints and in distinct populations of pregnant women with diabetes (i.e., GDM with fasting hyperglycemia, GDM with postprandial hyperglycemia, type 1 or type 2 diabetes). Further evaluation of whether exercise has distinct effects depending on prepregnancy body weight, fitness level, or insulin use and investigation of the impact of emerging technologies will also provide additional insight regarding the benefits of exercise in pregnant women with diabetes.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

Appendix

Table 2 Recent systematic reviews and intervention studies of exercise during pregnancy for women with (a) gestational diabetes mellitus, (b) type 2 diabetes, and (c) type 1 diabetes

	Components of exercise interventions				Effect of exercise on specified outcomes			
	Type (control group)	Frequency	Intensity	Timing and duration	Glycemic control	Insulin dose and/or requirement	Maternal	Fetal/neonatal
(a) Gestational diabetes								
Brown, 2017 [51••] (Cochrane review)	Aerobic, resistance, and combined aerobic + resistance (vs standard GDM care)	Various	Various	Various	Lower PPG (3 RCTs) Lower FBG (4 RCTs) No difference in maternal hypoglycemia (1 RCT)	No difference in the use of additional pharmacotherapy (4 RCTs)	No differences: gestational weight gain (2 RCTs) Preeclampsia (2 RCTs) C-section (5 RCTs) induction of labor (1 RCT)	No perinatal mortality events (1 RCT) No differences: morbidity/mortality composite (2 RCTs); neonatal hypoglycemia (1 RCT); stillbirth (1 RCT); gestational age (4 RCTs); preterm birth (5 RCTs); APGAR scores (1 RCT); macrosomia (1 RCT); birthweight (6 RCTs)
Davenport, 2018 [50•] (systematic review and meta-analysis, includes GDM studies only)	Acute; chronic (vs non-exercise control)	Various	Various	Various	Acute: Decreased post-exercise glucose (5 studies) Chronic: lower FPG (1 RCT) No difference in hypoglycemia (5 studies)	Lower insulin dose (3 RCTs) No difference in insulin requirement (10 RCTs)	N/A	N/A
Davenport, 2018 [34, 35•] (systematic review and meta-analysis, includes GDM studies only)	Any exercise or physical activity (vs non-exercise control)	Various	Various	Various	N/A	N/A	No differences: preterm labor (1 RCT); C-section (3 RCTs); total length of labor (1 RCT)	Lower birthweight (3 RCTs) No differences: macrosomia (1 RCT); preterm birth (2 RCTs); gestational age (3 RCTs); APGAR score at 1 min (2 RCTs); APGAR score at 5 min (1 RCT)
Cremona, 2018 [52•] (systematic review, includes GDM studies only)	Aerobic ($N = 3$); resistance training ($N = 2$); combined aerobic and resistance training ($N = 1$) (vs non-exercise control)	Various	Various	Various	Aerobic: lower BG (2 studies) Resistance: no difference in BG Combined: lower PPG,	Aerobic: lower insulin dose and fewer required insulin (2 studies); no difference in insulin (1 RCT)	N/A	N/A

Table 2 (continued)

	Components of exercise interventions				Effect of exercise on specified outcomes			
	Type (control group)	Frequency	Intensity	Timing and duration	Glycemic control	Insulin dose and/or requirement	Maternal	Fetal/neonatal
					no difference in FBG	Resistance: fewer required insulin (2 studies) Combined: N/A		
Kokic, 2018 [53•] (RCT, $N = 42$)	Combined aerobic, resistance, stretching (vs GDM diet)	Twice/week	Light-moderate (moderate: 65–75% maximum heart rate, 13–14 Borg scale)	50 min 6 weeks (recruited at ≤ 30 weeks of gestation)	Lower average PPG No difference in FBG	No insulin required	No differences: timing of birth; induction of labor; duration of labor; C-section	No differences: APGAR scores; ponderal index; neonatal complications
Kokic, 2018 [54] (pre-post intervention, $N = 18$)	Combined aerobic, resistance, stretching (no control; pre/post comparison)	Twice/week	Light-moderate (Moderate: 65–75% maximum heart rate, 13–14 Borg scale)	50 min 6 weeks (recruited at ≤ 30 weeks of gestation)	Lower post-exercise glucose	No insulin required	N/A	N/A
Coe, 2018 [55] (pre-post intervention, $N = 8$)	Postprandial treadmill walking (vs sitting)	Once daily	Moderate (3.3 METs, < 14 Borg scale)	30 min 2 days	No difference in overall average BG Lower PPG (CGM)	No insulin use (inclusion criteria)	N/A	N/A
Symons Downs, 2017 [56•] (RCT, $N = 65$)	Aerobic (in-person vs at home vs GDM diet)	Twice/week	Moderate	70 min 16 weeks (from 20 through 36 weeks of gestation)	No difference in FBG or PPG at 32 weeks Lower PPG at 36 weeks	No difference in insulin dose Later insulin initiation	N/A	N/A
(b) Type 2 diabetes								
E-Mekawy, 2012 [57•] (non-RCT, $N = 40$; BMI > 30 kg/m^2)	Cycling (vs normal daily activities)	Three/week	Moderate (60% maximum heart rate)	30 min 10 weeks (from 24 weeks of gestation)	Lower average BG	N/A All insulin-treated		Higher APGAR scores at 1-min No difference in APGAR scores at 5-min
(c) Type 1 diabetes								
Hollingsworth, 1987 [58•] (RCT, $N = 42$ type 1 diabetes; $N = 28$ non-diabetes)	Postprandial walking (vs usual care + pedometer)	Three/week	N/A	20 min 22–24 weeks (from 12 weeks of gestation	No differences: Glycemic control; hypoglycemia	No differences in insulin dose	No difference in gestational weight gain Decreased C-section	No differences: birth weight; BMI Decreased hypoglycemia, hypocalcemia,

Table 2 (continued)

	Components of exercise interventions				Effect of exercise on specified outcomes			
	Type (control group)	Frequency	Intensity	Timing and duration	Glycemic control	Insulin dose and/or requirement	Maternal	Fetal/neonatal
				through delivery)	Lower HbA1c and average glucose post-intervention		Increased preterm labor (NS)	hyperbilirubinemia, macrosomia
Kumareswaran, 2013 [59] (pre-post intervention, *N* = 10)	Walking (vs usual daily activity)	Five/day	Light-moderate (4.8 km/h, 2.6 km/h at 10% incline, 3.9 km/h; 7–15 Borg scale)	20 min × 3, 50 min × 2 Two days (average 20 weeks of gestation)	Lower average BG (CGM) Increased % time hypoglycemic (NS)	N/A All using closed-loop insulin pump		N/A

GDM gestational diabetes mellitus, *RCT* randomized controlled trial, *PPG* postprandial glucose, *FBG* fasting blood glucose, *N/A* no result available, *BG* blood glucose, *non-RCT* non-randomized trial, *BMI* body mass index, *HbA1c* hemoglobin A1c, *NS* not significant, *CGM* continuous glucose monitor

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ABSTRACT

Background

Gestational diabetes mellitus (GDM) is associated with both short- and long-term complications for the mother and her baby. Exercise interventions may be useful in helping with glycaemic control and improve maternal and infant outcomes.

The original review on *Exercise for diabetic pregnant women* has been split into two new review titles reflecting the role of exercise for pregnant women with gestational diabetes and for pregnant women with pre-existing diabetes.

Exercise for pregnant women with gestational diabetes for improving maternal and fetal outcomes (this review)

Exercise for pregnant women with pre-existing diabetes for improving maternal and fetal outcomes

Objectives

To evaluate the effects of exercise interventions for improving maternal and fetal outcomes in women with GDM.

Search methods

We searched the Cochrane Pregnancy and Childbirth Group's Trials Register (27 August 2016), ClinicalTrials.gov, the WHO International Clinical Trials Registry Platform (ICTRP) (18th August 2016), and reference lists of retrieved studies.

Selection criteria

We included randomised controlled trials (RCTs) comparing an exercise intervention with standard care or another intervention in pregnant women diagnosed with gestational diabetes. Quasi-randomised and cross-over studies, and studies including women with pre-existing type 1 or type 2 diabetes were not eligible for inclusion.

Data collection and analysis

All selection of studies, assessment of trial quality and data extraction was conducted independently by two review authors. Data were checked for accuracy.

Main results

We included 11 randomised trials, involving 638 women. The overall risk of bias was judged to be unclear due to lack of methodological detail in the included studies.

For the mother, there was no clear evidence of a difference between women in the exercise group and those in the control group for the risk of pre-eclampsia as the measure of hypertensive disorders of pregnancy (risk ratio (RR) 0.31, 95% confidence interval (CI) 0.01 to 7.09; two RCTs, 48 women; *low-quality evidence*), birth by caesarean section (RR 0.86, 95% CI 0.63 to 1.16; five RCTs, 316 women; I^2 = 0%; *moderate-quality evidence*), the risk of induction of labour (RR 1.38, 95% CI 0.71 to 2.68; one RCT, 40 women; *low-quality evidence*) or maternal body mass index at follow-up (postnatal weight retention or return to pre-pregnancy weight) (mean difference (MD) 0.11 kg/m^2, 95% CI -1.04 to 1.26; three RCTs, 254 women; I^2 = 0%; *high-quality evidence*). Development of type 2 diabetes, perineal trauma/tearing and postnatal depression were not reported as outcomes in the included studies.

For the infant/child/adult, a single small (n = 19) trial reported no perinatal mortality (stillbirth and neonatal mortality) events in either the exercise intervention or control group (*low-quality evidence)*. There was no clear evidence of a difference between groups for a mortality and morbidity composite (variously defined by trials, e.g. perinatal or infant death, shoulder dystocia, bone fracture or nerve palsy) (RR 0.56, 95% CI 0.12 to 2.61; two RCTs, 169 infants; I^2 = 0%; *moderate-quality evidence*) or neonatal hypoglycaemia (RR 2.00, 95% CI 0.20 to 20.04; one RCT, 34 infants; *low-quality evidence*). None of the included trials pre-specified large-for-gestational age, adiposity (neonatal/infant, childhood or adulthood), diabetes (childhood or adulthood) or neurosensory disability (neonatal/infant) as trial outcomes.

Other maternal outcomes of interest: exercise interventions were associated with both reduced fasting blood glucose concentrations (average standardised mean difference (SMD) -0.59, 95% CI -1.07 to -0.11; four RCTs, 363 women; I^2 = 73%; T^2 = 0.19) and a reduced postprandial blood glucose concentration compared with control interventions (average SMD -0.85, 95% CI -1.15 to -0.55; three RCTs, 344 women; I^2 = 34%; T^2 = 0.03).

Authors' conclusions

Short- and long-term outcomes of interest for this review were poorly reported. Current evidence is confounded by the large variety of exercise interventions. There was insufficient high-quality evidence to be able to determine any differences between exercise and control groups for our outcomes of interest. For the woman, both fasting and postprandial blood glucose concentrations were reduced compared with the control groups. There are currently insufficient data for us to determine if there are also benefits for the infant. The quality of the evidence in this review ranged from high to low quality and the main reason for downgrading was for risk of bias and imprecision (wide CIs, low event rates and small sample size). Development of type 2 diabetes, perineal trauma/tearing, postnatal depression, large-for-gestational age, adiposity (neonate/infant, childhood or adulthood), diabetes (childhood or adulthood) or neurosensory disability (neonate/infant) were not reported as outcomes in the included studies.

Further research is required comparing different types of exercise interventions with control groups or with another exercise intervention that reports on both the short- and long-term outcomes (for both the mother and infant/child) as listed in this review.

PLAIN LANGUAGE SUMMARY

Can exercise, for women with gestational diabetes, improve outcomes for mother and her baby?

What is the issue?

A previous Cochrane review on *Exercise for diabetic pregnant women* included women with pre-existing diabetes and women with gestational diabetes. That review has now been split into two new reviews on: exercise for pregnant women with gestational diabetes (this review) and exercise for pregnant women with pre-existing diabetes (the subject of another new review).

There will be similarities in the background, methods and outcomes between these two systematic reviews.

Gestational diabetes mellitus (GDM), or diabetes during pregnancy, has both short- and long-term complications for the mother and her baby. Women with GDM are at an increased chance of developing high blood pressure or pre-eclampsia during pregnancy, having their labour induced, giving birth by caesarean section, and experiencing perineal trauma. In the long term, up to half of women with GDM are likely to develop type 2 diabetes. Their babies are at increased risk of being born large-for-gestational age, experiencing a birth injury and being admitted to the neonatal intensive care unit. They are also more likely to develop metabolic syndrome in childhood and later life.

Why is this important?

Exercise may help to control blood sugar levels and improve outcomes for the mother and her baby, possibly leading to long-term health benefits. Physical activity for this review is planned, structured and repetitive body movements undertaken to improve physical fitness.

What evidence did we find?

We searched for evidence from randomised controlled trials in August 2016. We identified 11 trials that involved 638 pregnant women. They were conducted in middle-or high-income countries. We judged the overall risk of bias in the trials as unclear because of a lack of information about how the trials were conducted. Using GRADE, the quality of the evidence from the trials ranged from high to low quality. The main reasons for downgrading the quality were for risk of bias in the trials and imprecise effect sizes, low event rates and small numbers of participants.

For the mothers, exercising did not appear to reduce the risk of pre-eclampsia as the measure of hypertensive disorders of pregnancy (two trials, 48 women, *low-quality evidence*), birth by caesarean section (five trials, 316 women, *moderate-quality evidence*), or the risk of induction of labour (one trial, 40 women, *low-quality evidence*). The mothers had similar body mass index at follow-up in the exercise and control groups (three trials, 254 women, *high-quality evidence*). Exercising was associated with lower fasting blood glucose levels (four trials) and blood glucose levels after a meal (three trials) but with variations in effect sizes between the different trials. The exercise programmes varied between trials as did their duration and whether or not they were supervised. None of the included trials reported on perineal trauma, postnatal depression or development of type 2 diabetes.

For the babies, no deaths occurred around the time of birth in (one trial, 19 babies, *low-quality evidence*) and there was no evidence of any difference in the risk of ill-health (two trials, 169 babies, *moderate-quality evidence*) or low blood sugar levels (one trial, 34 babies, *low-quality evidence*). None of the trials reported on the number of large-for-gestational-age babies or babies that went on to develop diabetes in childhood or adulthood or neurosensory disability that became apparent during childhood.

What does this mean?

Although exercise appeared to be able to lower fasting blood sugar levels and sugar levels after a meal, we did not find any differences in other outcomes for pregnant women with GDM. The present evidence is insufficient to advise for or against women enrolling in exercise programmes. Even if exercise does not provide any benefit during pregnancy, this change in lifestyle may persist after birth and may help prevent the onset of type 2 diabetes and its long-term complications. Pregnant women with GDM who wish to enrol in an exercise programme may wish to discuss their choice with a health professional. Further research is needed comparing one exercise intervention with another (or with a control) and reporting on both the short- and long-term outcomes (for both the mother and infant/child/adult) as listed in this review.

SUMMARY OF FINDINGS

Summary of findings for the main comparison. Exercise compared to control for pregnant women with gestational diabetes for improving maternal outcomes

Exercise compared to control for pregnant women with gestational diabetes for improving maternal outcomes						
Patient or population: pregnant women with gestational diabetes **Setting:** USA, Italy, Brazil, Australia **Intervention:** exercise **Comparison:** control						
Outcomes	**Anticipated absolute effects*** **(95% CI)**		**Relative effect (95% CI)**	**№ of participants (studies)**	**Quality of the evidence (GRADE)**	**Comments**
	Risk with control	**Risk with exercise**				
Hypertensive disorders of pregnancy (pre-eclampsia)	43 per 1000	13 per 1000 (0 to 308)	RR 0.31 (0.01 to 7.09)	48 (2 RCTs)	⊕⊕⊝⊝ LOW [1,2]	Event rates were very low with 0/25 in the exercise group and 1/23 in the control group. No data were reported for pregnancy-induced hypertension or eclampsia.
Caesarean section	319 per 1000	274 per 1000 (201 to 370)	RR 0.86 (0.63 to 1.16)	316 (5 RCTs)	⊕⊕⊕⊝ MODERATE [1]	
Development of type 2 diabetes - not measured	-	-	-	-	-	This outcome was not measured in any of the included studies in this review.
Perineal trauma/tearing - not measured	-	-	-	-	-	This outcome was not measured in any of the included studies in this review.
Postnatal weight retention or return to pre-pregnancy weight (maternal BMI (follow-up) kg/m^2)	The mean maternal BMI (follow-up) kg/m2 was 0	MD 0.11 higher (1.04 lower to 1.26 higher)	-	254 (3 RCTs)	⊕⊕⊕⊕ HIGH	
Postnatal depression - not measured	-	-	-	-	-	This outcome was not measured in any of the included studies in this review.

Induction of labour	400 per 1000	552 per 1000 (284 to 1,000)	RR 1.38 (0.71 to 2.68)	40 (1 RCT)	⊕⊕⊝⊝ LOW [1,3]	Event rates and sample size were low 11/20 in exercise group and 8/20 in control group.

*__The risk in the intervention group__ (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: Confidence interval; **RR:** Risk ratio

GRADE Working Group grades of evidence
High quality: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate quality: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low quality: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low quality: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

[1] Lack of clarity for most items related to risk of bias - downgraded one level.
[2] Wide confidence intervals crossing the line of no effect and low event rates with a small sample size are suggestive of imprecision - downgraded one level.
[3] Imprecision - low event rates and small sample size - downgraded one level.

Summary of findings 2. Exercise compared to control for pregnant women with gestational diabetes for improving fetal outcomes

Exercise compared to control for pregnant women with gestational diabetes for improving maternal and fetal outcomes

Patient or population: pregnant women with gestational diabetes

Setting: USA, Italy
Intervention: exercise
Comparison: control

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	№ of participants (studies)	Quality of the evidence (GRADE)	Comments
	Risk with control	Risk with exercise				
Large-for-gestational age - not reported	-	-	-	-	-	None of the included studies in this review reported data for this outcome.
Perinatal mortality (stillbirth and neonatal mortality)	0 per 1000	0 per 1000 (0 to 0)	not estimable	19 (1 RCT)	⊕⊕⊝⊝ LOW [1,2]	There were no events in either the exercise or the control group and the sample size in only 19 infants.

Mortality and morbidity composite (variously defined by trials, e.g. perinatal or infant death, shoulder dystocia, bone fracture or nerve palsy)	65 per 1000	36 per 1000 (8 to 169)	RR 0.56 (0.12 to 2.61)	169 (2 RCTs)	⊕⊕⊕⊝ MODERATE [3]	Event rates and sample size were low with 2/61 in the exercise group and 7/108 in the control group.
Neonatal hypoglycaemia	59 per 1000	118 per 1000 (12 to 1,000)	RR 2.00 (0.20 to 20.04)	34 (1 RCT)	⊕⊕⊝⊝ LOW [1 3]	Event rates and sample size were low with 2/17 in the exercise group and 1/17 in the control group.
Adiposity - not reported	-	-	-	-	-	None of the included studies in this review reported data for this outcome at any life stage.
Diabetes (type 1, type 2) - not reported	-	-	-	-	-	None of the included studies in this review reported data for this outcome at any life stage.
Neurosensory disability	-	-	-	-	-	None of the included studies in this review reported data for this outcome.

*__The risk in the intervention group__ (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: Confidence interval; **RR:** Risk ratio

GRADE Working Group grades of evidence
High quality: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate quality: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low quality: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low quality: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

[1] There is a lack of clarity for most items associated with risk of bias - downgraded one level.
[2] Imprecision - There are no events in either group and the sample size is only 19 infants - downgraded one level.
[3] Imprecision - wide confidence intervals and low event rates - downgraded one level.

BACKGROUND

The original review by Ceysens and colleagues *Exercise for diabetic pregnant women* (Ceysens 2006) has been split into two new review titles reflecting the role of exercise for pregnant women with gestational diabetes and for pregnant women with pre-existing diabetes.

Exercise for pregnant women with gestational diabetes for improving maternal and fetal outcomes (this review)

Exercise for pregnant women with pre-existing diabetes for improving maternal and fetal outcomes

There will be similarities in the background, methods and outcomes between these two systematic reviews. Portions of the methods section of this review are based on a standard template used by the Cochrane Pregnancy and Childbirth Review Group.

Description of the condition

Gestational diabetes mellitus (GDM) is defined as "glucose intolerance or hyperglycaemia (high blood glucose concentration) with onset or first recognition during pregnancy" (WHO 1999) that usually resolves around the time of birth. Diagnosis is usually made following an oral glucose tolerance test (OGTT) although various definitions of glucose intolerance and subsequently classification of GDM exist (ACOG 2013; Coustan 2010; HAPO 2008; IADPSG 2010; NICE 2015). Recent definitions of GDM exclude overt diabetes which may be detected for the first time during pregnancy (IADPSG 2010; WHO 2014).

Rates of GDM are increasing globally, and up to one third of pregnancies are now thought to be affected (Cundy 2014; Duran 2014; Ferrara 2007; NICE 2015; Tran 2013). The incidence of GDM is likely to increase in parallel with increasing rates of maternal obesity and associated type 2 diabetes (Bottalico 2007; Petry 2010), and between different diagnostic criteria (Cundy 2014).

Non-modifiable risk factors associated with an increased chance of being diagnosed with GDM include: having a previous macrosomic infant (birthweight 4000 g or more) or having been diagnosed with GDM in a previous pregnancy (Petry 2010); older maternal age (Chamberlain 2013), ethnicity (e.g. South Asian, Middle Eastern), high parity, or having a first-degree relative with a history of type 2 diabetes or polycystic ovarian syndrome (Cypryk 2008; Petry 2010). Maternal overweight/obesity (Kim 2010), physically inactivity (Chasan-Taber 2008) and excessive gestational weight gain (Hedderson 2010) are modifiable risk factors that are associated with an increased chance of being diagnosed with GDM.

Throughout pregnancy maternal metabolism is altered (Lain 2007). The first trimester is associated with an increase in insulin secretion that enhances maternal nutrient storage for later fetal growth. During this stage of early pregnancy insulin sensitivity is stable or may even increase. The physiological demands of later pregnancy means that insulin sensitivity gradually decreases (Barbour 2007), and as a result, the fetus is able to increase glucose uptake for fetal growth. In non-diabetic women, normal blood glucose levels are maintained through a process of increasing insulin secretion (Barbour 2007; Lain 2007). Reductions in insulin signalling in women with GDM result in glucose intolerance, which promotes fetal glucose uptake (Barbour 2007).

Adverse outcomes for women associated with gestational diabetes

Women with GDM are at an increased chance of developing hypertensive disorders of pregnancy, having their labour induced (Crowther 2005; Landon 2009), giving birth by caesarean section (Landon 2009), and having perineal trauma (Jastrow 2010). In the long term, up to half of women with GDM are likely to proceed to be diagnosed with type 2 diabetes (Kim 2002).

Short- and long-term adverse outcomes for the neonate associated with gestational diabetes

Infants of mothers diagnosed with GDM are at an increased risk of being born large-for-gestational age (LGA) or macrosomic (Crowther 2005; Landon 2009), have respiratory distress syndrome, neonatal hypoglycaemia, hyperbilirubinaemia and being admitted to the neonatal intensive care unit (Metzger 2008; Reece 2009). These infants are also more likely to have a birth injury, including shoulder dystocia, bone fractures and/or nerve palsy (Esakoff 2009; Henriksen 2008), are more likely to have increased adiposity (Catalano 2003; Pettitt 1985; Pettitt 1993), and are more likely to develop metabolic syndrome in childhood and later life (Guerrero-Romero 2010; Harder 2009). These inter-generational health problems remain an important issue for public health policy.

Description of the intervention

The American College of Sports Medicine defines physical activity as any bodily movement that is produced as a result of the contraction of skeletal muscle and defines exercise as physical activity comprising planned, structured and repetitive body movements which are undertaken to improve one or more components of physical fitness (ACSM 2014).

Physical activity in pregnancy (in non-diabetic women) has been shown to be beneficial, has not been shown to be harmful to the fetus, and can potentially lead to long-term health benefits for the mother (Nascimento 2012). Benefits observed include cardio-respiratory fitness, prevention of stress urinary incontinence, prevention of lumbar pain, decreased depression and control of weight gain during pregnancy (Nascimento 2012).

In women with type 2 diabetes, who were not pregnant, physical activity combined with diet and hypoglycaemic medication has been shown to be effective in maintaining glycaemic control (Tuomilehto 2001).

This evidence may not be generalisable to pregnant women with GDM, but it does suggest that mild exercise during pregnancy may have the potential to reduce the risk of complications associated with GDM.

The American College of Obstetricians and Gynecologists (ACOG) notes that physical activity in pregnancy appears to have benefits for most women and has few risks associated with it, although some adaptation may be required due to usual anatomical and physiological changes in pregnancy (ACOG 2015). ACOG 2015 also recommends that a clinical evaluation is conducted prior to undertaking an exercise programme during pregnancy to ensure that there are no medical contraindications to participation and that participation in aerobic and strength-conditioning exercises should be encouraged in women before, during and after uncomplicated pregnancies.

Aerobic exercise during pregnancy is contraindicated in a number of medical conditions, including:

1. cardiac disease;
2. restrictive lung disease;
3. incompetent cervix/cerclage;
4. multiple gestation at risk of preterm birth;
5. persistent second or third trimester bleeding;
6. placenta praevia after 26 weeks' gestation;
7. preterm labour (current pregnancy);
8. ruptured membranes;
9. pre-eclampsia or pregnancy-induced hypertension;
10. severe anaemia (ACOG 2015).

Safe physical activities that are considered acceptable to continue with or initiate during an uncomplicated pregnancy, following medical advice include:

1. walking;
2. swimming;
3. stationary cycling;
4. low-impact aerobics;
5. modified yoga (avoiding positions that result in decreased venous return);
6. modified Pilates;
7. racquet sports;
8. running or jogging;
9. strength training (ACOG 2015).

The latter two activities in the list above should be undertaken following consultation with an obstetric care provider (ACOG 2015). During pregnancy the duration, frequency and intensity of physical activity may have to be modified (Nascimento 2012).

A number of activities are recommended to be avoided during pregnancy, including:

1. contact sports (e.g. ice hockey, soccer, boxing);
2. activities with a high risk of falling (e.g. skiing, surfing, off-road cycling);
3. scuba diving;
4. sky diving;
5. 'hot yoga' or 'hot Pilates' (ACOG 2015).

How the intervention might work

Glycaemic control may be improved in those with diabetes (type 1, type 2 or GDM) by the amount of physical activity as a result of the interaction between insulin sensitivity and uptake of glucose by skeletal muscle (Asano 2014). Skeletal muscles use a process of diffusion to take up glucose using a glucose transporter type 4 (GLUT4). Increases in insulin receptor substrate, insulin receptor and phosphatidylinositol 3-kinase (Chibalin 2000; Dela 1993; Hjeltnes 1998) following regular physical activity are associated with improvements in insulin sensitivity.

Why it is important to do this review

Rates of GDM continue to increase globally (NICE 2015) and are associated with both short- (Crowther 2005; Landon 2009; Reece 2009) and long-term (Guerrero-Romero 2010; Harder 2009) adverse effects for the woman and her infant. Identifying interventions for improving health outcomes for women with GDM and their infants is a priority. Exercise has been shown to have benefits for women without GDM (Tuomilehto 2001); the benefits and safety for women with GDM remains unclear.

OBJECTIVES

To evaluate the effects of exercise interventions for improving maternal and fetal outcomes in women with gestational diabetes mellitus (GDM).

METHODS

Criteria for considering studies for this review

Types of studies

We included published or unpublished randomised controlled trials in full-text or abstract format. Cluster-randomised trials were eligible for inclusion but none were identified. Quasi-randomised and cross-over trials were not eligible for inclusion. Conference abstracts were handled in the same way as full-text publications.

Types of participants

Pregnant women diagnosed with gestational diabetes mellitus (GDM) (as defined by trialist).

Women with known pre-gestational diabetes (type 1 or type 2 diabetes) were excluded as this will be covered in a different Cochrane review on *Exercise for pregnant women with pre-existing diabetes for improving maternal and fetal outcomes.*

Types of interventions

We included any type of exercise programme (+/- standard care) targeted at women with GDM at any stage of pregnancy compared with 1) standard care or 2) another intervention.

Types of outcome measures

Primary outcomes

Mother

1. Hypertensive disorders of pregnancy (as reported by trialists, including pre-eclampsia, pregnancy-induced hypertension, eclampsia)
2. Caesarean section
3. Development of type 2 diabetes

Neonatal/infant

1. Large-for-gestational age (≥ 4 kg)
2. Perinatal mortality (stillbirth and neonatal mortality)
3. Mortality or morbidity composite (variously defined by trials, e.g. perinatal or infant death, shoulder dystocia, bone fracture or nerve palsy)
4. Neurosensory disability

Secondary outcomes

Mother

1. Use of additional pharmacotherapy

2. Maternal hypoglycaemia (as defined by trialists)
3. Glycaemic control during/end of treatment (as defined by trialists)
4. Weight gain in pregnancy
5. Adherence to the intervention
6. Induction of labour
7. Placental abruption
8. Postpartum haemorrhage (as defined by trialists)
9. Postpartum infection
10. Perineal trauma/tearing
11. Breastfeeding at discharge, six weeks postpartum, six months or longer
12. Maternal mortality
13. Sense of well-being and quality of life
14. Behavioural changes associated with the intervention
15. Views of the intervention
16. Relevant biomarker changes associated with the intervention (including adiponectin, free fatty acids, triglycerides, high-density lipoproteins, low-density lipoproteins, insulin)

Long-term maternal outcomes

1. Postnatal depression
2. Postnatal weight retention or return to pre-pregnancy weight
3. Body mass index (BMI)
4. GDM in a subsequent pregnancy
5. Type 2 diabetes
6. Impaired glucose tolerance
7. Cardiovascular health (as defined by trialists, including blood pressure, hypertension, cardiovascular disease, metabolic syndrome)

Neonatal/infant

1. Stillbirth
2. Neonatal death
3. Macrosomia (greater than 4000 g; or as defined by individual study)
4. Small-for-gestational age (as defined by trialists)
5. Birth trauma (shoulder dystocia, bone fracture, nerve palsy)
6. Gestational age at birth
7. Preterm birth (< 37 weeks' gestation; and < 32 weeks' gestation)
8. Five-minute Apgar < seven
9. Birthweight and z score
10. Head circumference and z score
11. Length and z score
12. Ponderal index
13. Adiposity (including skinfold thickness measurements (mm), fat mass)
14. Neonatal hypoglycaemia (as defined by trialists)
15. Respiratory distress syndrome
16. Neonatal jaundice (hyperbilirubinaemia) (as defined by trialists)
17. Hypocalcaemia (as defined by trialists)
18. Polycythaemia (as defined by trialists)
19. Relevant biomarker changes associated with the intervention (including insulin, cord c-peptide)

Later infant and childhood secondary outcomes

1. Weight and z scores
2. Height and z scores
3. Head circumference and z scores
4. Adiposity (including BMI, skinfold thickness, fat mass)
5. Educational attainment
6. Blood pressure
7. Type I diabetes
8. Type 2 diabetes
9. Impaired glucose tolerance
10. Dyslipidaemia or metabolic syndrome

Child as an adult

1. Weight
2. Height
3. Adiposity (including BMI, skinfold thickness)
4. Cardiovascular health (as defined by trialists, including blood pressure, hypertension, cardiovascular disease, metabolic syndrome)
5. Employment, education and social status/achievement
6. Type 1 diabetes
7. Type 2 diabetes
8. Impaired glucose tolerance

Health service use

1. Number of antenatal visits or admissions
2. Number of hospital or health professional visits (including midwife, obstetrician, physician, dietician, diabetic nurse)
3. Admission to neonatal intensive care unit/nursery
4. Cost of maternal care
5. Cost of offspring care
6. Costs associated with the intervention
7. Costs to families associated with the management provided
8. Cost of dietary monitoring (e.g. diet journals, dietician, nurse visits, etc)
9. Costs to families - change of diet, extra antenatal visits
10. Extra use of healthcare services (consultations, blood glucose monitoring, length and number of antenatal visits)
11. Women's view of treatment advice
12. Duration of stay in neonatal intensive care unit or special care baby unit
13. Duration of maternal and neonatal hospital stay (antenatal, neonatal, postnatal)

Search methods for identification of studies

The following methods section of this review is based on a standard template used by Cochrane Pregnancy and Childbirth.

Electronic searches

We searched the Cochrane Pregnancy and Childbirth Group's Trials Register by contacting their Information Specialist (27 August 2016).

The Register is a database containing over 23,000 reports of controlled trials in the field of pregnancy and childbirth. For full search methods used to populate Pregnancy and Childbirth's Trials Register including the detailed search strategies for CENTRAL, MEDLINE, Embase and CINAHL; the list of handsearched journals and conference proceedings, and the list of journals reviewed via the current awareness service, please follow this link to the editorial information about the Cochrane Pregnancy and Childbirth in the Cochrane Library and select the '***Specialized Register***' section from the options on the left side of the screen.

Briefly, the Cochrane Pregnancy and Childbirth's Trials Register is maintained by their Information Specialist and contains trials identified from:

1. monthly searches of the Cochrane Central Register of Controlled Trials (CENTRAL);
2. weekly searches of MEDLINE (Ovid);
3. weekly searches of Embase (Ovid);
4. monthly searches of CINAHL (EBSCO);
5. handsearches of 30 journals and the proceedings of major conferences;
6. weekly current awareness alerts for a further 44 journals plus monthly BioMed Central email alerts.

Search results are screened by two people and the full text of all relevant trial reports identified through the searching activities described above is reviewed. Based on the intervention described, each trial report is assigned a number that corresponds to a specific Pregnancy and Childbirth review topic (or topics), and is then added to the Register. The Information Specialist searches the Register for each review using this topic number rather than keywords. This results in a more specific search set which has been fully accounted for in the relevant review sections (Included studies; Excluded studies; Studies awaiting classification; Ongoing studies).

In addition, we searched ClinicalTrials.gov and the WHO International Clinical Trials Registry Platform (ICTRP) (18th August 2016) for unpublished, planned and ongoing trial reports. The search terms we used are given in Appendix 1.

Searching other resources

We searched the reference lists of retrieved studies. We did not apply any language or date restrictions.

Data collection and analysis

The following methods section of this review is based on a standard template used by Cochrane Pregnancy and Childbirth.

Selection of studies

Two review authors independently assessed for inclusion all the potential studies we identified as a result of the search strategy. We resolved any disagreement through discussion or, if required, we consulted a third person.

We created a study flow diagram to map out the number of records identified, included and excluded (Figure 1).

Figure 1. Study flow diagram.

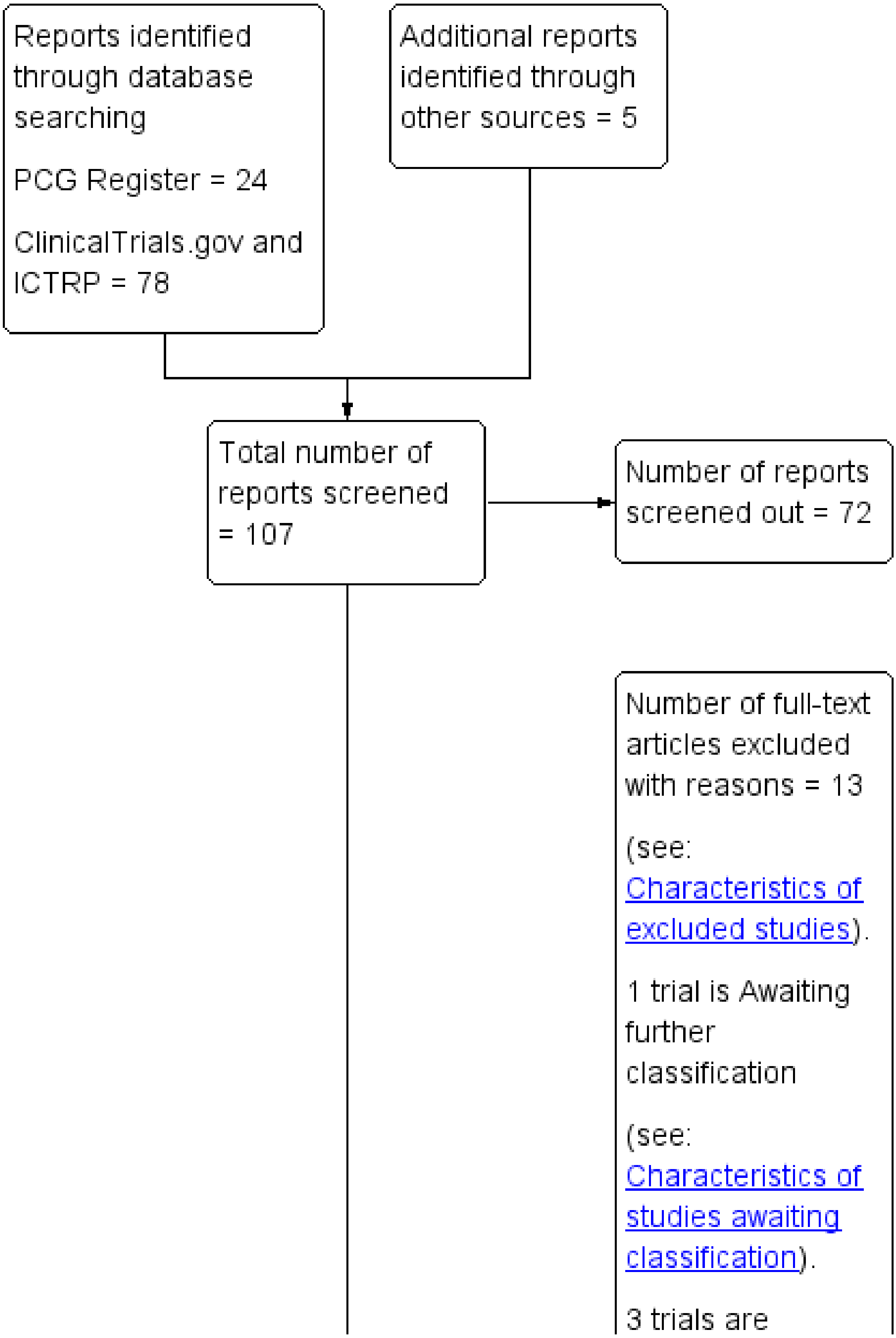
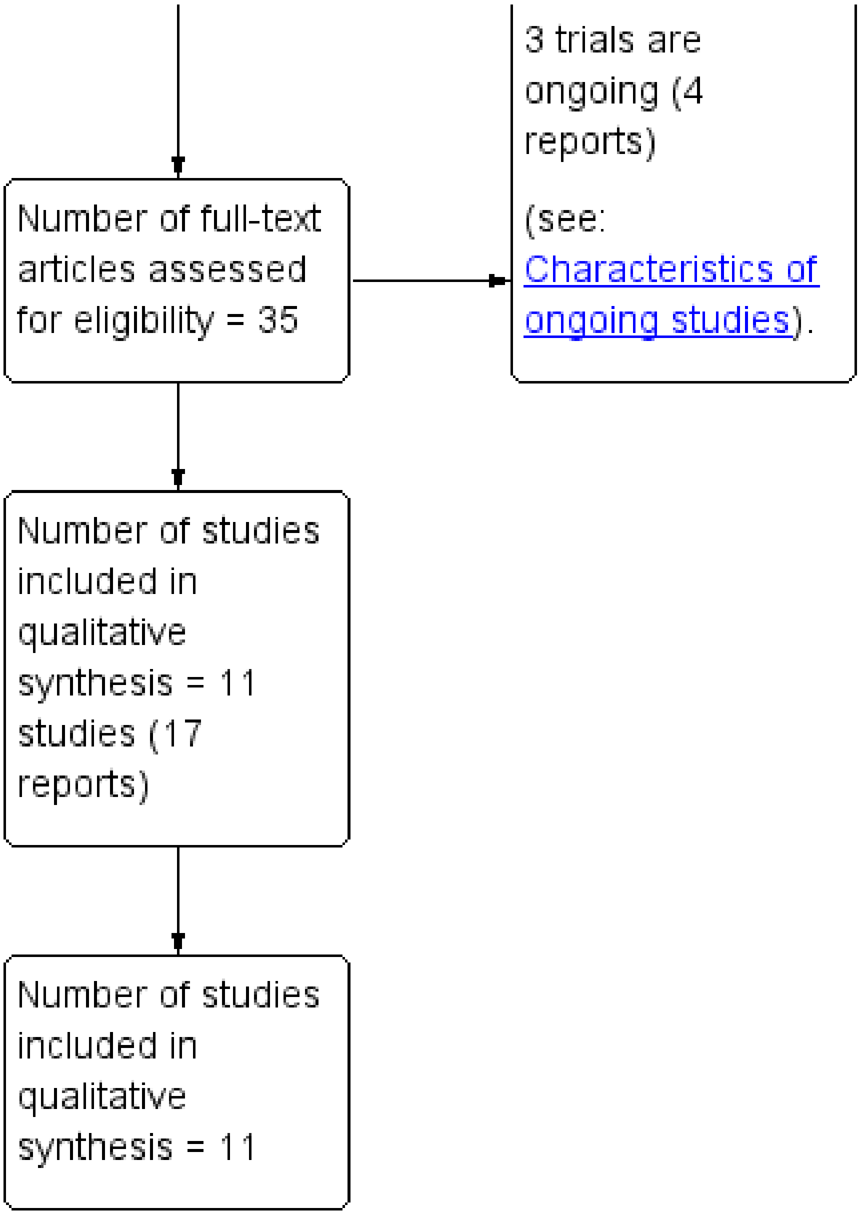


Figure 1. (Continued)



Data extraction and management

We designed a form to extract data. For eligible studies, two review authors extracted the data using the agreed form. We resolved discrepancies through discussion or, if required, we consulted a third person. We entered data into Review Manager software (RevMan 2014) and checked for accuracy. When information regarding any of the above was unclear, we attempted to contact authors of the original reports to provide further details.

Assessment of risk of bias in included studies

Two review authors independently assessed risk of bias for each study using the criteria outlined in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011). We resolved any disagreement by discussion or by involving a third person.

The following sections refer to individually-randomised trials.

(1) Random sequence generation (checking for possible selection bias)

We described for each included study the method used to generate the allocation sequence in sufficient detail to allow an assessment of whether it should produce comparable groups.

We assessed the method as:

- low risk of bias (any truly random process, e.g. random number table; computer random number generator);
- high risk of bias (any non-random process, e.g. odd or even date of birth; hospital or clinic record number);
- unclear risk of bias.

(2) Allocation concealment (checking for possible selection bias)

We described for each included study the method used to conceal allocation to interventions prior to assignment and assessed whether intervention allocation could have been foreseen in advance of, or during recruitment, or changed after assignment.

We assessed the methods as:

- low risk of bias (e.g. telephone or central randomisation; consecutively numbered sealed opaque envelopes);
- high risk of bias (open random allocation; unsealed or non-opaque envelopes, alternation; date of birth);
- unclear risk of bias.

(3.1) Blinding of participants and personnel (checking for possible performance bias)

We described for each included study the methods used, if any, to blind study participants and personnel from knowledge of which intervention a participant received. We considered that studies were at low risk of bias if they were blinded, or if we judged that the lack of blinding would be unlikely to affect results. We assessed blinding separately for different outcomes or classes of outcomes.

We assessed the methods as:

- low, high or unclear risk of bias for participants;
- low, high or unclear risk of bias for personnel.

(3.2) Blinding of outcome assessment (checking for possible detection bias)

We described for each included study the methods used, if any, to blind outcome assessors from knowledge of which intervention a participant received. We assessed blinding separately for different outcomes or classes of outcomes.

We assessed the methods used to blind outcome assessment as:

- low, high or unclear risk of bias.

(4) Incomplete outcome data (checking for possible attrition bias due to the amount, nature and handling of incomplete outcome data)

We described for each included study, and for each outcome or class of outcomes, the completeness of data including attrition and exclusions from the analysis. We stated whether attrition and exclusions were reported and the numbers included in the analysis at each stage (compared with the total randomised participants), reasons for attrition or exclusion where reported, and whether missing data were balanced across groups or were related to outcomes. Where sufficient information was reported, or could be supplied by the trial authors, we re-included missing data in the analyses.

We assessed the methods as:

- low risk of bias (e.g. no missing outcome data; missing outcome data balanced across groups);
- high risk of bias (e.g. numbers or reasons for missing data imbalanced across groups; 'as treated' analysis done with substantial departure of intervention received from that assigned at randomisation);
- unclear risk of bias.

(5) Selective reporting (checking for reporting bias)

We described for each included study how we investigated the possibility of selective outcome reporting bias and what we found.

We assessed the methods as:

- low risk of bias (where it is clear that all of the study's pre-specified outcomes and all expected outcomes of interest to the review have been reported);
- high risk of bias (where not all the study's pre-specified outcomes have been reported; one or more reported primary outcomes were not pre-specified; outcomes of interest were reported incompletely and so cannot be used; study fails to include results of a key outcome that would have been expected to have been reported);
- unclear risk of bias.

(6) Other bias (checking for bias due to problems not covered by (1) to (5) above)

We described for each included study any important concerns we have about other possible sources of bias.

We assessed whether each study was free of other problems that could put it at risk of bias:

- low risk of other bias;
- high risk of other bias;
- unclear whether there is risk of other bias.

(7) Overall risk of bias

We made explicit judgements about whether studies were at high risk of bias, according to the criteria given in the *Handbook* (Higgins 2011). With reference to (1) to (6) above, we assessed the likely magnitude and direction of the bias and whether we considered it is likely to impact on the findings. We explored the impact of the level of bias through undertaking sensitivity analyses - *see* Sensitivity analysis.

Assessment of the quality of the evidence using the GRADE approach

We assessed the quality of the evidence using the GRADE approach as outlined in the GRADE handbook in order to assess the quality of the body of evidence relating to the following outcomes for the mother and for the infant for the main comparisons of 1) exercise versus standard care and 2) exercise versus another intervention.

Maternal

1. Hypertensive disorders of pregnancy (as reported by trialists, including pre-eclampsia, pregnancy-induced hypertension, eclampsia)
2. Caesarean section
3. Development of type 2 diabetes
4. Perineal trauma/tearing
5. Postnatal weight retention or return to pre-pregnancy weight
6. Postnatal depression
7. Induction of labour

Child (as a fetus, neonate, child, adult)

1. Large-for-gestational age
2. Perinatal mortality (stillbirth and neonatal mortality)
3. Mortality and morbidity composite (variously defined by trials, e.g. perinatal or infant death, shoulder dystocia, bone fracture or nerve palsy)
4. Neonatal hypoglycaemia
5. Adiposity*
6. Diabetes (type 1, type 2)*
7. Neurosensory disability

We used the GRADEpro Guideline Development Tool to import data from Review Manager 5.3 (RevMan 2014) in order to create 'Summary of findings' tables. A summary of the intervention effect and a measure of quality for each of the above outcomes was produced using the GRADE approach. The GRADE approach uses five considerations (study limitations, consistency of effect, imprecision, indirectness and publication bias) to assess the quality of the body of evidence for each outcome. The evidence can be downgraded from 'high quality' by one level for serious (or by two levels for very serious) limitations, depending on assessments for risk of bias, indirectness of evidence, serious inconsistency, imprecision of effect estimates or potential publication bias.

*These outcomes will be reported for each stage of life where data are reported.

Measures of treatment effect

Dichotomous data

For dichotomous data, we presented results as summary risk ratio with 95% confidence intervals.

Continuous data

For continuous data, we used the mean difference if outcomes were measured in the same way between trials. We used the standardised mean difference (SMD) to combine trials that measured the same outcome, but used different methods.

Unit of analysis issues

Cluster-randomised trials

We did not identify any cluster-randomised trials for inclusion in this review. In future updates, if cluster-randomised trials are identified we will include them in the analyses along with individually-randomised trials. We will make adjustments using the methods described in the *Handbook* [Section 16.3.4 or 16.3.6] using an estimate of the intra-cluster correlation co-efficient (ICC) derived from the trial (if possible), from a similar trial or from a study of a similar population. If we use ICCs from other sources, we will report this and conduct sensitivity analyses to investigate the effect of variation in the ICC. We will consider it reasonable to combine the results from both cluster-randomised trials and individually-randomised trials if there is little heterogeneity between the study designs and the interaction between the effect of intervention and the choice of randomisation unit is considered to be unlikely. If cluster-randomised trials are included, we will seek statistical advice on appropriate analysis to enable inclusion of data in the meta-analyses.

Other unit of analysis issues

Multiple pregnancy

There may be unit of analysis issues that arise when the women randomised have a multiple pregnancy. We presented maternal data as per woman randomised and neonatal data per infant.

Multiple-arm studies

We identified one trial with multiple intervention arms (Bo 2014). We split the 'shared' group into two or more groups with smaller sample size and include two or more (reasonably independent) comparisons.

Dealing with missing data

For included studies, we noted levels of attrition. We explored the impact of including studies with high levels of missing data in the overall assessment of treatment effect by using sensitivity analysis.

For all outcomes, we carried out analyses, as far as possible, on an intention-to-treat basis, i.e. we attempted to include all participants randomised to each group in the analyses, and all participants were analysed in the group to which they were allocated, regardless of whether or not they received the allocated intervention. The denominator for each outcome in each trial was the number randomised minus any participants whose outcomes are known to be missing.

Assessment of heterogeneity

We assessed statistical heterogeneity in each meta-analysis using the Tau^2, I^2 and Chi^2 statistics. We regarded heterogeneity as substantial if an I^2 was greater than 30% and either the Tau^2 was greater than zero, or there was a low P value (less than 0.10) in the Chi^2 test for heterogeneity.

Assessment of reporting biases

In future updates, if there are 10 or more studies in the meta-analysis, we will investigate reporting biases (such as publication bias) using funnel plots. We will assess funnel plot asymmetry visually. If asymmetry is suggested by a visual assessment, we will perform exploratory analyses to investigate it.

Data synthesis

We carried out statistical analysis using the Review Manager software (RevMan 2014). We used fixed-effect meta-analysis for combining data where it was reasonable to assume that studies were estimating the same underlying treatment effect: i.e. where trials were examining the same intervention, and the trials' populations and methods were judged sufficiently similar. If there was clinical heterogeneity sufficient to expect that the underlying treatment effects differed between trials, or if substantial statistical heterogeneity was detected, we used random-effects meta-analysis to produce an overall summary, if an average treatment effect across trials was considered clinically meaningful. The random-effects summary was treated as the average of the range of possible treatment effects and we discussed the clinical implications of treatment effects differing between trials. If the average treatment effect was not clinically meaningful, we did not combine trials.

Where we used random-effects analyses, the results were presented as the average treatment effect with 95% confidence intervals, and the estimates of Tau^2 and I^2.

Subgroup analysis and investigation of heterogeneity

Had we identified substantial heterogeneity, we planned to investigate it using subgroup analyses and sensitivity analyses. We considered whether an overall summary was meaningful, and if it was, used random-effects analysis to produce it.

We planned to carry out the following subgroup analyses.

1. Group exercise versus individual exercise.
2. Low-level exercise (cumulative duration of exercise at 50% VO_2max (maximal oxygen consumption) of less than 180 minutes) versus high-level exercise (cumulative duration of exercise at 50% VO_2max of more than 180 minutes) intensity exercise.

The following outcomes were planned to be used in subgroup analysis where there were sufficient data.

Maternal outcomes

1. Hypertensive disorders of pregnancy (as reported by trialists, including pre-eclampsia, pregnancy-induced hypertension, eclampsia)
2. Caesarean section
3. Development of type 2 diabetes

Neonatal outcomes

1. Large-for-gestational age
2. Perinatal mortality (stillbirth and neonatal mortality)
3. Mortality or morbidity composite (variously defined by trials, e.g. perinatal or infant death, shoulder dystocia, bone fracture or nerve palsy)
4. Neurosensory disability

We were unable to conduct these subgroup analyses in the current review due to insufficient data. If sufficient data are included in future updates of this review, we will assess subgroup differences by interaction tests available within RevMan (RevMan 2014). We will report the results of subgroup analyses quoting the Chi^2 statistic and P value, and the interaction test I^2 value.

Sensitivity analysis

If there was evidence of significant heterogeneity, we planned to explore this by using the quality of the included trials for the primary outcomes. We planned to compare trials that had low risk of bias for allocation concealment with those judged to be of unclear or high risk of bias, and to exclude conference abstracts from the meta-analysis.

We also planned to investigate the effect of the randomisation unit (i.e. where we include cluster-randomised trials along with individually-randomised trials) but no cluster-randomised trials were identified.

As there was no statistical heterogeneity observed for the primary outcomes of this review, we did not conduct any sensitivity analyses.

RESULTS

Description of studies

Results of the search

The search of the Cochrane Pregnancy and Childbirth Group's Trials Register retrieved 24 records, we found 78 records in ClinicalTrials.gov and the WHO International Clinical Trials Registry Platform (ICTRP) and also five potential studies from other sources. See: Figure 1.

We included 11 trials (17 reports) (Adam 2014; Avery 1997; Bambicini 2012; Bo 2014; Brankston 2004; Bung 1991; de Barros 2010; Halse 2014; Jovanovic-Peterson 1989; Ramos 2015; Youngwanichsetha 2014) (Characteristics of included studies). One study is awaiting classification (Frias 2012) (Characteristics of studies awaiting classification). There are three ongoing studies (da Silva 2013; Kokic 2014; Shaw 2005).

Included studies

We included 11 trials (Adam 2014; Avery 1997; Bambicini 2012; Bo 2014; Brankston 2004; Bung 1991; de Barros 2010; Halse 2014; Jovanovic-Peterson 1989; Ramos 2015; Youngwanichsetha 2014).

Design

All of the included trials were parallel randomised controlled trials (RCTs).

Sample sizes

Sample sizes ranged from a minimum of six women (Ramos 2015) to a maximum of 180 women (Youngwanichsetha 2014). Only the Youngwanichsetha 2014 trial had a sample size of more than 100 women.

Setting

All trials were conducted in middle- or high-income countries. Three trials were conducted in the USA (Avery 1997; Bung 1991; Jovanovic-Peterson 1989) and in Brazil (Bambicini 2012; de Barros 2010; Ramos 2015), two trials in Canada (Adam 2014; Brankston 2004), and one trial each in Italy (Bo 2014), Australia (Halse 2014) and Thailand (Youngwanichsetha 2014). One trial was conducted in the 1990s (Bung 1991) and two trials in the 2000s (Bo 2014; de Barros 2010). For the remaining trials (Adam 2014; Avery 1997; Bambicini 2012; Brankston 2004; Halse 2014; Jovanovic-Peterson 1989; Ramos 2015; Youngwanichsetha 2014), no details were provided regarding timing of the trial.

Participants

All trials recruited pregnant women with a diagnosis of gestational diabetes mellitus (GDM).

Interventions and comparisons

The exercise interventions and comparisons were very varied and included the following.

1. A supervised, individualised follow-up with a kinesiologist versus standard counselling for physical activity (Adam 2014).
2. Exercise using a cycle ergometer for 30 minutes duration, three to four times per week including both supervised and unsupervised sessions versus standard care with no additional

exercise programme (Avery 1997). No details on the duration of the programme.

3. Aerobic activity (30 minutes brisk walking) or resistance exercises (30-minutes circuit workout with elastic-band exercises) versus a control group who remained seated for 30 minutes listening to explanations about Shantala exercises for the baby (Bambicini 2012).
4. All women were given an individually-prescribed diet (carbohydrates 48% to 50%, proteins 18% to 20%, fats 30% to 35%, fibre 20% to 25 g/day, no alcohol). Women in the exercise intervention group were advised to walk briskly at least 20 minutes/day. Women in the behaviour group were given individual oral/written recommendations for helping with healthy dietary choices (i.e. lowering carbohydrate intake, strategies for out-of-home eating, healthy cooking and food shopping and related behavioural suggestions), and debunking false myths about diet in pregnancy and women in the control group who were given individually-prescribed dietary recommendations only (n = 50) (Bo 2014). This study also included a combined behaviour and exercise group that was not included in this review.
5. The intervention group undertook a progressive physical conditioning program involving three supervised introductory sessions, and weekly contact with supervisor. Women were instructed to perform resistance training circuit-type exercises three times per week. Women were instructed to exercise at a level that felt “somewhat hard”, and were taught to monitor their heart rate to ensure that it did not rise above 140 beats/min during exercise. All exercise sessions were recorded in a log book (n = 16). The control group received standard diabetic diet advice: 40% carbohydrate, 20% protein, 40% fat, calculated at 24 kcal/kg to 30 kcal/kg per day on the basis of the woman's ideal pre-pregnant body weight. Women were asked not to begin a structured exercise program for the remainder of the pregnancy (Brankston 2004).
6. The intervention group was provided with dietary advice and instructed to conduct a non-sedentary lifestyle, and attend the exercise laboratory three times a week to exercise under medical supervision. Exercise was 45 minutes with two, five-minute breaks, on a recumbent bicycle, at 50% of their last determined maximum aerobic capacity (classed as moderate exercise) versus standard care insulin therapy and diet (Bung 1991).
7. All women received dietary advice from a nutritionist. The program consisted of a circuit of eight resistance training exercises using an elastic band to work the main muscle groups (chest, back, biceps, triceps, deltoid, quadriceps, thigh and calf muscles). Women were instructed to perform 15 repetitions of each exercise three times a week (once a week under supervision in the clinic, and twice a week at home) from recruitment (between 24 and 34 weeks) until the end of gestation. Women were instructed to exercise at a "somewhat heavy" intensity. Women were contacted by telephone at least once a week to verify adherence to the program (n = 32). The control group received usual care, and were questioned as to whether they had started some type of physical activity (N = 32) (de Barros 2010).
8. In addition to usual care, the intervention group took part in five sessions per week of a home-based exercise program (three supervised and two unsupervised) on an upright stationary cycle ergometer (continuous moderate intensity cycling, with intervals of varying intensity consisting of 15 to 60 seconds of higher intensity bouts every two minutes, interspersed with lower-intensity recovery pedalling in between, tailored to a percentage of the woman's age-predicted maximum heart rate). The intervention commenced at recruitment (between 26 and 30 weeks' gestation) until 34 weeks of gestation (n = 20). The comparison group had usual care (n = 20), which consisted of assessment of glycaemic control and counselling by a diabetes educator and dietician, and self-monitoring of fasting and 120-minute postprandial glucose levels (n = 20) (Halse 2014).
9. In addition to usual care, women in the intervention group participated in a six-week exercise program that consisted of 20 minutes of supervised aerobic training on an arm ergometer, sufficient to maintain target heart rate in a training range (n = 10). The control group was managed with a standard diet consisting of 40% carbohydrate, 20% protein, and 40% fat calculated at 24 kcal/kg to 30 kcal/kg/24 hours of present pregnant weight, divided into three meals and three snacks. Women in the control group did not participate in any structured exercise program (n = 9) (Jovanovic-Peterson 1989).
10. A 10-week program of regular aerobic exercise of three 50-minute sessions per week (no further details) (n = 2), versus 10 weeks of a 50-minute stretching and relaxation session once a week (n = 4) (Ramos 2015).
11. Training in mindfulness eating, and yoga exercise in two 50-minute sessions. Participants were provided with manuals and encouraged to continue mindfulness eating and yoga exercise at home five times a week for eight weeks (n = 90) versus standard diabetes care (n = 90) (Youngwanichsetha 2014).

Outcomes

Two trials reported hypertensive disorders of pregnancy (pre-eclampsia) - Avery 1997; Jovanovic-Peterson 1989.

Five trials reported caesarean section - Avery 1997; Bo 2014; Bung 1991; de Barros 2010; Halse 2014.

One trial reported perinatal mortality (stillbirth and neonatal mortality) - Jovanovic-Peterson 1989.

Two trials reported a mortality or morbidity composite - Bo 2014; Jovanovic-Peterson 1989.

Seven trials reported the use of additional pharmacotherapy - Adam 2014; Avery 1997; Bo 2014; Brankston 2004; de Barros 2010; Halse 2014; Jovanovic-Peterson 1989.

One trial reported maternal hypoglycaemia - Bung 1991.

Five trials reported glycaemic control during/end of treatment - Bo 2014; Bung 1991; Brankston 2004; Jovanovic-Peterson 1989; Youngwanichsetha 2014.

Three trials reported weight gain in pregnancy - Adam 2014; de Barros 2010; Halse 2014.

One trial reported adherence to the intervention - Jovanovic-Peterson 1989.

One trial reported induction of labour - Halse 2014.

Two trials reported maternal mortality - Avery 1997; Jovanovic-Peterson 1989.

One trial reported on views of the intervention - Halse 2014.

Three trials reported postnatal weight retention or return to pre-pregnancy weight (maternal BMI at follow-up) - Bo 2014; de Barros 2010; Halse 2014.

One trial reported stillbirth - Avery 1997.

Five trials reported macrosomia - Avery 1997; Bo 2014; Bung 1991; de Barros 2010; Jovanovic-Peterson 1989.

Four trials reported gestational age at birth - Avery 1997; Bung 1991; de Barros 2010; Halse 2014.

Five trials reported preterm birth - Avery 1997; Bo 2014; de Barros 2010; Halse 2014; Jovanovic-Peterson 1989.

One trial reported five-minute Apgar < seven - Bung 1991.

Six trials reported birthweight - Avery 1997; Bung 1991; de Barros 2010; Halse 2014; Jovanovic-Peterson 1989; Ramos 2015.

One trial reported length at birth - Bung 1991.

One trial reported neonatal hypoglycaemia - Bung 1991.

One trial reported respiratory distress syndrome - Bung 1991.

One trial reported hyperbilirubinaemia - Bung 1991.

One trial reported hypocalcaemia - Bung 1991.

No data were reported in the included trials for any of the other pre-specified outcomes for this review listed below.

For the mother: placental abruption, postpartum haemorrhage, postpartum infection, perineal trauma/tearing, breastfeeding at discharge, six weeks postpartum, six months or longer, sense of well-being and quality of life, behavioural changes associated with the intervention, relevant biomarker changes associated with the intervention, postnatal depression, postnatal weight retention or return to pre-pregnancy weight, BMI, GDM in a subsequent pregnancy, type 2 diabetes, impaired glucose tolerance, cardiovascular health.

For the infant: neurosensory disability, small-for-gestational age, birth trauma (shoulder dystocia, bone fracture, nerve palsy), birthweight z score, head circumference and z score, length and z score, ponderal index, neonatal adiposity, polycythaemia, relevant biomarker changes associated with the intervention, childhood weight and z scores, height and z scores, head circumference and z scores, adiposity, educational attainment, blood pressure, type 1 diabetes, type 2 diabetes, impaired glucose tolerance, dyslipidaemia or metabolic syndrome.

For the child as an adult: weight, height, adiposity, cardiovascular health, employment, education and social status/achievement, type 1 diabetes, type 2 diabetes, impaired glucose tolerance.

Health service outcomes: number of antenatal visits or admissions, number of hospital or health professional visits, admission to neonatal intensive care unit/nursery, cost of maternal care, cost of offspring care, costs associated with the intervention, costs to families associated with the management provided, cost of dietary monitoring, costs to families, extra use of healthcare services, women's view of treatment advice, duration of stay in neonatal intensive care unit or special care baby unit and duration of maternal and neonatal hospital stay.

Declarations of interest in the trial reports

Four publications clearly stated that there were no conflicts of interest (Adam 2014; Bo 2014; Halse 2014; Ramos 2015). Seven publications did not provide details on conflicts of interest (Avery 1997; Bambicini 2012; Brankston 2004; Bung 1991; de Barros 2010; Jovanovic-Peterson 1989; Youngwanichsetha 2014).

Sources of trial funding

Three publications declared funding sources, none of which were associated with the pharmaceutical industry (Bo 2014; de Barros 2010; Halse 2014). One trial (Avery 1997) reported funding sources from multiple sources (academic, governmental and other) that also included funding from Boehringer Manheim Corporation. The type of funding from Boehringer Manheim Corporation was unclear. No details on sources of funding were provided by seven publications (Adam 2014; Bambicini 2012; Brankston 2004; Bung 1991; Jovanovic-Peterson 1989; Ramos 2015; Youngwanichsetha 2014).

Excluded studies

Thirteen studies were excluded (Characteristics of excluded studies). Seven trials were excluded due to ineligible population (Barakat 2013; Chen 1997; Deshpande 2013; Fieril 2015; Melo 2008; Nobles 2015; Ong 2009). Five trials were of an ineligible trial design (Ehrlich 2016; Garcia-Patterson 2001; Lesser 1996; Moholdt 2013; Yin 2014), and in one trial (Berry 2013), the intervention was ineligible.

Studies awaiting classification

One study remains in Characteristics of studies awaiting classification (Frias 2012). ClinicalTrials.gov stated this trial has been terminated due to recruitment issues. We will attempt to contact the responsible party for further information.

Risk of bias in included studies

See Figure 2 and Figure 3.

Figure 2. 'Risk of bias' graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

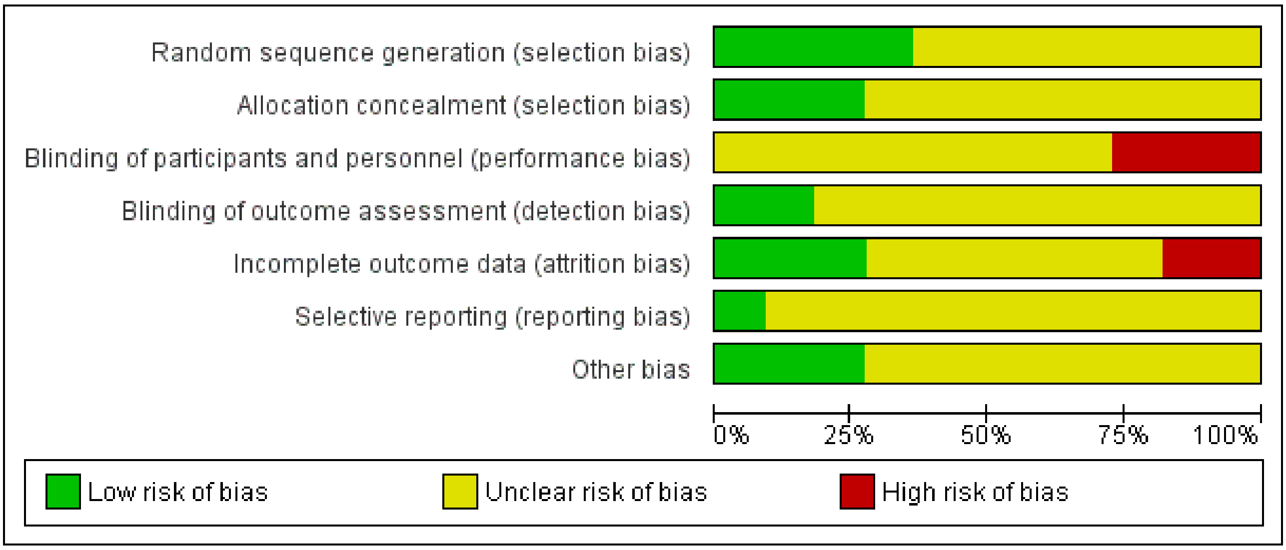


Figure 3. 'Risk of bias' summary: review authors' judgements about each risk of bias item for each included study.

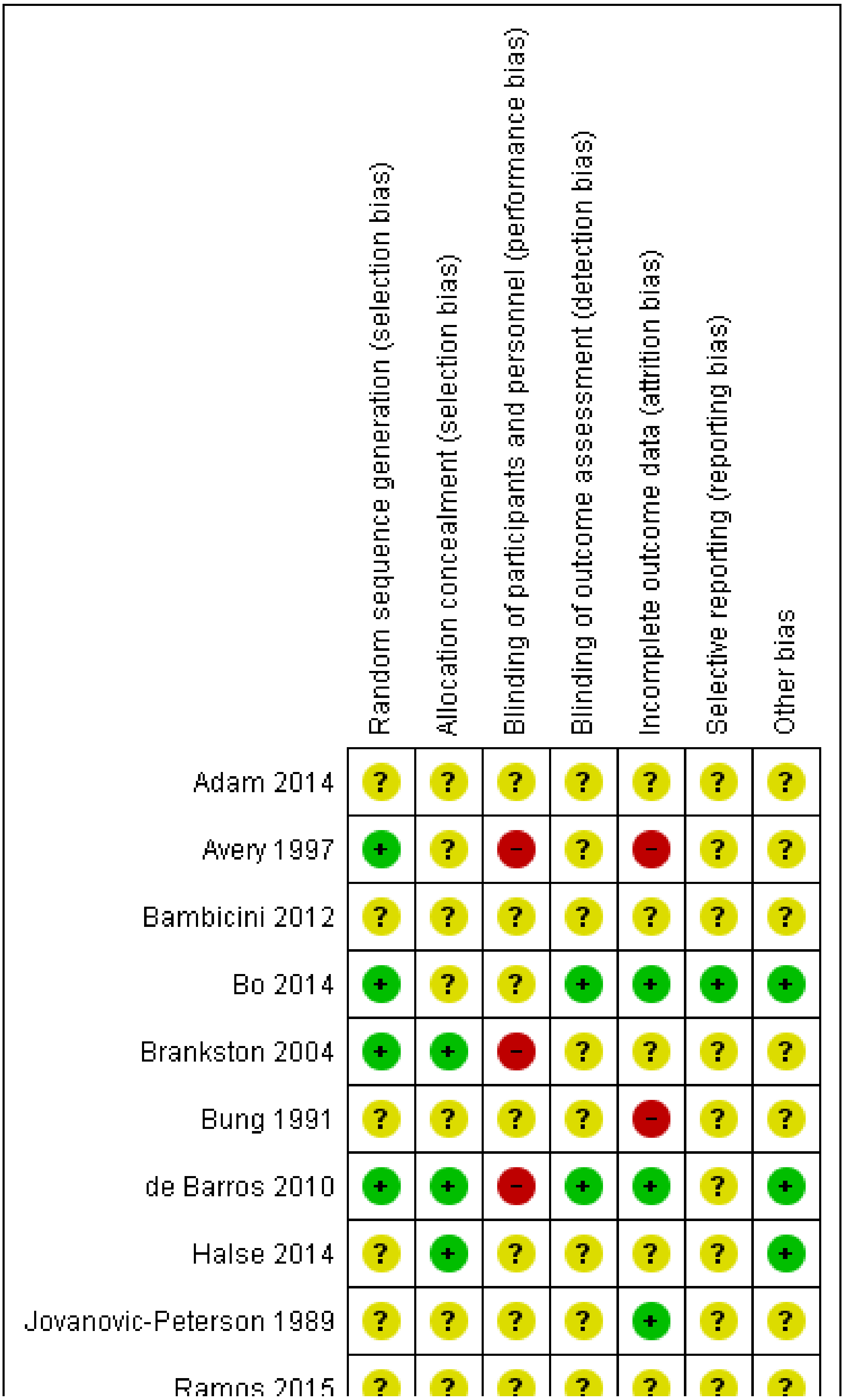
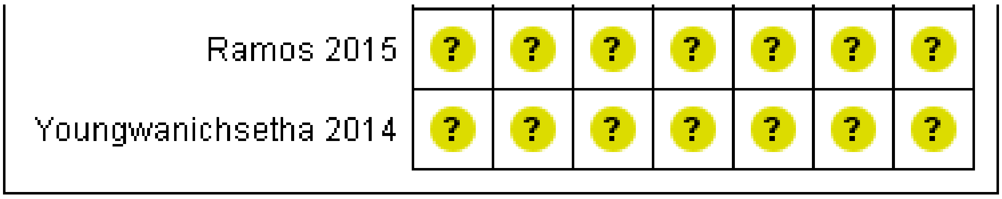


Figure 3. (Continued)



Allocation

Random sequence generation

Four trials were judged to be of low risk of bias. Avery 1997, Bo 2014, Brankston 2004 and de Barros 2010 reported using computer-generated random number tables.

Seven trials were judged as unclear risk of bias due to lack of methodological details (Adam 2014; Bambicini 2012; Bung 1991; Halse 2014; Jovanovic-Peterson 1989; Ramos 2015; Youngwanichsetha 2014).

Allocation concealment

Three trials were judged to be of low risk of bias. Brankston 2004, de Barros 2010 and Halse 2014 reported using sequentially numbered, opaque envelopes.

Eight trials were judged as unclear risk of bias due to lack of methodological details (Adam 2014; Avery 1997; Bambicini 2012; Bo 2014; Bung 1991; Jovanovic-Peterson 1989; Ramos 2015; Youngwanichsetha 2014).

Blinding

Performance bias

Eight trials were judged as unclear risk of bias due to lack of methodological details (Adam 2014; Bambicini 2012; Bo 2014; Bung 1991; Halse 2014; Jovanovic-Peterson 1989; Ramos 2015; Youngwanichsetha 2014). Bo 2014 reported that women were not blinded but dieticians and obstetricians who reported maternal/ neonatal complications, and the laboratory personnel were blinded to the group assignment.

Three trials were judged as high risk of bias as they stated that the participants were not blinded (Avery 1997; Brankston 2004; de Barros 2010).

Detection bias

Two trials were judged to be of low risk of bias. Bo 2014 reported that outcome assessors including dietitians, obstetricians and laboratory personnel were blinded to allocation. de Barros 2010 also stated that obstetricians recording data were blinded to group allocation.

Nine trials were judged as unclear risk of bias due to lack of methodological details (Adam 2014; Avery 1997; Bambicini 2012; Brankston 2004; Bung 1991; Halse 2014; Jovanovic-Peterson 1989; Ramos 2015; Youngwanichsetha 2014).

Incomplete outcome data

Three trials were judged to be of low risk of bias. Bo 2014, de Barros 2010, and Jovanovic-Peterson 1989 reported that all women were analysed.

Five trials were judged as unclear risk of bias due to lack of methodological detail (Adam 2014; Bambicini 2012; Halse 2014; Ramos 2015; Youngwanichsetha 2014). Brankston 2004 was judged to be of unclear risk of bias as they had data missing for some women who did not record blood glucose concentrations.

Two trials were judged to be high risk of bias. Avery 1997 reported that "several subjects gave birth before the follow-up exercise test", however the number of women included in the measures at the end is unclear and home blood glucose levels were reported for 10/15 women in the exercise group, and 12/14 women in the control group. It is unclear why the other women are missing. Seven of 41 women in the Bung 1991 were not analysed and some of these may be attributed to the intervention.

Selective reporting

One trial was judged to be of low risk of bias. Bo 2014 had a trial protocol available and all pre-specified outcomes were reported with the exception of birthweight.

Ten trials were judged as unclear risk of bias. Three due to the study being assessed from a brief conference abstract, without access to the study protocol (Adam 2014; Bambicini 2012; Ramos 2015). Six studies were assessed from a published report, without a protocol available (Avery 1997; Bung 1991; de Barros 2010; Halse 2014; Jovanovic-Peterson 1989; Youngwanichsetha 2014), and Brankston 2004 reported that on results without providing absolute values for women in the treatment and control groups.

Other potential sources of bias

Three trials were judged to be of low risk of bias. Bo 2014 reported no evidence of differences at baseline between intervention and control groups. de Barros 2010 has no evidence of other bias. For Halse 2014, the sample size was calculated to detect differences in blood glucose based on previous study and pilot data.

Eight trials were judged as unclear risk of bias. Three were published as a conference abstract and lacked methodological detail (Adam 2014; Bambicini 2012; Ramos 2015). Some imbalances were detected between groups at baseline (Avery 1997). Brankston 2004 reported that analysis was done by intention-to-treat, but not all women were included in all analyses and there were some differences between groups at baseline. In the Bung 1991 trial, there were small discrepancies in the reporting of data, for example birthweight and number of babies with Apgar less than seven at five minutes. There was insufficient methodological detail provided in Jovanovic-Peterson 1989 and Youngwanichsetha 2014 and these were judged as having an unclear risk of other bias.

Effects of interventions

See: **Summary of findings for the main comparison** Exercise compared to control for pregnant women with gestational diabetes for improving maternal outcomes; **Summary of findings 2** Exercise compared to control for pregnant women with gestational diabetes for improving fetal outcomes

Exercise versus control

Primary outcomes

Mother

1.1 Hypertensive disorders of pregnancy (as reported by trialists, including pre-eclampsia, pregnancy-induced hypertension, eclampsia)

There was no clear evidence of a difference between women in the exercise group (0/25) and those in the control group (1/25) for the risk of pre-eclampsia (risk ratio (RR) 0.31, 95% confidence interval (CI) 0.01 to 7.09; two RCTs, 48 women; *low-quality evidence*). Data should be interpreted with caution due to low event rates and small sample size suggesting imprecision (Analysis 1.1). No data were reported for pregnancy-induced hypertension or eclampsia.

1.2 Caesarean section

There was no clear evidence of a difference between women in the exercise and control groups for the risk of birth by caesarean section (RR 0.86, 95% CI 0.63 to 1.16; five RCTs, 316 women; I^2 = 0%; *moderate-quality evidence*) (Analysis 1.2).

None of the included trials pre-specified development of type 2 diabetes as a trial outcome.

Neonatal/infant

1.3 Perinatal mortality (stillbirth and neonatal mortality)

A single small trial (Jovanovic-Peterson 1989) including only 19 women reported data for perinatal mortality. There were no events in either the exercise intervention or control group (*low-quality evidence)* (Analysis 1.3).

1.4 Mortality or morbidity composite (variously defined by trials, e.g. perinatal or infant death, shoulder dystocia, bone fracture or nerve palsy)

There was no clear evidence of a difference between groups for the risk of a mortality or morbidity composite outcome (RR 0.56, 95% CI 0.12 to 2.61; two RCTs, 169 infants; I^2 = 0%; *moderate-quality evidence*) (Analysis 1.4).

None of the included trials pre-specified large-for-gestational age, or neurosensory disability (childhood) as trial outcomes.

Secondary outcomes

Mother

1.5 Use of additional pharmacotherapy

There was no clear evidence of a difference between groups found between exercise and control groups for the use of additional pharmacotherapy (RR 0.76, 95% CI 0.54 to 1.08; seven RCTs, 413 women; I^2 = 5%) (Analysis 1.5).

1.6 Maternal hypoglycaemia

One small trial of 34 women (Bung 1991) reported no events of maternal hypoglycaemia in either the exercise intervention or control groups (Analysis 1.6).

1.7 Glycaemic control at end of treatment (mean)

Allocation to the control group was associated with a reduced blood glucose concentration at end of treatment compared with the exercise group (mean difference (MD) 0.28 mmol/L, 95% CI 0.04 to 0.52; one RCT, 34 women). It is unclear if a MD of 0.28 mmol/L is of clinical significance (Analysis 1.7).

1.8 Glycaemic control at end of treatment (fasting blood glucose concentration)

Exercise was associated with a reduced fasting blood glucose concentration compared with control (average standardised mean difference (SMD) -0.59, 95% CI -1.07 to 0.11; four RCTs, 363 women; I^2 = 73%, T^2 = 0.19) (Analysis 1.8). The heterogeneity may be attributable to differences in the interventions.

1.9 Glycaemic control at end of treatment (postprandial blood glucose concentration)

Exercise was associated with a reduced postprandial blood glucose concentration compared with control (average SMD -0.85, 95% CI -1.15 to -0.55; three RCTs, 344 women; I^2 = 34%, T^2 = 0.03) (Analysis 1.9). The heterogeneity may be attributable to differences in the interventions.

1.10 Glycaemic control at end of treatment (glycated haemoglobin (HbA1c))

There was no clear evidence of a difference in glycated haemoglobin (HbA1c) between exercise and control groups (MD -0.43 mmol/mol, 95% CI -0.51 to 0.35; two RCTs, 320 women; I^2 = 0%; Analysis 1.10).

1.11 Glycaemic control at end of treatment (glucose tolerance test)

There was evidence of a reduced glucose tolerance test result at end of treatment for women in the exercise group compared with the control group (MD -81.60 mg/dl, 95% CI -96.03 to -67.17; one RCT, 19 women; Analysis 1.11).

1.12 Weight gain in pregnancy

There was no clear evidence of a difference between groups for weight gain in pregnancy (MD -0.34 kg, 95% CI -1.25 to 0.58; two RCTs, 104 women; I^2 = 0%; Analysis 1.12). The increase in weight differs substantially between the two studies (Analysis 1.12). We cannot find an explanation for this and both studies reported weight in kg.

1.13 Weight gain in pregnancy (excessive)

There was no clear evidence of a difference between groups for excessive weight gain in pregnancy (RR 0.90, 95% CI 0.47 to 1.72; one RCT, 79 women; Analysis 1.13).

1.14 Adherence to the intervention

There was no clear evidence of a difference between groups for adherence to the intervention (RR 1.00, 95% CI 0.83 to 1.21; one RCT, 19 women; Analysis 1.14).

1.15 Induction of labour

There was no clear evidence of a difference between exercise and control groups for the risk of induction of labour (RR 1.38, 95% CI 0.71 to 2.68; one RCT, 40 women; *low-quality evidence;* Analysis 1.15).

1.16 Maternal mortality

Two trials including a total of 48 women reported data on maternal mortality (Avery 1997; Jovanovic-Peterson 1989). There were no events in either the exercise intervention or control group (Analysis 1.16).

1.17 Views of the intervention (favourable)

One trial (40 women) reported data on favourable views of the intervention (Halse 2014). The MD was inestimable (Analysis 1.17).

1.18 Postnatal weight retention or return to pre-pregnancy weight (maternal BMI (follow-up) kg/m2)

There was no clear evidence of a difference between groups for maternal BMI at follow-up (MD 0.11 kg/m^2, 95% CI -1.04 to 1.26; three RCTs, 254 women; I^2 = 0%; *high-quality evidence;* Analysis 1.18).

Neonatal/infant

1.19 Stillbirth

One trial reported stillbirth (n = 29; Avery 1997). There were no events in either the exercise intervention group or the control group (Analysis 1.19).

1.20 Macrosomia

There was no clear evidence of a difference in the risk of being born macrosomic between the exercise intervention and control groups (RR 0.69, 95% CI 0.35 to 1.35; five RCTs, 296 infants; I^2 = 0%; Analysis 1.20).

1.21 Gestational age at birth

There was no clear evidence of a difference for gestational age at birth between exercise intervention and control groups (MD -0.01 weeks, 95% CI -0.40 to 0.38; four RCTs, 167 infants; I^2 = 0%; Analysis 1.21).

1.22 Preterm birth

There was no clear evidence of a difference between exercise intervention and control groups for the risk of preterm birth (RR 0.95, 95% CI 0.39 to 2.36; five RCTs, 302 infants; I^2 = 0%; Analysis 1.22).

1.23 Five-minute Apgar score less than seven

There was no clear evidence of a difference for the five-minute Apgar score less than seven between exercise intervention and control groups (RR 0.33, 95% CI 0.01 to 7.65; one RCT, 34 infants; Analysis 1.23).

1.24 Birthweight

There was no clear evidence of a difference between exercise intervention and control groups for birthweight (MD -61.50 g, 95% CI -195.21 to 72.20; six RCTs, 192 infants; I^2 = 0%; Analysis 1.24).

1.25 Length at birth (cm)

There was no clear evidence of a difference between exercise intervention and control groups for length at birth (MD -1.70 cm, 95% CI -3.41 to 0.01; one RCT, 34 infants; Analysis 1.25).

1.26 Neonatal hypoglycaemia

There was no clear evidence of a difference between exercise and control groups (RR 2.00, 95% CI 0.20 to 20.04; one RCT, 34 infants; *low-quality evidence*; Analysis 1.26).

1.27 Respiratory distress syndrome

There were no events of respiratory distress syndrome in either the exercise intervention or control groups reported in a single small trial of 34 infants (Bung 1991) (Analysis 1.27).

1.28 Neonatal jaundice (hyperbilirubinaemia)

There was no clear evidence of a difference between exercise intervention and control groups for hyperbilirubinaemia (RR 0.33, 95% CI 0.01 to 7.65; one RCT, 34 infants; Analysis 1.28).

1.29 Hypocalcaemia

There were no events of hypocalcaemia in either the exercise intervention or control groups reported in a single small trial of 34 infants (Bung 1991) (Analysis 1.29).

1.30 Duration of hospital stay

Duration of hospital stay more than four days was reported by Bo 2014. It is unclear if this is maternal, neonatal or both. The authors report 13/50 for the diet only group, 9/51 for the exercise only group, and 17/49 for the behavioural group. No data for mean duration of hospital stay were provided.

Secondary outcomes not reported in the included studies

The following secondary, long-term, adulthood and health service use outcomes specified in this review were not included as prespecified trial outcomes in any of the included trials.

1. **Mother -** placental abruption, postpartum haemorrhage, postpartum infection, perineal trauma/tearing, breastfeeding at discharge, six weeks postpartum, six months or longer, sense of well-being and quality of life, behavioural changes associated with the intervention, relevant biomarker changes associated with the intervention.
2. **Maternal long-term outcomes -** postnatal depression, GDM in a subsequent pregnancy, type 2 diabetes, impaired glucose tolerance, cardiovascular health.
3. **Neonatal/infant -** neonatal death, small-for-gestational age, birth trauma (shoulder dystocia, bone fracture, nerve palsy), birthweight z score, head circumference and z score, length z score, ponderal index, adiposity, polycythaemia, relevant biomarker changes associated with the intervention.
4. **Later infant and childhood secondary outcomes -** weight and z scores, height and z scores, head circumference and z scores, adiposity, educational attainment, blood pressure, type 1 diabetes, type 2 diabetes, Impaired glucose tolerance, dyslipidaemia or metabolic syndrome.
5. **Child as an adulthood -** weight, height, adiposity, cardiovascular health, employment, education and social status/achievement, type 1 diabetes, type 2 diabetes, impaired glucose tolerance.

6. **Health service use -** number of antenatal visits or admissions, number of hospital or health professional visits, admission to neonatal intensive care unit/nursery, cost of maternal care, cost of offspring care, costs associated with the intervention, costs to families associated with the management provided, cost of dietary monitoring, costs to families - change of diet, extra antenatal visits, extra use of healthcare services (consultations, blood glucose monitoring, length and number of antenatal visits), women's view of treatment advice, duration of stay in neonatal intensive care unit or special care baby unit).

DISCUSSION

Summary of main results

We included 11 randomised controlled trials involving 638 women that compared exercise interventions with a control group in women with gestational diabetes.

For the mother: we found no clear evidence of a difference for the risk of pre-eclampsia, birth by caesarean section, the risk of induction of labour or maternal body mass index at follow-up. Data for development of type 2 diabetes, perineal trauma/tearing and postnatal depression were not reported in the included studies (Summary of findings for the main comparison). Exercise interventions were associated with a reduced fasting (Analysis 1.8) and postprandial blood (Analysis 1.9) glucose concentration compared with the control group. However, caution is advised in interpreting these data due to heterogeneity, which is most likely due to the variation in the content and methods associated with the interventions themselves.

For the infant/child: we found no clear evidence of a difference for a composite outcome of neonatal mortality and morbidity or neonatal hypoglycaemia. There were no events of perinatal mortality reported. There were no data reported for large-for gestational age, adiposity, diabetes or neurosensory disability in childhood (Summary of findings 2).

Both short- and long-term outcomes of interest for this review were poorly reported in the included studies.

Overall completeness and applicability of evidence

There was a wide variation in the components of the exercise intervention, the duration of the intervention and whether the intervention was supervised or unsupervised. Short- and long-term outcomes of interest for this review for the mother and for the infant/child were poorly reported. The sample sizes of the included studies were small, ranging from a minimum of six women (Ramos 2015) to a maximum of 180 women (Youngwanichsetha 2014). All of the included studies were conducted in middle-or high-income countries. The data lack overall completeness and are unlikely to be applicable to all settings.

Quality of the evidence

We judged the overall risk of bias of the included studies to be unclear due to lack of methodological details. Using GRADE methodology, the quality of evidence for the selected outcomes ranged from high to low quality (Summary of findings for the main comparison; Summary of findings 2). The main reason for the downgrading of evidence was for risk of bias and imprecision. Sample sizes and event rates were low and data were often associated with wide confidence intervals.

Potential biases in the review process

We believe that every effort was made to attempt to minimise biases in the review process. We conducted a systematic search of the literature for randomised controlled trial evidence, we did not use any restrictions for language or publication date. Where necessary, we attempted to make contact with authors of primary studies to obtain additional methodological and/or outcome data. We have adhered to Cochrane methodology for searching, data extraction and analysis.

Agreements and disagreements with other studies or reviews

A systematic review by Harrison 2016 reported a similar association between exercise interventions and lower fasting and postprandial blood glucose concentration compared with control. They had identified the same trials for inclusion as our review.

AUTHORS' CONCLUSIONS

Implications for practice

There is currently insufficient evidence to support or refute enrolling pregnant women with gestational diabetes into exercise programmes. However, even if exercise is not beneficial during pregnancy, this change in lifestyle may persist after birth and may help prevent the onset of type 2 diabetes and its long-term complications. Pregnant women with gestational diabetes who wish to enrol in an exercise programme may wish to discuss their choice with a health professional.

Implications for research

Further trials with larger sample sizes involving women with gestational diabetes are needed to evaluate this intervention, comparing different types of exercise intervention with control groups or with another exercise intervention and focusing on both short- and long-term outcomes for both the mother and the infant/child (such as those listed in this review).

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* Indicates the major publication for the study

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Adam 2014

Methods	Parallel randomised controlled trial.
Participants	79 women randomised. **Inclusion criteria:** pregnant women diagnosed with GDM. **Exclusion criteria:** not described. **Setting:** Montreal, Canada. **Timing:** no details.
Interventions	Exercise group - individualised follow-up by kinesiologist (n = 40) versus control group - general counselling about physical activity (n = 39).
Outcomes	Primary outcome was the use of insulin. Secondary outcomes included excessive gestational weight gain according to the IOM guidelines, evaluation of medical intervention (non stress test and induction) and a composite outcome of maternal and fetal complications (hypertension, pre-eclampsia, caesarean section, assisted delivery, macrosomia, prematurity, neonatal unit admission).
Notes	There was also a third “control” group. However, these women were not randomly assigned to receive 'no advice' about physical activity, they were matched for age, BMI at term, and GDM diagnosis to women in the trial. Data for this group have not been included in this review. **Funding source:** no details. **Declarations of interest:** statement that there are no conflicts of interest.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	"randomly assigned" no other information.
Allocation concealment (selection bias)	Unclear risk	No details.
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	No details.

Adam 2014 *(Continued)*

Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No details.
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	No details as to whether all participants completed the trial.
Selective reporting (reporting bias)	Unclear risk	The study was assessed from a brief conference abstract, without access to the study protocol.
Other bias	Unclear risk	The report states that "characteristics were similar at baseline". There is no power calculation, but the authors comment that the study could be under-powered to show differences.

Avery 1997

Methods	Parallel randomised controlled trial.
Participants	33 women randomised. **Inclusion criteria:** physician or certified nurse-midwife diagnosis of GDM, 34 weeks' gestation or less, no other important medical or obstetric complications, ability to read and write English, age 18-40 years, no current regular exercise regimen for continuous 30-minute periods more than twice per week. **Exclusion criteria:** no details, although "19 women were ineligible for medical reasons" and "three subjects in the control group were withdrawn for medical reasons" (p12). 3 women were excluded because exercise was recommended to them by the care provider. **Setting:** USA, large mid-western health maintenance organisation. **Timing:** no details.
Interventions	Exercise group - exercise for 30 minutes 3 to 4 times weekly for the remainder of the pregnancy. 5 minutes warm up, 5 minutes cool down, 20 minutes cycle ergometer or walking at 70% of estimated maximal heart rate. 2 exercise sessions were in the presence of the investigator, with maternal and fetal monitoring. Once or twice a week, the women exercised unsupervised (n = 16). versus control group - continued dietary therapy and usual physical activity level. They were asked not to change their current amount of activity. They were telephoned weekly by the investigator to monitor progress in the study and were asked to record any exercise (n = 17).
Outcomes	Daily fasting and postprandial blood glucose levels, HbA_1C, incidence of exogenous insulin therapy, incidence of newborn hypoglycaemia.
Notes	Funding: National Institute of Nursing Research, National Institute of Health NR06568-01A1; the American Diabetes Association, MN Affiliate; the March of Dimes, Greater Twin Cities Chapter; Boehringer Manheim Corporation; the Clinical Research and Education Fund, Group Health Foundation. **Funding source:** National Institute of Nursing Research, National Institutes of Health, American Diabetes Association, March of Dimes, Greater Twin Cities Chapter, Boehringer Manheim Corporation, Clinial Research and Education Fund. **Declarations of interest:** no details.

Avery 1997 *(Continued)*

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	“Group assignment was determined using a random-numbers table by the block randomisation procedure”.
Allocation concealment (selection bias)	Unclear risk	No details.
Blinding of participants and personnel (performance bias) All outcomes	High risk	“subjects were not blinded as to the nature of the study intervention”.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No details.
Incomplete outcome data (attrition bias) All outcomes	High risk	The number of eligible women was 144, however 19 were ineligible for medical reasons, 21 were beyond 34 weeks’ gestation, 68 declined, and exercise was recommended to 3 by the care provider. Withdrawals - exercise group n = 16 (1 woman subsequently dropped out); control group n = 17 (3 women were subsequently withdrawn for medical reasons). “several subjects gave birth before the follow-up exercise test”, however the number of women included in the measures at the end is unclear. Home blood glucose levels are reported for 10/15 women in the exercise group, and 12/14 women in the control group. It is unclear why the other women's results are missing.
Selective reporting (reporting bias)	Unclear risk	This study was assessed from a published report, without a protocol available.
Other bias	Unclear risk	Baseline characteristics were mostly similar, however parity was higher in the exercise group. The trial authors are aware that the trial is underpowered to detect differences in blood glucose values or HbA_1C.

Bambicini 2012

Methods	Parallel randomised 3-arm trial.
Participants	17 women randomised. **Inclusion criteria:** pregnant women with GDM, 27 to 37 weeks' gestation. **Exclusion criteria:** not described. **Setting:** Sao Paulo, Brazil. **Timing:** no details.
Interventions	Exercise group 1: aerobic activity: 30 minutes brisk walking (n = 6). Exercise group 2: resistance exercises: 30 minutes circuit workout with elastic-band exercises (n = 5) versus

Bambicini 2012 *(Continued)*

	control group: remained seated for 30 minutes listening to explanations about Shantala exercises for the baby (n = 6).
Outcomes	Capillary blood glucose before, at the end of session and 1 hour after.
Notes	**Funding source:** no details. **Declarations of interest:** no details.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	"randomized" no other details.
Allocation concealment (selection bias)	Unclear risk	No details.
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	No details.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No details.
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	No details.
Selective reporting (reporting bias)	Unclear risk	Not described. Assessed from a brief abstract, without the trial protocol.
Other bias	Unclear risk	Very little detail of methodology reported.

Bo 2014

Methods	2 x 2 factorial randomised controlled trial.
Participants	200 women randomised. **Inclusion criteria:** pregnant women, age 18-50, 24-26th weeks of gestation, GDM diagnosis based on a 75 g OGTT, singleton pregnancy. **Exclusion criteria:** BMI > 40 kg/m^2, any known diseases, medications or obstetrical absolute/relative contraindications to exercise. **Setting:** Sant'Anna Hospital, Torino, Italy. **Timing:** July 2009-February 2012.
Interventions	All women were given an individually-prescribed diet (carbohydrates 48% to 50%, proteins 18% to 20%, fats 30% to 35%, fibre 20 g to 25 g/day, no alcohol). In addition:

Bo 2014 *(Continued)*

	Group E: advised to briskly walk at least 20 minutes/day. N = 51. Group B: individually oral/written recommendations for helping with healthy dietary choices (i.e. lowering carbohydrate intake, strategies for out-of-home eating, healthy cooking and food shopping and related behavioural suggestions) and debunking false myths about diet in pregnancy. N = 49. Group BE brisk walk and dietary advice n = 50. Group D (control group): individually-prescribed dietary recommendations only n = 50. All women were monitored by weekly phone calls and visited every 2 weeks to monitor adverse events and protocol adherence. Participants self-monitored capillary blood glucose concentrations 4-6 times per day with a glucometer.
Outcomes	Fasting glucose values, high-density lipoprotein (HDL)-cholesterol, triglycerides, insulin, Homeostasis-Model-Assessment-Insulin Resistance (HOMA-IR), high-sensitivity C-reactive protein (CRP), glycated haemoglobin (HbA1c), postprandial glucose, maternal/neonatal complications.
Notes	**Funding source:** Regione Piemonte 2009. **Declarations of interest:** the authors report no conflicts of interest.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	"Randomization was stratified by baseline body mass index (BMI) and METs, and was implemented through a website (www.epiclin.it)".
Allocation concealment (selection bias)	Unclear risk	No details provided on method used to conceal allocation.
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	It was not feasible to blind women to the intervention. However, "The dieticians, the obstetricians who reported maternal/neonatal complications, and the laboratory personnel were blinded to the group assignment".
Blinding of outcome assessment (detection bias) All outcomes	Low risk	"It is possible that women in the exercise group could have over-reported exercise or declared healthier nutritional habit. However, all the outcomes, which were blindly measured, were consistent with the declared lifestyle changes". Outcome assessment was done by dieticians, obstetricians and laboratory personnel who were blinded to group allocation.
Incomplete outcome data (attrition bias) All outcomes	Low risk	The authors state that "All participants completed the study".
Selective reporting (reporting bias)	Low risk	The protocol was available for this trial. All prespecified outcomes except infant birthweight were reported.
Other bias	Low risk	Baseline characteristics appear to be similar across groups. The sample size was calculated to have 95% statistical power to detect at least a 10% reduction in fasting glucose by exercise. The authors acknowledge that the study is underpowered to find small differences in the incidence of adverse maternal/neonatal outcomes.

Brankston 2004

Methods	Parallel randomised controlled trial.
Participants	Possibly 38 women randomised. **Inclusion criteria:** otherwise healthy pregnant women with GDM, between age 20 and 40 years, gestational age between 26 and 32 weeks', BMI below 40 kg/m^2, nonsmokers, who were not involved in a regular exercise program. **Exclusion criteria:** no details. **Setting:** Alberta, Canada. Diabetic Outpatient Clinics at the Royal Alexandra and Grey Nuns Hospitals in Edmonton. **Timing:** not stated.
Interventions	Exercise group: progressive physical conditioning program. 3 supervised introductory sessions, and weekly contact with supervisor. Instructed to perform resistance training circuit-type exercises 3 times per week. Women were instructed to exercise at a level that felt "somewhat hard", and were taught to monitor their heart rate to ensure that it did not rise above 140 beats/min during exercise. All exercise sessions were recorded in a log book (n = 16) versus control group: diet alone. Standard diabetic diet advice: 40% carbohydrate, 20% protein, 40% fat, calculated at 24 to 30 kcal/kg per day on the basis of the woman's ideal pre-pregnant body weight. Women were asked not to begin a structured exercise program for the remainder of the pregnancy (n = 16).
Outcomes	Primary outcome: requirement for insulin. Secondary outcomes: latency to insulin treatment, amount of insulin required, gestational age at birth, birthweight.
Notes	**Funding source:** no details. **Declarations of interest:** no details.

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Random numbers table used.
Allocation concealment (selection bias)	Low risk	Sequentially numbered opaque envelopes.
Blinding of participants and personnel (performance bias) All outcomes	High risk	No blinding.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No details.
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	38 women randomised. However physicians advised against the program for 3 women because of pregnancy-induced hypertension, and 2 women who were randomised to exercise did not enter the program. 1 woman dropped out of the study due to time constraints: it does not say which group she was ran-

Brankston 2004 *(Continued)*

		domised to, but exercise would demand more time commitment so probably this group). "four women in each group did not record their blood glucose measurements adequately" so these data are missing from blood glucose levels.
Selective reporting (reporting bias)	Unclear risk	The protocol was not available for this trial, so it was assessed from only the published report. Several outcomes are reported in the text as "no significant differences" but without providing the number of women/infants (gestational age at delivery, rate of caesarean deliveries, birthweight).
Other bias	Unclear risk	The report states that the analyses were done by intention to treat, however 6 women who were probably randomised to the exercise group were not included in the analyses. The groups had similar baseline physical characteristics, although the diet-alone group had a significantly higher mean pre-pregnant body mass (weight) than the diet plus exercise group.

Bung 1991

Methods	Parallel randomised controlled trial.
Participants	41 women randomised. **Inclusion criteria:** pathological results in a OGTT and persisting fasting blood glucose values > 105, but < 130 mg/dl after a failed 1 week ADA diet trial (24 to 30 kcal/kg/day); following the clinical protocol these women would then require Insulin therapy. No contraindications to exercise, before 33 weeks' pregnancy (to allow at least 4 weeks of exercise). **Exclusion criteria**: other medical or obstetrical complications of pregnancy; women at risk for premature labour. **Setting:** high risk obstetrical clinic of Los Angeles County/University of Southern California Women's Hospital. **Timing:** May – November 1990.
Interventions	Exercise group - exercise and diet. Instructed to conduct a non-sedentary lifestyle, and attend the exercise laboratory 3 times a week to exercise under medical supervision. 45 minutes with 2 x 5-minute breaks, on a recumbent bicycle, at 50% of their last determined maximum aerobic capacity (classed as moderate exercise) (n = 21) versus Control group - insulin therapy and diet (n = 20).
Outcomes	Heart rate and uterine activity. Clinical data, pregnancy complications, maternal and neonatal outcome variables.
Notes	**Funding source:** no details. **Declarations of interest:** no details.

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**

Bung 1991 *(Continued)*

Random sequence generation (selection bias)	Unclear risk	Double-stratified randomisation, but no information on sequence generation.
Allocation concealment (selection bias)	Unclear risk	No details.
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	No details.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No details.
Incomplete outcome data (attrition bias) All outcomes	High risk	17/21 women in the exercise group completed the study. 4 women were excluded for: pPROM, non-compliance with exercises, moving away, and withdrew. 17/20 women in the control group completed the study. 3 women did not return to the clinic and were lost to follow-up. Some of this attrition may be related to the intervention, but these women were not included in the analyses.
Selective reporting (reporting bias)	Unclear risk	Assessed from published reports without access to the protocol.
Other bias	Unclear risk	There were small discrepancies between reports, for example birthweight and number of babies with Apgar < 7 at 5 minutes.

de Barros 2010

Methods	Parallel randomised controlled trial.
Participants	**64 women** **Inclusion criteria:** pregnant women with a diagnosis of GDM, sedentary according to the International Physical Activity Questionnaire (IPAQ), nonsmokers, age 18-45 years, no physical factor or disease limiting exercise, singleton pregnancy, absence of fetal malformation upon ultrasound, gestational age 24-34 weeks', no risk factors for preterm delivery. **Exclusion criteria:** clinical or obstetric complications contraindicating exercise during pregnancy and loss to follow-up. **Setting:** Obstetric clinic of the University Hospital, University of Sao Paulo School of Medicine, Brazil. **Timing:** October 2006-November 2008.
Interventions	Exercise group - resistance exercise program with an elastic band. Women exercised 3 times a week, for 30-40 minutes, on non-consecutive days, twice a week at home and once in the clinic under supervision. Women were instructed to maintain an exercise intensity of 5 or 6 on an exertion scale, which is “somewhat heavy” exercise perception. Exercises were adapted by the researcher at the weekly clinic to maintain this intensity. Women started the program about 90 minutes after eating and after measuring capillary glycaemia. If capillary glucose levels were between 100 mg/dL and 250 mg/dL, women did the program, otherwise they waited until the next day (n = 32) versus

de Barros 2010 *(Continued)*

	control group - no change to prenatal routine care, weekly outpatient visits. Occasional questions about whether they had started any physical activity. Instructed not to start any new type of physical activity after randomisation (n = 32).
Outcomes	Requirement for insulin, amount of insulin required, latency to insulin requirement (weeks), mean glucose levels, percentage of weeks spent within the target glucose range, maternal BMI at birth, pregnancy weight gain, gestational age at delivery, birthweight.
Notes	Sample size was calculated as 30 women in each group to show reduction in insulin requirement. **Funding source:** Coodenacao de Aperfeicoamento de Pessoal de Nivel Superior. **Declarations of interest:** no details.

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	“Women admitted to the study were randomized using a computer-generated random series produced by a person not related to the protocol”
Allocation concealment (selection bias)	Low risk	Sequential sealed opaque envelopes.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Women were not blinded, and the main researcher knew their allocation. “The obstetricians responsible for clinical and prenatal care and data recording was unaware to which group the patients belonged, and only the main researcher questioned the patients with respect to the exercise practice”
Blinding of outcome assessment (detection bias) All outcomes	Low risk	The obstetricians recording data were blinded to group allocation.
Incomplete outcome data (attrition bias) All outcomes	Low risk	After randomisation, 1 woman withdrew because of lack of time to perform the exercise program, and another started using metformin for glycaemic control. These women were included in the analyses.
Selective reporting (reporting bias)	Unclear risk	This trial was assessed from a published report, without access to the protocol.
Other bias	Low risk	No evidence of other bias.

Halse 2014

Methods	Parallel randomised controlled trial.
Participants	40 women randomised. **Inclusion criteria:** pregnant women, within 1 week of GDM diagnosis, singleton pregnancy, between 26 and 30 weeks' gestation, normal 18 week anatomy scan, BMI ≤ 45 kg/m^2, non-exercise program, medically cleared for exercise participation. **Exclusion criteria:** less than 18 years of age, unable to understand the implications of participation, on any medications at the time of recruitment, low-lying placenta, pre-existing diabetes (type 1 or 2), or cardiac disease. **Setting:** King Edward Memorial Hospital, Perth, Western Australia, Australia.

Halse 2014 *(Continued)*

	Timing: no details.
Interventions	Exercise group: experimental intervention: home-based exercise program involving 5 sessions per week continued until week 34 of gestation. 3 sessions per week were supervised, 2 were unsupervised, using an upright stationary cycle ergometer. Sessions were 25-30 minutes in week 1, increasing to 40-45 minutes by week 4 (n = 20). versus control group: continued with their usual physical activity regimen for the duration of the intervention. Both groups: assessment of glycaemic control and counselling by a diabetes educator and dietician. Daily fasting and 120 minutes postprandial glucose levels after breakfast, lunch and dinner. Food and drink diary.
Outcomes	Aerobic fitness, maternal weight gain, obstetric and neonatal outcomes.
Notes	**Funding source:** University of Western Australia, Women's and Infants Research Foundation, National Health and Medical Research Council. **Declarations of interest:** publication states there were no personal or financial conflicts of interest.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	“randomized”, no description of sequence generation.
Allocation concealment (selection bias)	Low risk	“Concealed, sequentially numbered opaque envelopes selected by each participant”.
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	No details.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No details.
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	No attrition is described, however the mode of delivery for control group adds up to 19, not 20.
Selective reporting (reporting bias)	Unclear risk	This study was assessed from published reports, without access to a protocol.
Other bias	Low risk	Sample size was calculated to detect differences in blood glucose based on previous study and pilot data.

Jovanovic-Peterson 1989

Methods	Parallel randomised controlled trial.
Participants	39 women randomised.

Jovanovic-Peterson 1989 *(Continued)*

	Inclusion criteria: pregnant women with gestational diabetes diagnosed according to standard protocol. The study appears to have started at 28 weeks' gestation. **Exclusion criteria:** maternal morbidity (1 woman with placenta praevia was excluded from the study). **Setting:** USA. **Timing:** not stated.
Interventions	Exercise group: supervised arm ergometer training, 20 minutes, 3 times a week for 6 weeks, plus diet (24 to 30 kcal/kg/24 hours; 20% protein, 40% carbohydrate, 40% fat). Target heart rate: (220-age in years) x 70% unless > 140 bpm, then target was 140 bpm (n = 20) versus control group: diet alone (24 to 30 kcal/kg/24 hours; 20% protein, 40% carbohydrate, 40% fat), divided into 3 meals and 3 snacks. Women did not participate in any structured exercise program (n = 19).
Outcomes	Blood glucose, glycosylated Hb.
Notes	**Funding source:** no details. **Declarations of interest:** no details.

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	“women were randomized into two groups by drawing a number”.
Allocation concealment (selection bias)	Unclear risk	No details.
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	No details.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No details.
Incomplete outcome data (attrition bias) All outcomes	Low risk	“one woman was dropped from the study because she was found to have placenta previa”, the woman appears to have been excluded before randomisation, and otherwise all women are accounted for.
Selective reporting (reporting bias)	Unclear risk	This study was assessed from a published report without access to the protocol.
Other bias	Unclear risk	There is incomplete reporting of methodology, possibly due to publication in 1989. The diet group had lower peak 1 hour plasma glucose on 100 g glucose tolerance test at the start of the study.

Ramos 2015

Methods	Parallel-arm, randomised controlled trial.

Ramos 2015 *(Continued)*

Participants	6 women randomised (interim report from an ongoing trial) **Inclusion**: pregnant women with gestational diabetes, over 20 years old, gestational age 20-27 weeks, singleton pregnancy, no orthopaedic limitations, non-smoker, medical clearance for exercise. **Exclusion**: pre-eclampsia, fetal malformations, intrauterine fetal death. **Setting**: prenatal clinics, Hospital de Clinicas de Porto Alegre, Brazil. **Timing**: not stated.
Interventions	Exercise group: low-intensity aerobic training in cycle-ergometer for 50 minutes per session, 3 times a week, for 10 weeks (n = 2) versus control group: relaxation and stretching for 50 minutes per session, once a week for 10 weeks (n = 4).
Outcomes	(from protocol on clinicaltrials.gov NCT01885234) Glycated haemoglobin (HbA1c), homeostasis model assessment (HOMA), first ventilatory threshold, type of delivery, weight and length of newborn.
Notes	**Funding source:** no details. **Declarations of interest:** publication lists no conflicts of interest.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	States "randomised" however, no details provided of method used to generate the random sequence.
Allocation concealment (selection bias)	Unclear risk	No description of method used to conceal allocation.
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not described, but unlikely due to the nature of the intervention.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Protocol states single blind (investigator), but no further details provided.
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Study is ongoing.
Selective reporting (reporting bias)	Unclear risk	Assessed from protocol and very brief interim abstract; not all prespecified outcomes were reported at this stage.
Other bias	Unclear risk	Insufficient information at this stage.

Youngwanichsetha 2014

Methods	Parallel-arm, randomised controlled trial.

Youngwanichsetha 2014 *(Continued)*

Participants	180 women. **Inclusion**: pregnant women diagnosed with GDM A1, 24-30 weeks gestational age, fasting blood glucose concentration less than 105 mg/dL, postprandial blood glucose concentration less than 120 mg/dL, not receiving insulin therapy for glycaemic control, no serious complications such as gestational hypertension, pre-eclampsia, preterm labour or other serious health problems. **Exclusion**: blood glucose concentration higher than 120 mg/L and therefore receiving insulin therapy for glycaemic control. **Setting**: tertiary hospital in southern Thailand, which is the referral centre for diabetes care. **Timing**: not stated.
Interventions	Exercise group: trained to perform mindfulness eating and yoga exercise in 2 50 minute sessions. Then encouraged to continue mindfulness eating and yoga exercise at home for 15 to 20 minutes, 5 times a week for 8 weeks. Encouraged and monitored by the research team every week by phone and at face to face appointments (n = 90) versus control group: standard diabetes care (n = 90).
Outcomes	Fasting and postprandial blood glucose concentrations, glysated haemoglobin (HbA1c).
Notes	**Funding source:** no details. **Declarations of interest:** no details.

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	No information provided on method used to generate random sequence.
Allocation concealment (selection bias)	Unclear risk	Opaque envelopes used. No information provided on numbering sequence.
Blinding of participants and personnel (performance bias) All outcomes	Unclear risk	Not described as blinded. Unlikely due to nature of intervention.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	No mention of blinding of outcome assessors.
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	90 women were randomised to each group. 5 women from each group did not complete the study or were lost to follow-up.
Selective reporting (reporting bias)	Unclear risk	This study was assessed from a published report without access to the protocol, however outcomes specified in the publication were reported on.
Other bias	Unclear risk	Unclear

BMI: body mass index
bpm: beats per minute

GDM: gestational diabetes mellitus
Hb: haemoglobin
OGTT: oral glucose tolerance test
pPROM: preterm premature rupture of membranes

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Barakat 2013	Ineligible population: examines the effect of exercise on the prevention of GDM.
Berry 2013	Ineligible intervention: the exercise component of the intervention commences at 6 weeks post-partum.
Chen 1997	Ineligible population: the participants have an abnormal oral glucose challenge test, but are not diagnosed with GDM.
Deshpande 2013	Ineligible population: participants are women with "high risk pregnancy" including women with diabetes at the time of trial entry.
Ehrlich 2016	Ineligible trial design: prospective cohort study - not randomised.
Fieril 2015	Ineligible population: participants were healthy women without GDM.
Garcia-Patterson 2001	Ineligible trial design: not randomised.
Lesser 1996	Ineligible trial design: cross-over trial.
Melo 2008	Ineligible population: healthy participants.
Moholdt 2013	Ineligible trial design: cross-over trial.
Nobles 2015	Ineligible population: examines the effect of exercise in prevention of GDM.
Ong 2009	Ineligible population: participants do not have a diagnosis of GDM.
Yin 2014	Ineligible trial/population: systematic review on effect of physical activity on prevention of GDM.

GDM: gestational diabetes mellitus

Characteristics of studies awaiting assessment *[ordered by study ID]*

Frias 2012

Methods	Interventional treatment trial.
Participants	Women, 18 years and older, newly diagnosed with GDM. Women with pre-existing diabetes are excluded.
Interventions	Intervention group: instructed on moderate-to-vigorous intensity exercise. Control group: routine diet and exercise counselling.
Outcomes	Need for medication for diabetes Birthweight

Frias 2012 *(Continued)*

	HbA1c at delivery Mode of delivery
Notes	ClinicalTrials.gov stated this trial has been terminated due to recruitment issues. Attempts will be made to contact the responsible party for further information.

GDM: gestational diabetes mellitus

Characteristics of ongoing studies *[ordered by study ID]*

da Silva 2013

Trial name or title	Effects of an aquatic physical exercise program on glycaemic control and perinatal outcomes of gestational diabetes.
Methods	Parallel-arm randomised controlled trial.
Participants	Instituto de Medicina Integral Prof. Fernando Figueira (IMIP, Recife, Brazil. Pregnant women recently diagnosed with GDM by OGTT between 24 and 28 weeks' gestation using IADPSG criteria.
Interventions	Comparison group - usual care consisting of standard dietary and exercise advice. Intervention group - in addition to standard dietary and exercise advice, participants in the intervention group will take part in aquatic exercises such as walking, walking backwards, swimming laps, jogging, step climbing and strength exercises in a temperature maintained swimming pool for 45 minutes, 3 times a week, conducted from GDM diagnosis until the end of the third trimester.
Outcomes	Primary - glucose control. Secondary - weight gain in pregnancy, systolic and diastolic blood pressure, pre-eclampsia, urinary tract infections, vaginal infections, intrauterine growth restriction, preterm birth, caesarean section, birth injury, macrosomia, maternal or neonatal intensive care admission.
Starting date	Recruitment between August 2013 to March 2014.
Contact information	joaoguilherme@imip.org.br
Notes	Reference for protocol: da Silva 2013b Clinicaltrials.gov identifier: NCT01940003.

Kokic 2014

Trial name or title	Structured aerobic and resistance exercise and gestational diabetes.
Methods	Parallel-arm randomised controlled trial.
Participants	Association for Functional Rehabiliations, Recreation and Applied Kinesiology Impulse, Zagreb, Croatia. Pregnant women between the ages of 20 and 40, with established diagnosis of GDM.
Interventions	Comparison group - standard antenatal care.

Kokic 2014 *(Continued)*

	Intervention group - participation in a 50-minute structured exercise program twice a week consisting of aerobic, resistance and stretching and relaxation exercises, conducted from GDM diagnosis until the end of pregnancy.
Outcomes	Primary - number of women with complications during pregnancy, labour and delivery, blood glucose levels, need for insulin and oral hypoglycaemic drugs, caesarean section and other operative delivery methods, other adverse occurrences during pregnancy. Secondary - macrosomia, weight gain in pregnancy, body mass and fat percentage, lower back pain, physical activity in pregnancy (questionnaire).
Starting date	Janurary 2014 - December 2014.
Contact information	Iva Sklempe Kokic.
Notes	Clinicaltrials.gov identifier: NCT02196571.

Shaw 2005

Trial name or title	Strength training in gestational diabetes mellitus.
Methods	Parallel-arm randomised controlled trial.
Participants	International Diabetes Insitute, Melbourne, Australia. Pregnant women between the ages of 18 and 40 years, diagnosed with GDM.
Interventions	Comparison group - usual care. Intervention group - supervised 45-minute strength training program twice a week from diagnosis of GDM to birth.
Outcomes	Primary - changes in fasting glucose concentrations. Secondary - changes in HbA1c, use of insulin, time until use of insulin, insulin resistance, blood pressure, muscle strength.
Starting date	Retrospectively registered - start date March 2005.
Contact information	jshaw@idi.org.au
Notes	ANZCTR identifier: ACTRN12605000378628.

GDM: gestational diabetes mellitus
OGTT: oral glucose tolerance test

DATA AND ANALYSES

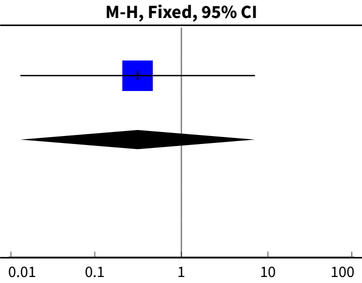
Comparison 1. Exercise versus control

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Hypertensive disorders of pregnancy (pre-eclampsia)	2	48	Risk Ratio (M-H, Fixed, 95% CI)	0.31 [0.01, 7.09]
2 Caesarean section	5	316	Risk Ratio (M-H, Fixed, 95% CI)	0.86 [0.63, 1.16]
3 Perinatal mortality (stillbirth and neonatal mortality)	1	19	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
4 Mortality and morbidity composite (variously defined by trials, e.g. perinatal or infant death, shoulder dystocia, bone fracture or nerve palsy)	2	169	Risk Ratio (M-H, Fixed, 95% CI)	0.56 [0.12, 2.61]
5 Use of additional pharmacotherapy	7	413	Risk Ratio (M-H, Fixed, 95% CI)	0.76 [0.54, 1.08]
6 Maternal hypoglycaemia	1	34	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
7 Glycaemic control end of treatment (Mean)	1	34	Mean Difference (IV, Fixed, 95% CI)	0.28 [0.04, 0.52]
8 Glycaemic control end of treatment (Fasting blood glucose concentration)	4	363	Std. Mean Difference (IV, Random, 95% CI)	-0.59 [-1.07, -0.11]
9 Glycaemic control end of treatment (Postprandial blood glucose concentration)	3	344	Std. Mean Difference (IV, Random, 95% CI)	-0.85 [-1.15, -0.55]
10 Glycaemic control end of treatment (HbA1c)	2	320	Mean Difference (IV, Fixed, 95% CI)	-0.43 [-0.51, -0.35]
11 Glycaemic control end of treatment (Glucose tolerance test)	1	19	Mean Difference (IV, Fixed, 95% CI)	-81.6 [-96.03, -67.17]
12 Weight gain in pregnancy	2	104	Mean Difference (IV, Fixed, 95% CI)	-0.34 [-1.25, 0.58]
13 Weight gain in pregnancy (Excessive)	1	79	Risk Ratio (M-H, Fixed, 95% CI)	0.9 [0.47, 1.72]
14 Adherence to the intervention	1	19	Risk Ratio (M-H, Fixed, 95% CI)	1.0 [0.83, 1.21]
15 Induction of labour	1	40	Risk Ratio (M-H, Fixed, 95% CI)	1.38 [0.71, 2.68]
16 Maternal mortality	2	48	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
17 Views of the intervention (favourable)	1	40	Mean Difference (IV, Fixed, 95% CI)	0.0 [0.0, 0.0]
18 Postnatal weight retention or return to pre-pregnancy weight	3	254	Mean Difference (IV, Fixed, 95% CI)	0.11 [-1.04, 1.26]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
18.1 Maternal BMI (follow-up) kg/m2	3	254	Mean Difference (IV, Fixed, 95% CI)	0.11 [-1.04, 1.26]
19 Stillbirth	1	29	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
20 Macrosomia	5	296	Risk Ratio (M-H, Fixed, 95% CI)	0.69 [0.35, 1.35]
21 Gestational age at birth	4	167	Mean Difference (IV, Fixed, 95% CI)	-0.01 [-0.40, 0.38]
22 Preterm birth	5	302	Risk Ratio (M-H, Fixed, 95% CI)	0.95 [0.39, 2.36]
23 Five-minute Apgar < seven	1	34	Risk Ratio (M-H, Fixed, 95% CI)	0.33 [0.01, 7.65]
24 Birthweight	6	192	Mean Difference (IV, Fixed, 95% CI)	-61.50 [-195.21, 72.20]
25 Length (cm) (at birth)	1	34	Mean Difference (IV, Fixed, 95% CI)	-1.70 [-3.41, 0.01]
26 Neonatal hypoglycaemia	1	34	Risk Ratio (M-H, Fixed, 95% CI)	2.0 [0.20, 20.04]
27 Respiratory distress syndrome	1	34	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]
28 Neonatal jaundice (hyperbilirubinaemia)	1	34	Risk Ratio (M-H, Fixed, 95% CI)	0.33 [0.01, 7.65]
29 Hypocalcaemia	1	34	Risk Ratio (M-H, Fixed, 95% CI)	0.0 [0.0, 0.0]

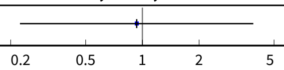
Analysis 1.1. Comparison 1 Exercise versus control, Outcome 1 Hypertensive disorders of pregnancy (pre-eclampsia).

Study or subgroup	Exercise n/N	Control n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Jovanovic-Peterson 1989	0/10	0/9			Not estimable
Avery 1997	0/15	1/14		100%	0.31[0.01,7.09]
Total (95% CI)	**25**	**23**		**100%**	**0.31[0.01,7.09]**
Total events: 0 (Exercise), 1 (Control)					
Heterogeneity: Not applicable					
Test for overall effect: Z=0.73(P=0.47)					



Analysis 1.2. Comparison 1 Exercise versus control, Outcome 2 Caesarean section.

Study or subgroup	Exercise n/N	Control n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Avery 1997	3/15	3/14		6.17%	0.93[0.22,3.88]



Study or subgroup	Exercise n/N	Control n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Bo 2014	4/26	10/49		13.78%	0.75[0.26,2.17]
Bo 2014	5/25	13/50		17.22%	0.77[0.31,1.92]
Bung 1991	2/17	3/17		5.96%	0.67[0.13,3.5]
de Barros 2010	21/31	24/32		46.94%	0.9[0.66,1.24]
Halse 2014	5/20	5/20		9.94%	1[0.34,2.93]
Total (95% CI)	**134**	**182**		**100%**	**0.86[0.63,1.16]**
Total events: 40 (Exercise), 58 (Control)					
Heterogeneity: Tau²=0; Chi²=0.4, df=5(P=1); I²=0%					
Test for overall effect: Z=0.99(P=0.32)					
		Favours exercise	0.2 0.5 1 2 5	Favours control	

Analysis 1.3. Comparison 1 Exercise versus control, Outcome 3 Perinatal mortality (stillbirth and neonatal mortality).

Study or subgroup	Exercise n/N	Control n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Jovanovic-Peterson 1989	0/10	0/9			Not estimable
Total (95% CI)	**10**	**9**			**Not estimable**
Total events: 0 (Exercise), 0 (Control)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
		Favours exercise	0.01 0.1 1 10 100	Favours control	

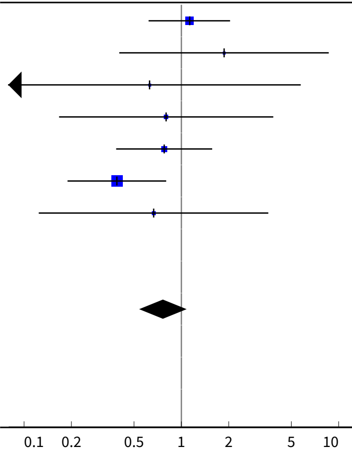
Analysis 1.4. Comparison 1 Exercise versus control, Outcome 4 Mortality and morbidity composite (variously defined by trials, e.g. perinatal or infant death, shoulder dystocia, bone fracture or nerve palsy).

Study or subgroup	Exercise n/N	Control n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Bo 2014	1/26	2/49		29.38%	0.94[0.09,9.91]
Bo 2014	1/25	5/50		70.62%	0.4[0.05,3.24]
Jovanovic-Peterson 1989	0/10	0/9			Not estimable
Total (95% CI)	**61**	**108**		**100%**	**0.56[0.12,2.61]**
Total events: 2 (Exercise), 7 (Control)					
Heterogeneity: Tau²=0; Chi²=0.29, df=1(P=0.59); I²=0%					
Test for overall effect: Z=0.74(P=0.46)					
		Favours exercise	0.01 0.1 1 10 100	Favours control	

Analysis 1.5. Comparison 1 Exercise versus control, Outcome 5 Use of additional pharmacotherapy.

Study or subgroup	Exercise n/N	Control n/N	Weight	Risk Ratio M-H, Fixed, 95% CI
Adam 2014	15/40	13/39	25.99%	1.13[0.62,2.04]
Avery 1997	4/15	2/14	4.09%	1.87[0.4,8.65]
Bo 2014	1/26	3/49	4.11%	0.63[0.07,5.74]
Bo 2014	2/25	5/50	6.58%	0.8[0.17,3.84]
Brankston 2004	7/16	9/16	17.77%	0.78[0.38,1.57]
de Barros 2010	7/32	18/32	35.54%	0.39[0.19,0.8]
Halse 2014	2/20	3/20	5.92%	0.67[0.12,3.57]
Jovanovic-Peterson 1989	0/10	0/9		Not estimable
Total (95% CI)	**184**	**229**	**100%**	**0.76[0.54,1.08]**

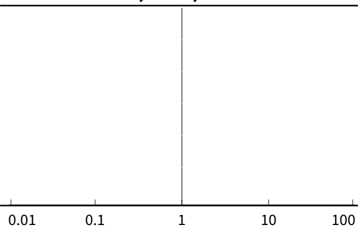
Total events: 38 (Exercise), 53 (Control)
Heterogeneity: $Tau^2=0$; $Chi^2=6.33$, df=6(P=0.39); $I^2=5.26\%$
Test for overall effect: Z=1.52(P=0.13)



Analysis 1.6. Comparison 1 Exercise versus control, Outcome 6 Maternal hypoglycaemia.

Study or subgroup	Exercise n/N	Control n/N	Weight	Risk Ratio M-H, Fixed, 95% CI
Bung 1991	0/17	0/17		Not estimable
Total (95% CI)	**17**	**17**		**Not estimable**

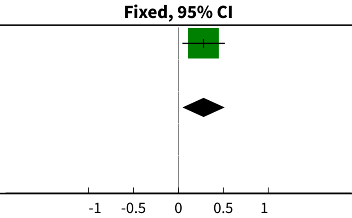
Total events: 0 (Exercise), 0 (Control)
Heterogeneity: Not applicable
Test for overall effect: Not applicable



Analysis 1.7. Comparison 1 Exercise versus control, Outcome 7 Glycaemic control end of treatment (Mean).

Study or subgroup	Exercise N	Exercise Mean(SD)	Control N	Control Mean(SD)	Weight	Mean Difference Fixed, 95% CI
Bung 1991	17	5.2 (0.4)	17	4.9 (0.4)	100%	0.28[0.04,0.52]
Total ***	**17**		**17**		**100%**	**0.28[0.04,0.52]**

Heterogeneity: Not applicable
Test for overall effect: Z=2.33(P=0.02)

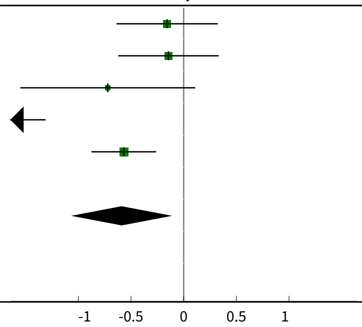


Analysis 1.8. Comparison 1 Exercise versus control, Outcome 8 Glycaemic control end of treatment (Fasting blood glucose concentration).

Study or subgroup	Exercise N	Exercise Mean(SD)	Control N	Control Mean(SD)	Std. Mean Difference Random, 95% CI	Weight	Std. Mean Difference Random, 95% CI
Bo 2014	25	72.5 (10.1)	50	74.1 (10.1)		23.52%	-0.16[-0.64,0.32]
Bo 2014	26	72.5 (10.1)	49	74.1 (11.4)		23.63%	-0.14[-0.62,0.33]
Brankston 2004	12	4.7 (0.4)	12	5.1 (0.7)		16.01%	-0.72[-1.55,0.11]
Jovanovic-Peterson 1989	10	70.1 (6.6)	9	87.6 (6.2)		9.48%	-2.61[-3.9,-1.31]
Youngwanichsetha 2014	85	83.4 (7.7)	85	87.9 (7.9)		27.36%	-0.57[-0.87,-0.26]
Total ***	**158**		**205**			**100%**	**-0.59[-1.07,-0.11]**

Heterogeneity: Tau^2=0.19; Chi^2=14.62, df=4(P=0.01); I^2=72.63%

Test for overall effect: Z=2.41(P=0.02)

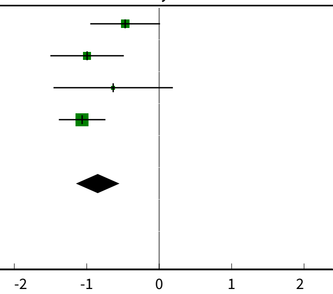


Analysis 1.9. Comparison 1 Exercise versus control, Outcome 9 Glycaemic control end of treatment (Postprandial blood glucose concentration).

Study or subgroup	Exercise N	Exercise Mean(SD)	Control N	Control Mean(SD)	Std. Mean Difference Random, 95% CI	Weight	Std. Mean Difference Random, 95% CI
Bo 2014	26	104.3 (19.8)	49	112.5 (15.8)		25.36%	-0.47[-0.95,0.01]
Bo 2014	25	104.3 (19.8)	50	121.8 (16.1)		23.69%	-1[-1.5,-0.49]
Brankston 2004	12	6 (0.3)	12	6.4 (0.8)		11.26%	-0.63[-1.46,0.19]
Youngwanichsetha 2014	85	103.7 (9.9)	85	114.4 (10.1)		39.69%	-1.06[-1.39,-0.74]
Total ***	**148**		**196**			**100%**	**-0.85[-1.15,-0.55]**

Heterogeneity: Tau^2=0.03; Chi^2=4.57, df=3(P=0.21); I^2=34.39%

Test for overall effect: Z=5.53(P<0.0001)

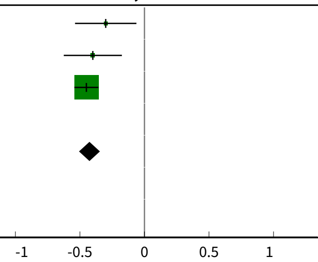


Analysis 1.10. Comparison 1 Exercise versus control, Outcome 10 Glycaemic control end of treatment (HbA1c).

Study or subgroup	Exercise N	Exercise Mean(SD)	Control N	Control Mean(SD)	Mean Difference Fixed, 95% CI	Weight	Mean Difference Fixed, 95% CI
Bo 2014	26	4.6 (0.5)	49	4.9 (0.5)		11.62%	-0.3[-0.54,-0.06]
Bo 2014	25	4.6 (0.5)	50	5 (0.4)		12.96%	-0.4[-0.63,-0.17]
Youngwanichsetha 2014	85	5.2 (0.2)	85	5.7 (0.4)		75.42%	-0.45[-0.54,-0.36]
Total ***	**136**		**184**			**100%**	**-0.43[-0.51,-0.35]**

Heterogeneity: Tau^2=0; Chi^2=1.38, df=2(P=0.5); I^2=0%

Test for overall effect: Z=10.3(P<0.0001)



Analysis 1.11. Comparison 1 Exercise versus control, Outcome 11 Glycaemic control end of treatment (Glucose tolerance test).

Study or subgroup	Exercise N	Exercise Mean(SD)	Control N	Control Mean(SD)	Mean Difference Fixed, 95% CI	Weight	Mean Difference Fixed, 95% CI
Jovanovic-Peterson 1989	10	105.9 (18.9)	9	187.5 (12.9)		100%	-81.6[-96.03,-67.17]
Total ***	**10**		**9**			**100%**	**-81.6[-96.03,-67.17]**
Heterogeneity: Not applicable							
Test for overall effect: Z=11.08(P<0.0001)							

Favours exercise -100 -50 0 50 100 Favours control

Analysis 1.12. Comparison 1 Exercise versus control, Outcome 12 Weight gain in pregnancy.

Study or subgroup	Exercise N	Exercise Mean(SD)	Control N	Control Mean(SD)	Mean Difference Fixed, 95% CI	Weight	Mean Difference Fixed, 95% CI
de Barros 2010	32	11.3 (5.6)	32	12.6 (5.3)		11.67%	-1.36[-4.04,1.32]
Halse 2014	20	0.8 (1.3)	20	1 (1.8)		88.33%	-0.2[-1.17,0.77]
Total ***	**52**		**52**			**100%**	**-0.34[-1.25,0.58]**
Heterogeneity: $Tau^2=0$; $Chi^2=0.64$, df=1(P=0.42); $I^2=0\%$							
Test for overall effect: Z=0.72(P=0.47)							

Favours exercise -2 -1 0 1 2 Favours control

Analysis 1.13. Comparison 1 Exercise versus control, Outcome 13 Weight gain in pregnancy (Excessive).

Study or subgroup	Exercise n/N	Control n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Adam 2014	12/40	13/39		100%	0.9[0.47,1.72]
Total (95% CI)	**40**	**39**		**100%**	**0.9[0.47,1.72]**
Total events: 12 (Exercise), 13 (Control)					
Heterogeneity: Not applicable					
Test for overall effect: Z=0.32(P=0.75)					

Favours exercise 0.005 0.1 1 10 200 Favours control

Analysis 1.14. Comparison 1 Exercise versus control, Outcome 14 Adherence to the intervention.

Study or subgroup	Exercise n/N	Control n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Jovanovic-Peterson 1989	10/10	9/9		100%	1[0.83,1.21]
Total (95% CI)	**10**	**9**		**100%**	**1[0.83,1.21]**
Total events: 10 (Exercise), 9 (Control)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					

Favours exercise 0.01 0.1 1 10 100 Favours control

Analysis 1.15. Comparison 1 Exercise versus control, Outcome 15 Induction of labour.

Study or subgroup	Exercise n/N	Control n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Halse 2014	11/20	8/20		100%	1.38[0.71,2.68]
Total (95% CI)	**20**	**20**		**100%**	**1.38[0.71,2.68]**
Total events: 11 (Exercise), 8 (Control)					
Heterogeneity: Not applicable					
Test for overall effect: Z=0.94(P=0.35)					
		Favours exercise	0.01 0.1 1 10 100	Favours control	

Analysis 1.16. Comparison 1 Exercise versus control, Outcome 16 Maternal mortality.

Study or subgroup	Exercise n/N	Control n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Avery 1997	0/14	0/15			Not estimable
Jovanovic-Peterson 1989	0/10	0/9			Not estimable
Total (95% CI)	**24**	**24**			**Not estimable**
Total events: 0 (Exercise), 0 (Control)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
		Favours exercise	0.01 0.1 1 10 100	Favours control	

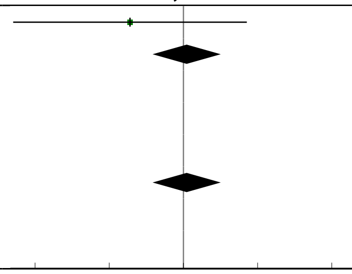
Analysis 1.17. Comparison 1 Exercise versus control, Outcome 17 Views of the intervention (favourable).

Study or subgroup	Exercise N	Exercise Mean(SD)	Control N	Control Mean(SD)	Mean Difference Fixed, 95% CI	Weight	Mean Difference Fixed, 95% CI
Halse 2014	20	7 (0)	20	6 (1)			Not estimable
Total ***	**20**		**20**				**Not estimable**
Heterogeneity: Not applicable							
Test for overall effect: Not applicable							
				Favours exercise	-100 -50 0 50 100	Favours control	

Analysis 1.18. Comparison 1 Exercise versus control, Outcome 18 Postnatal weight retention or return to pre-pregnancy weight.

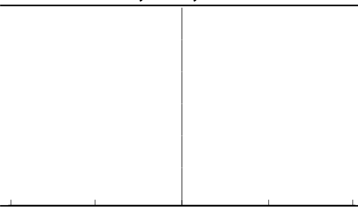
Study or subgroup	Exercise N	Exercise Mean(SD)	Control N	Control Mean(SD)	Mean Difference Fixed, 95% CI	Weight	Mean Difference Fixed, 95% CI
1.18.1 Maternal BMI (follow-up) kg/m2							
Bo 2014	26	27.7 (4.3)	49	27.5 (4.4)		31.01%	0.2[-1.86,2.26]
Bo 2014	25	27.7 (4.3)	50	27.5 (4.5)		29.97%	0.2[-1.9,2.3]
de Barros 2010	32	30.4 (4.4)	32	29.9 (4.1)		30.51%	0.46[-1.62,2.54]
				Favours exercise	-5 -2.5 0 2.5 5	Favours control	

Study or subgroup	Exercise N	Exercise Mean(SD)	Control N	Control Mean(SD)	Mean Difference Fixed, 95% CI	Weight	Mean Difference Fixed, 95% CI
Halse 2014	20	28.3 (6.5)	20	30.1 (6.2)		8.5%	-1.8[-5.74,2.14]
Subtotal ***	**103**		**151**			**100%**	**0.11[-1.04,1.26]**
Heterogeneity: Tau²=0; Chi²=1.03, df=3(P=0.79); I²=0%							
Test for overall effect: Z=0.19(P=0.85)							
Total ***	**103**		**151**			**100%**	**0.11[-1.04,1.26]**
Heterogeneity: Tau²=0; Chi²=1.03, df=3(P=0.79); I²=0%							
Test for overall effect: Z=0.19(P=0.85)							
				Favours exercise	-5 -2.5 0 2.5 5	Favours control	



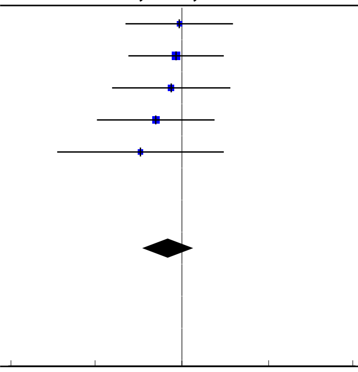
Analysis 1.19. Comparison 1 Exercise versus control, Outcome 19 Stillbirth.

Study or subgroup	Exercise n/N	Control n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Avery 1997	0/15	0/14			Not estimable
Total (95% CI)	**15**	**14**			**Not estimable**
Total events: 0 (Exercise), 0 (Control)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					
		Favours exercise	0.01 0.1 1 10 100	Favours control	



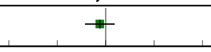
Analysis 1.20. Comparison 1 Exercise versus control, Outcome 20 Macrosomia.

Study or subgroup	Exercise n/N	Control n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Avery 1997	3/15	3/14		17.02%	0.93[0.22,3.88]
Bo 2014	3/25	7/50		25.59%	0.86[0.24,3.04]
Bo 2014	2/26	5/49		19.01%	0.75[0.16,3.62]
Bung 1991	2/17	4/17		21.93%	0.5[0.11,2.38]
de Barros 2010	1/32	3/32		16.45%	0.33[0.04,3.04]
Jovanovic-Peterson 1989	0/10	0/9			Not estimable
Total (95% CI)	**125**	**171**		**100%**	**0.69[0.35,1.35]**
Total events: 11 (Exercise), 22 (Control)					
Heterogeneity: Tau²=0; Chi²=0.88, df=4(P=0.93); I²=0%					
Test for overall effect: Z=1.09(P=0.28)					
		Favours exercise	0.01 0.1 1 10 100	Favours control	



Analysis 1.21. Comparison 1 Exercise versus control, Outcome 21 Gestational age at birth.

Study or subgroup	Exercise N	Exercise Mean(SD)	Control N	Control Mean(SD)	Mean Difference Fixed, 95% CI	Weight	Mean Difference Fixed, 95% CI
Avery 1997	15	39.4 (1.2)	14	39.7 (0.9)		26.04%	-0.3[-1.07,0.47]
				Favours exercise	-5 -2.5 0 2.5 5	Favours control	



Study or subgroup	Exercise N	Exercise Mean(SD)	Control N	Control Mean(SD)	Mean Difference Fixed, 95% CI	Weight	Mean Difference Fixed, 95% CI
Bung 1991	17	38.9 (1.7)	17	38.2 (2)		9.89%	0.7[-0.55,1.95]
de Barros 2010	32	38.6 (1.1)	32	38.6 (1.2)		45.56%	0.04[-0.54,0.62]
Halse 2014	20	38.6 (1.7)	20	38.7 (1.2)		18.51%	-0.1[-1.01,0.81]
Total ***	**84**		**83**			**100%**	**-0.01[-0.4,0.38]**
Heterogeneity: Tau²=0; Chi²=1.86, df=3(P=0.6); I²=0%							
Test for overall effect: Z=0.05(P=0.96)							
				Favours exercise	-5 -2.5 0 2.5 5	Favours control	

Analysis 1.22. Comparison 1 Exercise versus control, Outcome 22 Preterm birth.

Study or subgroup	Exercise n/N	Control n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Avery 1997	0/15	0/14			Not estimable
Bo 2014	1/25	4/50		29.46%	0.5[0.06,4.24]
Bo 2014	1/26	2/49		15.32%	0.94[0.09,9.91]
de Barros 2010	3/32	3/32		33.14%	1[0.22,4.59]
Halse 2014	3/20	2/20		22.09%	1.5[0.28,8.04]
Jovanovic-Peterson 1989	0/10	0/9			Not estimable
Total (95% CI)	**128**	**174**		**100%**	**0.95[0.39,2.36]**
Total events: 8 (Exercise), 11 (Control)					
Heterogeneity: Tau²=0; Chi²=0.63, df=3(P=0.89); I²=0%					
Test for overall effect: Z=0.1(P=0.92)					
		Favours exercise	0.01 0.1 1 10 100	Favours control	

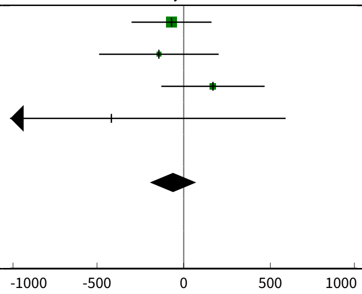
Analysis 1.23. Comparison 1 Exercise versus control, Outcome 23 Five-minute Apgar < seven.

Study or subgroup	Exercise n/N	Control n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Bung 1991	0/17	1/17		100%	0.33[0.01,7.65]
Total (95% CI)	**17**	**17**		**100%**	**0.33[0.01,7.65]**
Total events: 0 (Exercise), 1 (Control)					
Heterogeneity: Not applicable					
Test for overall effect: Z=0.69(P=0.49)					
		Favours exercise	0.001 0.1 1 10 1000	Favours control	

Analysis 1.24. Comparison 1 Exercise versus control, Outcome 24 Birthweight.

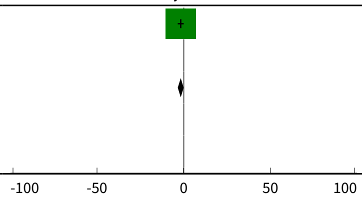
Study or subgroup	Exercise N	Exercise Mean(SD)	Control N	Control Mean(SD)	Mean Difference Fixed, 95% CI	Weight	Mean Difference Fixed, 95% CI
Avery 1997	15	3419 (528)	14	3609 (428)		14.69%	-190[-538.8,158.8]
Bung 1991	17	3379 (534)	17	3482 (502)		14.73%	-103[-451.4,245.4]
				Favours exercise	-1000 -500 0 500 1000	Favours control	

Study or subgroup	Exercise N	Exercise Mean(SD)	Control N	Control Mean(SD)	Mean Difference Fixed, 95% CI	Weight	Mean Difference Fixed, 95% CI
de Barros 2010	32	3230 (450)	32	3300 (490)		33.65%	-70[-300.5,160.5]
Halse 2014	20	3176 (625)	20	3319 (478)		15.03%	-143[-487.84,201.84]
Jovanovic-Peterson 1989	10	3634 (317)	9	3465 (343)		20.13%	169[-129.02,467.02]
Ramos 2015	2	3620 (714)	4	4037 (180)		1.77%	-417[-1422.13,588.13]
Total ***	**96**		**96**			**100%**	**-61.5[-195.21,72.2]**
Heterogeneity: Tau²=0; Chi²=3.57, df=5(P=0.61); I²=0%							
Test for overall effect: Z=0.9(P=0.37)							



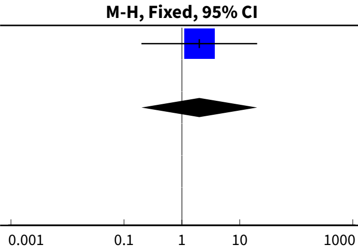
Analysis 1.25. Comparison 1 Exercise versus control, Outcome 25 Length (cm) (at birth).

Study or subgroup	Exercise N	Exercise Mean(SD)	Control N	Control Mean(SD)	Mean Difference Fixed, 95% CI	Weight	Mean Difference Fixed, 95% CI
Bung 1991	17	49.3 (2)	17	51 (3)		100%	-1.7[-3.41,0.01]
Total ***	**17**		**17**			**100%**	**-1.7[-3.41,0.01]**
Heterogeneity: Not applicable							
Test for overall effect: Z=1.94(P=0.05)							



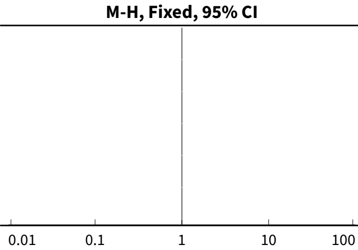
Analysis 1.26. Comparison 1 Exercise versus control, Outcome 26 Neonatal hypoglycaemia.

Study or subgroup	Exercise n/N	Control n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Bung 1991	2/17	1/17		100%	2[0.2,20.04]
Total (95% CI)	**17**	**17**		**100%**	**2[0.2,20.04]**
Total events: 2 (Exercise), 1 (Control)					
Heterogeneity: Not applicable					
Test for overall effect: Z=0.59(P=0.56)					



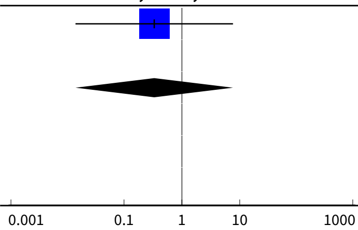
Analysis 1.27. Comparison 1 Exercise versus control, Outcome 27 Respiratory distress syndrome.

Study or subgroup	Exercise n/N	Control n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Bung 1991	0/17	0/17			Not estimable
Total (95% CI)	**17**	**17**			**Not estimable**
Total events: 0 (Exercise), 0 (Control)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					



Analysis 1.28. Comparison 1 Exercise versus control, Outcome 28 Neonatal jaundice (hyperbilirubinaemia).

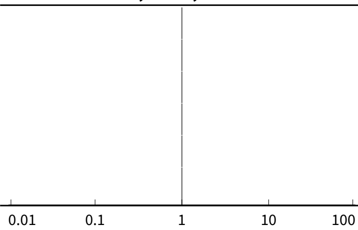
Study or subgroup	Exercise n/N	Control n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Bung 1991	0/17	1/17		100%	0.33[0.01,7.65]
Total (95% CI)	**17**	**17**		**100%**	**0.33[0.01,7.65]**
Total events: 0 (Exercise), 1 (Control)					
Heterogeneity: Not applicable					
Test for overall effect: Z=0.69(P=0.49)					



Favours exercise — Favours control

Analysis 1.29. Comparison 1 Exercise versus control, Outcome 29 Hypocalcaemia.

Study or subgroup	Exercise n/N	Control n/N	Risk Ratio M-H, Fixed, 95% CI	Weight	Risk Ratio M-H, Fixed, 95% CI
Bung 1991	0/17	0/17			Not estimable
Total (95% CI)	**17**	**17**			**Not estimable**
Total events: 0 (Exercise), 0 (Control)					
Heterogeneity: Not applicable					
Test for overall effect: Not applicable					



Favours exercise — Favours control

APPENDICES

Appendix 1. Search terms for ICTRP and ClinicalTrials.gov

exercise AND GDM

exercise AND gestational diabetes

exercise AND diabetes AND pregnancy

CONTRIBUTIONS OF AUTHORS

Dr Julie Brown guarantees this review. Dr Gilles Ceysens and Dr Michel Boulvain prepared the original (Ceysens 2006) review upon which this review is based. For this review, Dr Brown joined the team to provide methodological support to update the review, which was split into two new reviews on: exercise for pregnant women with gestational diabetes, and exercise for pregnant women with pre-existing diabetes. A new protocol (Ceysens 2016) was developed to inform this review.

DECLARATIONS OF INTEREST

Dr Gilles Ceysens - none known.

Dr Julie Brown - none known.

Dr Michel Boulvain received research funding from Centre de Recherche Clinique (Advanced researcher grant scheme (2007-2010)) to study exercise in pregnancy. One of the studies was a randomised controlled trial evaluating the effects of exercise in women with gestational diabetes. This study may be eligible for inclusion in this review - Michel Boulvain will not be involved in any decisions relating to the inclusion of his own study in this review. All tasks relating to that study (assessment for inclusion, risk of bias, data extraction) will be carried out by the other members of the review team who were not directly involved in the trial. In 2012, he was invited to speak at the DIP 2012 Congress on gestational diabetes and was reimbursed for travel and accommodation.

SOURCES OF SUPPORT

Internal sources

- Liggins Institute, University of Auckland, New Zealand.

  Support for infrastructure to develop this protocol and update the review was received from the Liggins Institute, University of Auckland.

External sources

- National Institute for Health Research (NIHR), UK.

  NIHR Cochrane Programme Grant Project: 13/89/05 – Pregnancy and childbirth systematic reviews to support clinical guidelines, UK

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

There are some differences between our published protocol (Ceysens 2016) and this full review.

Dr Julie Brown has now taken over the role of contact person and guarantor for this review.

Methods/types of outcomes - we edited the outcome 'Large for gestational age' to include the criterion '(≥ 4 kg)'.

Methods/Assessment of the quality of the body of evidence using the GRADE approach - for consistency, we edited some outcome names to match the list of outcomes in the main methods. This relates to the following outcomes.

Maternal

1. 'Hypertensive disorders of pregnancy' has now been edited to 'Hypertensive disorders of pregnancy (as reported by trialists, including pre-eclampsia, pregnancy-induced hypertension, eclampsia)'
2. 'Perineal trauma' has now been edited to 'Perineal trauma/tearing'
3. 'Return to pre-pregnancy weight' has now been edited to 'Postnatal weight retention or return to pre-pregnancy weight'

Child (as a fetus, neonatal child or adult)

1. 'Perinatal mortality' has been edited to 'Perinatal mortality (stillbirth and neonatal mortality)'
2. 'Composite outcome of serious neonatal outcomes' has been edited to 'Mortality and morbidity composite (variously defined by trials, e.g. perinatal or infant death, shoulder dystocia, bone fracture or nerve palsy)'
3. We clarified that 'Diabetes' could be either type 1 or type 2 and could relate to later infant, childhood or for the child as an adult
4. We clarified that 'Adiposity' could relate to the neonate, later during infancy, childhood or for the child as an adult

Methods to be utilised in future updates, as appropriate

Data collection and analysis

Unit of analysis issues

Multiple-arm studies

We will avoid 'double-counting' of participants by combining group to create a single pair-wise comparison, if possible. In this version of the review it was not possible to do this so we split the 'shared' group into two or more groups with smaller sample sizes to include two or more reasonably independent comparisons.

Sensitivity analysis

Planned sensitivity analyses were not carried out because we did not observe substantial heterogeneity in our analysis and did not include cluster-randomised controlled trials. We will perform planned sensitivity analyses for the review's primary outcomes in future updates, if appropriate.

Subgroup analysis and investigation of heterogeneity

Planned subgroup analyses were not carried out due to insufficient data - these will be performed in future updates, if appropriate.

INDEX TERMS

Medical Subject Headings (MeSH)

Body Mass Index; Cesarean Section; Diabetes, Gestational [*therapy]; Dystocia [epidemiology]; Exercise Therapy [*methods]; Hypoglycemia [epidemiology]; Labor, Induced [statistics & numerical data]; Perinatal Mortality; Pre-Eclampsia [epidemiology]; Randomized Controlled Trials as Topic

MeSH check words

Adult; Female; Humans; Infant; Infant, Newborn; Pregnancy

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Combination of a structured aerobic and resistance exercise improves glycaemic control in pregnant women diagnosed with gestational diabetes mellitus. A randomised controlled trial

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ABSTRACT

Problem: Gestational diabetes mellitus, defined as any carbohydrate intolerance first diagnosed during pregnancy, is associated with a variety of adverse outcomes, both for the mother and her child.
Aim: To investigate the impact of a structured exercise programme which consisted of aerobic and resistance exercises on the parameters of glycaemic control and other health-related outcomes in pregnant women diagnosed with gestational diabetes mellitus.
Methods: Thirty-eight pregnant women diagnosed with gestational diabetes mellitus were randomised to two groups. Experimental group was treated with standard antenatal care for gestational diabetes mellitus, and regular supervised exercise programme plus daily brisk walks of at least 30 min. Control group received only standard antenatal care for gestational diabetes mellitus. The exercise programme was started from the time of diagnosis of diabetes until birth. It was performed two times per week and sessions lasted 50–55 min.
Findings: The experimental group had lower postprandial glucose levels at the end of pregnancy ($P < 0.001$). There was no significant difference between groups in the level of fasting glucose at the end of pregnancy. Also, there were no significant differences in the rate of complications during pregnancy and birth, need for pharmacological therapy, maternal body mass and body fat percentage gains during pregnancy, and neonatal Apgar scores, body mass and ponderal index. Neonatal body mass index was higher in the experimental group ($P = 0.035$).
Conclusion: The structured exercise programme had a beneficial effect on postprandial glucose levels at the end of pregnancy.

Statement of significance

Problem or issue

Gestational diabetes mellitus is associated with an increased rate of perinatal complications and long-term morbidity.

What is already known

Aerobic or resistance exercise programmes from previous trials proved beneficial effects of exercise on the course and outcomes of pregnancy. Combination of aerobic and resistance exercise has synergistic effects in patients with type 2 diabetes.

What this paper adds

Combining aerobic and resistance exercises has beneficial effects on glycaemic control. Furthermore, it is a safe therapeutic strategy for pregnant women with gestational diabetes mellitus.

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1. Introduction

Gestational diabetes mellitus (GDM) is defined as any carbohydrate intolerance first diagnosed during pregnancy.[1] It accounts for 90–95% of all cases of diabetes in pregnancy and is the most common metabolic disorder encountered during pregnancy.[2] The prevalence of GDM is rising, and it is directly related to the prevalence of type 2 diabetes in a given population.[2,3]

GDM is associated with a variety of adverse outcomes, both for the mother and for the fetus. Possible consequences for the mother include an increased rate of perinatal complications, hypertension during pregnancy and preeclampsia. Long term, there is an increased risk of developing type 2 diabetes, metabolic syndrome, obesity, cardiovascular morbidities and recurrent GDM.[2,4] Maternal hyperglycaemia causes an excessive transfer of nutrients – specifically glucose – to the fetus, resulting in fetal hyperinsulinaemia, fetal adiposity, macrosomia and perinatal complications. Long term, these children are also at increased risk of developing obesity, metabolic syndrome, type 2 diabetes and hypertension.[5]

The primary aim of treating GDM is to optimize glycaemic control and improve pregnancy outcomes.[6] Changes in diet and lifestyle are usually recommended as the primary therapeutic strategy to achieve acceptable glycaemic control.[3] If these measures fail to establish adequate glycaemic control within 1–2 weeks, pharmacological therapy is introduced. It is also recommended to continue or initiate exercise at moderate intensity for all pregnant women without contraindications.[2,3]

Exercise is associated with significant, beneficial physiological and metabolic changes and responses to exercise are not different in comparison to the non-pregnant population.[7] Today, physical activity is recommended as a part of antenatal care.[8] Furthermore, exercise leads to improved insulin sensitivity and blood glucose levels in patients with type 2 diabetes.[9] Both aerobic and resistance exercises, especially in combination, have shown beneficial effects in patients with type 2 diabetes.[10] Studies have shown a correlation between higher levels of physical activity before and during early pregnancy with a lower risk of developing GDM.[11]

While the use of exercise in the treatment of type 2 diabetes is supported by plenty of evidence, there is a limited body of evidence exploring the effects of exercise on the course and outcomes of GDM. Only nine prospective trials were found that investigate this subject, seven randomised,[12–18] and two non-randomised.[19,20] Seven of these trials examined the effects of aerobic exercise programmes,[12–14,17–20] whereas only two examined the role of resistance exercises.[15,16] None of the trials examined the effects of combining aerobic and resistance exercises.

Hence, the purpose of this trial was to investigate the health-related effects of implementing a supervised, individualised, structured exercise programme, consisting of aerobic and resistance exercises, on the course and outcomes of GDM. We hypothesized that this exercise programme would improve: glycaemic control, the rate of complications during pregnancy, weight gain and body fat percentage changes during the pregnancy, the rate of complications and mode of birth, and the health status and weight of the newborn.

2. Participants, ethics and methods

2.1. Design and ethics

A randomised controlled trial was conducted between July 2014 and January 2015 comparing an exercise programme with standard antenatal care for GDM. Ethical approval was obtained from the University Hospital Centre Zagreb and the University Hospital Merkur, Zagreb, Croatia and the trial was registered with Clinicaltrials.gov (NCT 02196571). Written, informed consent was obtained from every participant. The trial was conducted in accordance with the Declaration of Helsinki.

2.2. Participants

Participants were recruited by direct contact at two university hospitals in Zagreb, Croatia. Inclusion criteria were: an established diagnosis of gestational diabetes according to the criteria published by the International Association of the Diabetes and Pregnancy Study Groups,[21] aged between 20 and 40. The upper limit for gestational age at the time of inclusion was set at 30 weeks, to allow a minimum exercise period of 6 weeks, until at least the 36th week of pregnancy. Exclusion criteria were: a medical history of diabetes and miscarriages, pharmacological treatment prior to enrolment in the trial, existing comorbidities, and contraindications for exercise as outlined in criteria published by the American College of Obstetricians and Gynecologists (ACOG).[22]

Participants were randomized by block randomisation using a web-based computerized procedure into two groups: experimental and control. The staff involved with the exercise sessions and assessments had no influence on the randomisation procedure. Due to the nature of the study, participants were not blinded. Physicians and laboratory staff were blinded.

2.3. Assessments and measurements

Baseline information taken at the initial interview included: demographic data, medical history including obstetric history, lifestyle habits, physical activity levels and body height and mass at the start of the pregnancy. Pregnant women randomised to the experimental group (EG) were scheduled for their first exercise session. In the 30th, 33rd and 36th week, anthropometric measurements were taken from both groups. Relevant medical documentation was also reviewed in order to assess the course of pregnancy and glycaemic control. Following childbirth, data was gathered on: glycaemic control during the final weeks of pregnancy, the course of birth, neonatal health status and anthropometric information.

All anthropometric measurements were performed by a blinded physiotherapist. These included body mass, arm circumference and skinfold thickness. Body mass was measured using a medical grade digital scale, measuring to the nearest 0.1 kg. This was used to calculate body mass index. Skinfold thickness and arm circumference were measured as recommended by the Manual of International Standards for Anthropometric Assessment.[23] Skinfold thickness was measured using a skinfold caliper (Harpendem Skinfold Caliper, Baty International, Burgess Hill, UK) at the biceps brachii and triceps brachii muscles, and in the subscapular area. Measurements of arm circumference, skinfold thickness and height were fed into the equation by Kannieappan et al.[24] specifically developed and validated for use in pregnant women in order to calculate body fat percentage. Data on neonatal weight, length, Apgar score and health status was extracted from the hospital discharge letter, and used to calculate neonatal body mass index and ponderal index according to the standard equations. Participants' physical activity levels were assessed at baseline and in the 30th and 36th weeks of pregnancy using the Pregnancy Physical Activity Questionnaire.[25]

An oral glucose tolerance test was performed and blood glucose profiles calculated in the medical biochemistry laboratory at the above mentioned hospitals. Analyses were done according to standard operating protocols for the accredited laboratory (International Standards Organization (ISO) 15189 Medical laboratories – particular requirements for quality and competence) and according to recommendations by the Croatian Chamber of Medical Biochemists. After a diagnosis of GDM was established using the oral glucose tolerance test, all participants had their fasting and postprandial glucose levels measured monthly or bi-monthly for the duration of their pregnancy. Four capillary blood samples were taken: before the first meal in the morning, 2 h after breakfast, 2 h after lunch and 2 h after dinner.

2.4. Intervention

Women in the EG were started on an individualised, structured exercise programme two times per week, along with their standard prenatal care. Participants in this group were also asked to undertake at least 30 min of brisk walking per day. The exercise programme began following an established diagnosis of GDM, and continued throughout the duration of pregnancy. Attendance was recorded at every exercise session and the women were instructed to keep a diary of their daily walks. The minimum total duration of the exercise programme was set at 6 weeks. The minimum acceptable attendance of calculated expected exercise sessions between the time of inclusion in the trial and the 38th week of pregnancy was set at 70%. Women in the CG received standard prenatal care for GDM alone, but were not discouraged from exercising on their own.

Each exercise session lasted for 50–55 min and consisted of aerobic exercise (20 min), resistance exercises (20–25 min), pelvic floor and stretching exercises, and a period of relaxation to end the session (10 min). The aerobic part of the session was performed on treadmill (Axos Runner, Heinz Kettler GmbH, Ense-Parsit, Germany) and aimed to achieve a heart rate within the aerobic zone (65–75% of maximum heart rate), i.e. target values were 13–14 on the Borg Rating of Perceived Exertion scale.[26] Women were free to adjust the velocity and incline of the treadmill to achieve the target intensity. Maternal heart rate was monitored continuously (Mio Alpha, Mio Global, Vancouver, BC, Canada). Baseline heart rate was measured before each session (after 5 min of relaxation), and average values for the aerobic and resistance parts of the session recorded separately. Target heart rate was calculated using Karvonen's formula. Maximum heart rate was determined using the traditional formula 220-age.

Resistance exercises incorporated all major muscle groups, and were performed at each session with the same target values on the Borg Rating of Perceived Exertion scale as for the aerobic part of the session. Six different exercises were performed in three sets of 10–15 repetitions in each set. Three standardized resistance exercise protocols were developed and interchanged. These included exercises for the trunk, and upper and lower limb muscles. They were carried out using body weight, elastic bands (TheraBand, The Hygenic Corporation, Akron, OH, USA) and hand held weights of 0.5 and 1 kg (Aerobic Dumbbels, Heinz Kettler GmbH, Ense-Parsit, Germany). Stretching and pelvic floor exercises were performed at the end of every session, followed by a short period of relaxation to allow a thorough cool-down.

All participants were commenced on medical nutrition therapy recommended for women with GDM. This consisted of 1800 kcal per day: 20% proteins (90 g), 30% fat (60 g) and 50% carbohydrates (225 g), distributed over three main meals and three snacks.

2.5. Statistical methods

Statistical analysis was performed using SPSS 19.0 (IBM, Armonk, NY, USA). Descriptive statistics were calculated for all variables of interest, and included mean value, standard deviation,

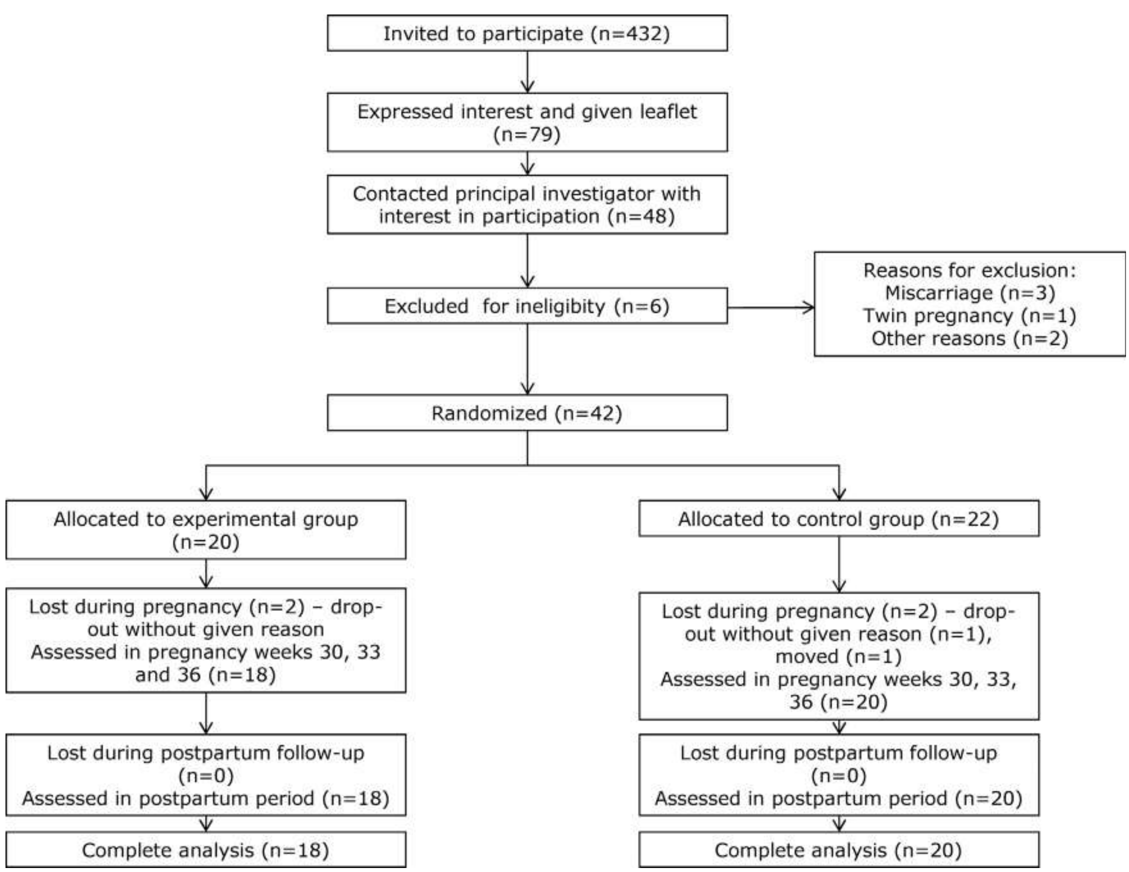

Fig. 1. Flow chart of study participants.

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and minimum and maximum values where appropriate. The Shapiro-Wilk test was used to check for normality of data and Levene's test to check for homogeneity of variances. The two-tailed Mann Whitney U without Bonferroni correction test was used to compare baseline participants' characteristics and analyse and compare results between the groups of: the Pregnancy Physical Activity Questionnaire, the rate of complications in pregnancy and during birth, maternal anthropometric measurements at specific time points during pregnancy, neonatal Apgar scores, the rate of neonatal complications and neonatal anthropometric data. An independent sample T-test was used to assess for significant differences in fasting and postprandial glucose levels measured at the end of pregnancy.

Pearson's correlation coefficent (r) was used to calculate the correlation coefficient between main outcomes (fasting and postprandial glucose levels, neonatal anthropometric data) and body mass and gain during specific periods of pregnancy, as well as activity levels as measured by the Pregnancy Physical Activity Questionnaire. Maternal anthropometric measures were correlated with baseline data and levels of physical activity during pregnancy.

The point-biserial correlation coefficient (r_{pbi}) was used to determine the relationship between main outcomes (fasting and postprandial glucose levels, neonatal anthropometric data) and baseline characteristics of the participants, as well as determining the relationship between complications in pregnancy and during birth with maternal anthropometric measures and activity levels as measured by the Pregnancy Physical Activity Questionnaire. The level of significance was set at $P < 0.05$. Cohen's d (d) and effect size (r) were calculated for all outcome variables with the level of significance ≤ 0.05.

3. Results

A total of 42 women diagnosed with GDM were finally enrolled in the trial and randomised to two groups: 20 to the EG and 22 to the CG. Four participants (9.52%) dropped out of the trial, two from the EG (10%) and two from the CG (9.09%) (Fig. 1). The experimental and the control group were well matched, without differences in baseline variables (Table 1) ($P > 0.05$).

A total of 365 exercise sessions were performed during the trial, with an average of 20.28 ± 7.68 sessions performed per subject. The minimum number of exercise sessions performed per subject was 12, and the maximum 34. The average rate of adherence to protocol regarding performed versus planned sessions was high (84.22%), above the 70% threshold set, making the intervention successful for all participants in the EG. We achieved satisfactory exercise intensity in both parts of each exercise session, with an average intensity of 65.06 ± 4.42% of maximum heart rate, while maintaining target intensity values of 13–14 on the Borg Rating of Perceived Exertion scale. Adherence to daily brisk walking was also well above the 70% threshold, with an average of 95.56 ± 4.54%.

While there was no difference in baseline levels of physical activity between the EG and CG, we found significant differences in the 30th and 36th weeks of pregnancy in favour of EG. The most significant difference – with large effect size – was in the level of sport/exercise activity, with women in the EG recording more sport/exercise activities both during week 30 ($P < 0.001$, $d = 2.37$, $r = 0.76$) and week 36 ($P < 0.001$, $d = 2.41$, $r = 0.77$), compared to the EG. Moderate intensity activities ($P = 0.016$, $d = 0.63$, $r = 0.30$) and transportation activities ($P = 0.024$, $d = 0.82$, $r = 0.38$) were also higher in the EG in the 36th week of pregnancy.

None of the participants from either group required any pharmacological treatment during pregnancy. Final fasting and postprandial glucose values were measured between the 38th and the 40th weeks of pregnancy. While average fasting glucose level was lower in the EG, this was not significant ($P = 0.367$). However, when an average of 3 postprandial glucose levels was calculated, this was significantly lower in the EG, with a large effect size ($P < 0.001$, $d = 1.38$, $r = 0.57$) (Table 2).

Fasting glucose level positively correlated with body mass in the 30th and 36th weeks of pregnancy, ($r = 0.326$, $P = 0.46$; $r = 0.343$,

Table 1
Baseline characteristics for the experimental and control groups.

Variable	EG (N = 18)	CG (N = 20)	P
Maternal age (years; mean ± SD)	32.78 ± 3.83	31.95 ± 4.91	0.478
Body height (m; mean ± SD)	1.67 ± 0.07	1.68 ± 0.06	0.762
Pre-pregnancy body mass (kg; mean ± SD)	68.03 ± 13.65	71.60 ± 15.48	0.515
Pre-pregnancy BMI in (kg/m^2; mean ± SD)	24.39 ± 4.89	25.29 ± 4.65	0.515
Gestational age at diagnosis (week; mean ± SD)	22.44 ± 6.55	20.80 ± 6.05	0.409
Parity (mean ± SD)	0.72 ± 0.83	0.85 ± 0.99	0.806
75 g OGTT (mmol/L; mean ± SD)			
Fasting	5.20 ± 0.39	5.10 ± 0.38	0.515
1 h	9.62 ± 2.14	8.57 ± 2.21	0.219
2 h	7.29 ± 2.26	7.08 ± 1.67	0.696
Education			0.851
Secondary level (N; (%))	7 (38.89)	7 (35.00)	
Tertiary level (N; (%))	11 (61.11)	13 (65.00)	
Pre-pregnancy regular physical activity (N; (%))	9 (50.00)	15 (75.00)	0.196
Positive family history of diabetes mellitus (N; (%))	7 (38.89)	8 (40.00)	0.965
Total activity (MET-h × week^{-1}; mean ± SD)	158.22 ± 74.54	126.11 ± 44.63	0.128
Total activity of light intensity and above (≥1.5 METs) (MET-h × week^{-1}; mean ± SD)	133.06 ± 74.83	101.75 ± 43.40	0.108
By intensity of activity			
Sedentary (<1.5 METs) (MET-h × week^{-1}; mean ± SD)	25.16 ± 13.82	24.36 ± 17.09	0.696
Light (1.5–2.9 METs) (MET-h × week^{-1}; mean ± SD)	100.22 ± 46.40	78.44 ± 30.09	0.167
Moderate (3.0–5.9 METs) (MET-h × week^{-1}; mean ± SD)	32.69 ± 43.70	22.92 ± 22.35	0.696
Vigorous (≥6.0 METs) (MET-h × week^{-1}; mean ± SD)	0.17 ± 0.33	0.40 ± 0.76	0.478
By type of activity			
Household/caregiving (MET-h × week^{-1}; mean ± SD)	84.90 ± 71.59	63.58 ± 39.90	0.264
Occupational (MET-h × week^{-1}; mean ± SD)	19.41 ± 30.69	6.90 ± 21.25	0.085
Sport/exercise (MET-h × week^{-1}; mean ± SD)	3.15 ± 1.98	2.15 ± 2.18	0.061
Transportation activity (MET-h × week^{-1}; mean ± SD)	15.65 ± 6.08	17.86 ± 11.60	0.930
Inactivity (MET-h × week^{-1}; mean ± SD)	35.10 ± 16.90	35.61 ± 23.53	0.640

BMI – body mass index; CG – control group; EG – experimental group; MET – metabolic equivalent; N – sample size; OGTT – oral glucose tolerance test.

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Table 2
Glucose levels at the end of pregnancy.

Variable	EG (N = 18)			CG (N = 20)			P
	Mean ± SD	Min	Max	Mean ± SD	Min	Max	
Fasting glucose level (mmol/L)	4.32 ± 0.26	3.90	4.70	4.44 ± 0.46	3.60	5.30	0.367
Average of 3 postprandial glucose levels (mmol/L)	4.66 ± 0.46	3.67	5.60	5.30 ± 0.47	4.80	6.30	<0.001

CG – control group; EG – experimental group; max – maximum; min – minimum; N – sample size.

P = 0.035 respectively). Conversely, pre-pregnancy regular physical activity negatively correlated with fasting glucose level ($r_{pbi} = -0.429$, P = 0.007). There was a strong negative correlation between sport and exercise levels in the 30th and 36th weeks of pregnancy, (r = −0.527, P = 0.001; r = −0.537, P = 0.001 respectively) and a positive correlation between inactivity levels and postprandial glucose levels (r = 0.369, P = 0.023). We did not find any significant correlation between glycaemic parameters and: duration of intervention, adherence to protocol or the number of exercise sessions attended.

Complications in pregnancy were rare with none occurring in the EG. There were slight differences in body weight, body fat percentage and mass gain during specific time periods of pregnancy between the groups, but none were significant. No significant correlations were identified between mass gain and gain in body fat percentage, and: duration of intervention, adherence to protocol or number of exercise sessions attended.

While the EG had a slightly earlier onset of labour, there was no significant difference between the groups in the timing of birth, with all subjects giving birth between the 38th and 40th week of pregnancy. More labour inductions occurred in the CG, but without statistical significance. There were no significant differences between the groups in: the rates of prolonged labour, instrumental delivery or Cesarean section, Apgar score, neonatal body mass, neonatal length, ponderal index or the rate of neonatal complications (Table 3). There was a significant difference in neonatal body mass index, which was higher in the EG (P = 0.035, d = −0.76, r = −0.35). Percentage of exercise intensity negatively correlated with neonatal body mass (r = −0.481, P = 0.043) and body mass index (r = −0.469, P = 0.05).

4. Discussion

The purpose of this trial was to investigate the impact of a structured programme of aerobic and resistance exercises on the course and outcomes of gestational diabetes mellitus. To the best of our knowledge, this is the first study to investigate the effects of combining aerobic and resistance exercises in pregnant women with GDM, and also the first to investigate the effects of an individualised exercise programme of this type.

Physical activity became the cornerstone of health promotion and disease prevention, not only in the non-pregnant population, but also for pregnant women. All major guidelines on antenatal healthcare recommend exercise in pregnancy for women without contraindications. Furthermore, the American Diabetes Association[2] and ACOG[3] recommend exercise for women with GDM.

We were able to confirm our hypothesis regarding the parameters of glycaemic control, but only partially. Fasting glucose levels at the end of pregnancy – measured between the 38th and the 40th weeks – were lower in the EG, but the difference was not significant (P = 0.367). This result is similar to that achieved by Callaway et al.[27] who observed that fasting glucose levels were lower in their EG in the 28th week of pregnancy, but not in the 36th week. Our trial found that, conversely, when an average of 3 postprandial measurements was calculated, this was lower in the EG, with statistical significance and a large effect size (P < 0.001, d = 1.38, r = 0.57). This is in accordance with the results from another trial,[18] where overall postprandial glucose concentration was lower in the EG compared to the CG (P = 0.046). Likewise, a further four trials[12,15,17,20] previously reported a significant decrease in postprandial glucose levels following the implementation of their exercise interventions. It is likely that this is the outcome of improved peripheral insulin sensitivity resulting from regular exercise.

The average weight gain in pregnancy is quoted as being 12.5 kg[28] with a proposed target weight gain for healthy women with a normal body mass of between 11 and 16 kg. Overweight women should not gain more than 11 kg during pregnancy, and obese women not more than 9 kg.[29] Our EG would be classified as being in the normal weight category, with an average body mass index of 24.39 ± 4.89 kg/m^2. Our CG was slightly overweight (body mass index = 25.29 ± 4.65 kg/m^2), but the difference between the groups was not significant (P = 0.515). There were no differences in weight gain or fat mass gain during pregnancy between the pregnant women who participated in our structured exercise programme and those who received only standard antenatal care. De Barros et al.[16] also failed to detect any significant changes in body mass index at birth and body mass gained during pregnancy between the exercising and non-exercising groups. Conversely, Artal et al.[19] observed a decrease in the total body mass gained

Table 3
Obstetric and neonatal outcomes.

Variable	EG (N = 18) Mean ± SD	CG (N = 20) Mean ± SD	P
Week of birth	38.89 ± 0.90	39.45 ± 0.60	0.063
Prolonged labour (N (%))	1 (5.56)	2 (10)	0.633
Labour induction (N (%))	3 (11.11)	7 (35)	0.346
Instrumental delivery (N (%))	1 (5.56)	0 (0)	0.784
Caesarean section (N (%))	5 (27.78)	5 (25)	0.696
Apgar 1 min (mean ± SD)	9.89 ± 0.47	9.80 ± 0.70	0.828
Apgar 5 min (mean ± SD)	10 ± 0.00	10 ± 0.00	1.000
Neonatal hypoglycaemia (N(%))	0 (0)	0 (0)	1.000
Other neonatal complications (N(%)) (hyperbilirubinaemia)	0 (0)	1 (5)	0.806
Neonatal body mass (g)	3514.45 ± 413.57	3377.00 ± 494.27	0.393
Neonatal length (cm)	50.11 ± 2.25	50.25 ± 2.51	0.851
Neonatal PI (kg/m^3)	2.66 ± 0.63	2.65 ± 0.16	0.093
Neonatal BMI (kg/m^2)	13.96 ± 0.97	13.21 ± 1.01	0.035

BMI – body mass index; CG – control group; EG – experimental group; N – sample size; PI – ponderal index.

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($P < 0.01$) as well as in the average body mass gained per week ($P < 0.05$) in the EG.

No complications were encountered in the EG during pregnancy, and there were no significant differences between the groups. There were two cases of pregnancy-induced hypertension in the CG, one of which progressed to preeclampsia. The implementation of this exercise programme did not reduce the rate of complications during birth. We observed excellent Apgar scores in both groups. Exercise in pregnancy did not cause any adverse effects on the fetus or neonate, in accordance with previous findings.[30] There were no significant differences between the groups in neonatal weight, length and PI. Contrary to our expectations, however, neonatal body mass index was slightly higher in the experimental group ($P = 0.035$). Still, neonatal body mass in both groups was well within healthy limits. These findings are similar to those of previous trials where no significant difference was observed in neonatal body mass between exercising and non exercising women diagnosed with gestational diabetes mellitus.[13,14,16,19,20]

The main limitation of this study was the small sample size. According to the new criteria, however, there were no exact data on the prevalence of gestational diabetes mellitus in the Croatian population, preventing the calculation of an ideal sample size. It is, therefore, possible that the studied population is not representative of the general population affected by GDM. Participation in this trial was on a voluntary basis, thereby allowing the possibility for a selection bias towards those women with more awareness of their condition and those more committed to adhering to lifestyle changes. Another limitation of this study was the failure to track and analyse dietary intake. All participants, however, received the same medical nutrition intervention.

5. Conclusion

In conclusion, we successfully proved that the combination of aerobic and resistance exercises offers significant benefits for women with gestational diabetes mellitus. Specific guidelines for the optimal type, frequency, duration and intensity of exercise should be developed and incorporated into the general guidelines for the treatment of GDM.

Conflicts of interest

None.

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Author contributions

I. S. K. contributed to the study concept, protocol development, data collection, statistical analysis, and writing of the manuscript. M. I. contributed to the study concept, protocol development, data collection, and review and editing of the manuscript. G. B. and R. P. contributed to the study concept, protocol development, and review and editing of the manuscript. T. K. contributed to the protocol development, data collection, and editing of the manuscript. B. S. contributed to the protocol development, statistical analysis, and review of the manuscript. I. S. K. is the guarantor of this study, and as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. All authors have approved the final article.

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ORIGINAL ARTICLE

Guidelines for exercise during normal pregnancy and gestational diabetes: a review of international recommendations

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Abstract
Objective To summarize and present the main guidelines for exercise during normal pregnancy and pregnancy complicated by gestational diabetes mellitus (GDM).
Methods Relevant guidelines were retrieved through the electronic databases PubMed (MEDLINE), CENTRAL (Cochrane), and Embase; reference sections of the retrieved publications; proceedings of the main congresses in the field; and websites of relevant organizations published during the years 2000–2018.
Results All guidelines recommend aerobic training from 60 to 150 min/week, with an upper limit of 30 min/day. Exercise is safe, even on a daily basis. Resistance exercise is suggested by five national guidelines (Australia, Canada, Denmark, Norway, and the UK). Discrepancies exist regarding the recommended intensity of exercise. Canada, Japan, Spain, and the UK use both objective (heart rate and maximum oxygen consumption) and subjective criteria (Borg's Scale and talk test) to determine the effectiveness and safety of exercise. Only Canada provides specific recommendations, according to the woman's age and level of physical condition. Women with GDM on no insulin treatment do not need to take extra precautions during exercise. However, due to their condition of hyperglycemia, they must comply with the recommendation issued for type 2 diabetes. The prescription and supervision of exercise should be carried out in a similar way as for uncomplicated pregnancies. Finally, women with GDM on insulin treatment need to follow the same recommendations as for those for pregnant women with type 1 diabetes.
Conclusion Health professionals must be informed about the correct planning and execution of physical exercise programs so as to safely achieve the maximum effectiveness of exercise-induced health-related benefits in pregnant women.

Keywords Pregnancy · Guidelines · Physical exercise · Gestational diabetes mellitus

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Abbreviations

ACOG	American College of Obstetricians and Gynecologists
ACSM	American College of Sport Medicine
ADA	American Diabetes Association
APSS	Adult Pre-Exercise Screening System
BMI	Body mass index
bpm	Beats per minute
CSEP	Canadian Society for Exercise Physiology
ESSA	Exercise and Sport Science Australia
FITT	Frequency (F), intensity (I), time (T), and type (T)
GDM	Gestation diabetes mellitus
GLUT4	Glucose transporter type 4
HRR	Heart rate reserve
MET	Metabolic equivalent of task

NELIP	Nutrition and Exercise Lifestyle Intervention Program
PARmed-x	Physical Activity Readiness Medical Examination
SOGC	Society of Obstetricians and Gynecologists of Canada
VO_{2max}	Maximum consumption of oxygen

Introduction

Pregnancy is the ideal opportunity to adopt a healthy way of living if this has not been done previously. Measures, such as cessation of smoking, reduction of alcohol and caffeine intake, improvement of dietary habits, and physical exercise all contribute to both the improved health of the mother and optimal fetal development [1]. In addition, regular exercise is known to be beneficial for maternal and fetal health, preventing an excess the mother's body fat and the development of gestational diabetes mellitus (GDM) [2, 3]. Finally, weight loss via physical exercise may protect ovarian function by increasing insulin sensitivity and improving the hormonal profile [4, 5].

Exercise during gestation positively affects both the pregnant woman and the fetus. The main benefits for the pregnant woman include improvement of physical condition, control of body weight, shorter duration of labor, quicker recovery after childbirth, prevention of health conditions such as GDM, pregnancy-induced hypertension and pre-eclampsia, and reduced risks of premature birth [6]. A prospective cohort study (the Nurses' Health Study II, $n = 21{,}765$) showed that exercise before pregnancy is associated with a risk reduction in GDM; both intense exercise and moderate activity (e.g., brisk walking) result in similar risk reduction [7]. Furthermore, participation in any physical activity during the first 20 weeks of pregnancy leads to 50% risk reduction in GDM [8].

Studies have demonstrated psychological benefits for the pregnant woman who adopts an exercise program, such as reduction of anxiety and depression, as well as an improved sense of well-being [9]. An essential fact that concerns long-term health is that women who systematically exercise during pregnancy have a 75% higher probability of continuing exercise after delivery [10].

Concerning the fetus, because regular exercise reduces the mother's body fat, this enhances the transfer of oxygen and reduces the diffusion of carbon dioxide through the placenta, thus having a positive impact on fetal development [11]. Exercise during pregnancy improves the resistance of the fetal arteries and reduces the risk for heart conditions during later life [12]. In addition, sounds and vibrational stimuli accompanying exercise can accelerate the development of the fetal brain. There is evidence that offspring of mothers who exercised during pregnancy score higher in IQ tests and exhibit higher verbal abilities at the ages of 1 and 5 years [13].

All international organizations recommend exercise during pregnancy, provided there are no complications during the gestational period [11, 14–20]. However, despite these recommendations, the majority of pregnant women do not exercise, explaining that they are not in the right mood or feel a sense of tiredness and discomfort during pregnancy [16]. However, a primary factor in women's reluctance to exercise during pregnancy is a lack of incentives and encouragement on the part of health professionals. Only a minority of women mentioned that their physicians suggested they should participate in regular exercise programs [21]. Possible reasons for this oversight is the lack of proper education in this respect among physicians, the structure of health systems that does not allow such practices, outdated beliefs that exercise during pregnancy may be harmful, and the fact that women's level of physical condition is often less than optimal at the beginning of pregnancy [1].

In the USA and Norway, 56 and 59% of pregnant women, respectively, exercise; in Canada, this percentage is as much as 85%. On the other hand, in the USA and Canada, although women do exercise, only 23% of them actually follow the suggested guidelines, while in Norway, the rate is also low, at 28%. In Greece, this proportion is much smaller. In a study conducted at the University of Crete, 21.5% of women exercise before pregnancy, but only 6.2% continue to exercise during pregnancy. In addition, 71.4% of these women prefer walking and 18.6% joined a non-intensive program of aerobic exercise [19]. The percentage of Greek women who exercise according to guidelines is not known. Giving women an appropriate exercise prescription can encourage them to participate in physical activity safely and efficiently throughout pregnancy and thus, in addition to many other benefits, to prevent and/or manage gestational diabetes mellitus (GDM) [2, 3].

In order to rectify this situation, it is necessary to improve the education of health professionals and physical education experts so that the considerable benefits of exercising during pregnancy may be communicated to all mothers-to-be [1, 15]. This study aims to review and critically appraise the exercise guidelines for pregnant women (issued by the international scientific organizations) with or without GDM.

Methods

Relevant guidelines were retrieved through the electronic databases PubMed (MEDLINE), CENTRAL (Cochrane), and Embase; the reference sections of the retrieved publications; the proceedings of the main congresses in the field; and the websites of relevant organizations, published during the years 2000–2018. The following terms and their combinations were used: pregnancy, guidelines, physical exercise, and gestational diabetes mellitus.

Historical aspects

The first guidelines for exercise during pregnancy were published in 1985 by the American College of Obstetricians and Gynecologists (ACOG); they were very conservative and based on the lowest common denominator of physical activity among the general population, as reported in 1978 by the American College of Sports Medicine (ACSM). Since then, a general upper limit of exercise intensity at 140 beats per minute (bpm) has been set for optimal safety. The exercise intensity of this guideline, which was never adequately supported by evidence, was commonly adopted among those who were involved in exercise during pregnancy. At that time, exercise was considered safe only for women who had been engaged in physical activities before pregnancy, while women who were not engaged in such activities could participate in very light activities [22].

The updated ACOG guidelines in 1994 stated that it was not necessary to record heart rate, the upper limit of heart rate being at that time based on the woman's subjective sense of tiredness and subjective obstetric symptoms [22]. After 2002, exercise guidelines were published by at least 11 international organizations based in nine countries. These guidelines have several dissimilarities, especially in the evaluation of exercise intensity. Nevertheless, all of them agree that it is appropriate for pregnant women to participate for at least 30 min, during most of the days of the week, in an aerobic exercise program and resistance training of medium intensity. Supplementary Table 1 illustrates the most important guidelines for exercise during pregnancy issued by the international organizations.

Precautions before starting an exercise program

Introductory facts

Before a woman starts a systematic exercise program, a full checkup must be performed to determine possible medical or obstetric contraindications [16]. The exercise must be adjusted to the needs of the pregnancy and personalized according to the needs of each woman. Useful tools for the prescription of exercise are questionnaires, filled in by the pregnant woman, physician, midwife, and trainer, such as the Adult Pre-Exercise Screening System (APSS) and the Physical Activity Readiness Medical Examination for Pregnancy (PARmed-x for Pregnancy), which are recommended by the Canadian Society for Exercise Physiology (CSEP). The questionnaires collect useful information on the woman's medical record before and during pregnancy, her level of physical condition, and her daily activities and obligations. This information makes the planning of the program more well-grounded (Table 1) [15].

Safety

For the pregnant woman, as for any individual, exercise constitutes any physical activity that stimulates, balances, and strengthens a number of bodily functions, thereby conferring health and physical fitness. However, when the stress of exercise rises above the optimum level due to extreme environmental conditions, such as temperature, humidity, and altitude, certain safety measures must be adopted, as summarized below.

Table 1 General instructions for designing prenatal exercise programs

It is advisable to include the following activities:	It is advisable to avoid the following activities:
• Gradual warm-ups and cooldowns to enhance circulation and prevent blood pooling • General muscle strengthening, focusing on muscles such as pelvic floor and core • Modified programs of muscle strengthening • Modification of exercises from the supine or standing position, such as "four-point kneeling," sitting on a fitness ball, and lying on one side • Flexibility training, limited to a comfortable range of movement • Relaxation • Exercises for labor preparation • Appropriate, low-impact exercises • Modified exercise programs, to avoid overheating • In the case of pregnancy-related musculoskeletal conditions, exercises must not deteriorate the condition	• Exercises of high intensity, requiring sudden or throwing movements • Exercises whose intensity or duration make the woman feel hot, exhausted, or excessively sweaty • Sudden changes in intensity and/or position • Any exercise that requires breath-holding or the Valsalva maneuver • Any exercise that places a significant load on the abdominal or pelvic floor muscles, including abdominal curls, sit-ups, planks, and hovers • Stretching beyond a comfortable range of movement, due to increased ligament laxity caused by hormonal changes • Weight lifting, beyond a comfortable range of movement • Exercises requiring supine position, after the 16th week of pregnancy • Exercises requiring prolonged standing, especially in combination with upper body muscle strengthening (increased risk off fainting) • Sports requiring physical contact, to minimize the risk of falls and blows to the abdomen • Any exercise that may cause or worsen any pregnancy-related condition

Source: [15] (modified)

Temperature–humidity The international organizations propose that pregnant women should not exercise in temperatures that are high or too low or in conditions of high humidity [9].

Altitude The guidelines of the CSEP suggest that exercise is safe between 1800 and 2500 m altitude. The ACOG states that exercise is safe at an altitude up to 1800 m, but care is needed at higher altitudes. Women should be aware of any symptoms that might cause them to interrupt exercise, as well as signs of altitude sickness. The Norwegian and British guidelines specify that 4–5 days are required to become accustomed to altitudes above 2500 m. The general view is that it is better to avoid exercise at such altitudes [23, 24].

Depth The guidelines provide strict warnings concerning diving during pregnancy and the risk of embolism under water caused by trapped bubbles. The fetus is not protected by decompression procedures, given that the fetal pulmonary circulation cannot filter the formation of bubbles [11, 20, 25–29].

Other parameters Warm-up and recovery periods should never be absent from any training unit or any exercise program. Pregnant women should exercise wearing light and comfortable clothing and footwear. The Japanese guidelines recommend exercising between 10:00 and 14:00 since fewer uterine contractions occur between these hours [24].

Posture–position The supine position during pregnancy results in decreased heart rate due to the pressure of the uterus on the inferior vena cava, which can, very frequently, cause supine hypotensive syndrome [11, 23, 25, 27]. It is thus recommended that exercise in the supine position should be avoided after the first trimester and that such positions as lying sideways, sitting (recommended by the Danish guidelines [29]), or standing should be preferred [20], especially during resistance exercise.

Contraindications

Absolute and relative contraindications for aerobic exercise during pregnancy according to the ACOG are presented in Supplementary Table 2. Reasons for terminating exercise during pregnancy are shown in Supplementary Table 3.

Actions after the beginning of an exercise program

Introductory facts

According to the Canadian guidelines, the prescription for an exercise program should be made by adopting the "FITT" principle, an acronym standing for frequency (F), intensity (I), time (T), and type (T), parameters that define an exercise program, while underscoring the concept of "fitness" [20].

Frequency and time

The Canadian and UK guidelines suggest 15 min of exercise, three times a week, and a progressive increase of the duration to 30 min; frequency should be set at four times a week, even if the intensity is reduced. The guidelines from Denmark [29] and Norway [23, 24], as well as those of the ACOG, recommend that pregnant women exercise daily for at least 30 min at average intensity. The guidelines from Japan recommend aerobic exercise, to be done for over 60 min two to three times a week [27], while the guidelines from Spain recommend exercise two to three times a week, without, however, specifying the duration [29]. In summary, a frequency of two to four times a week and exercise duration of 30 min is, overall, considered to be efficacious and safe.

Intensity

Intensity constitutes the most difficult but most important parameter to consider when designing an exercise program for pregnancy. In general, intensity during a normal pregnancy does not need to be different from that for a non-pregnant state: the ACSM guidelines on physical condition can be followed: fast walking at 3–4 metabolic equivalent of task (MET) [14].

There is evidence that 16–28 MET exercising per week at a 60% intensity of heart rate reserve (HRR) reduces the risk of gestational diabetes and, possibly, pregnancy-induced hypertension and pre-eclampsia. A 28-MET per-week exercise program is equivalent to walking at a speed of 3.2 km/h for 11.2 h per week [30].

According to the ACOG, exercise at 60–70% of HRR or 50–60% of maximum consumption of oxygen (VO_{2max}) is safe for most pregnant women. Women who were physically active before pregnancy can safely exercise at the highest levels of these values [16]. In a meta-analysis of high-intensity programs (81% of HRR), no complications were observed in the mother or the fetus [31]. Regarding exercise intensity, the Canadian and Norwegian guidelines recommend physical activities of high intensity and competitiveness, while the Australian guidelines advise very close observation by a physician [32].

Given the variability of heart rate during pregnancy, the ACOG does not consider it necessary to record the heart rate of pregnant women on an exercise program. Intensity can be regulated by the Borg Scale, a frequently used quantitative measure of perceived exertion during physical activity and exercise (desired levels 12–14, light to hard), or by the "talk test." The latter was developed as an informal, subjective method of estimating appropriate cardiorespiratory exercise intensity. The method entails maintaining an intensity of exercise at which conversation is comfortable and not affected or limited by deep and frequent breaths necessary to meet the oxygen demands of working muscles [33].

Table 2 summarizes the recommendations of the international organizations regarding exercise intensity during pregnancy. The CSEP is the only one that provides detailed recommendations about heart rate, based on the pregnant woman's age, level of physical condition, and BMI (Table 3) [34, 35].

Type

Both aerobic and resistance exercises are considered safe and do not exert any adverse effects during pregnancy [16].

Resistance exercise Data on resistance exercise is scarce. To prevent high blood pressure, it is generally suggested that isometric exercises should be avoided as well as exercises with heavy weights and numerous repetitions [16]. The Norwegian guidelines strictly warn against exercises with heavy loads. The Canadian guidelines suggest exercises with light weights and more repetitions and avoidance of exercises that require the supine position and holding one's breath with techniques such as the Valsalva maneuver. An interventional resistance program (1 set, 12 repetitions, several muscle groups, gestational week 28–38) reported that the fetal heart rate was not affected [36].

Stretching exercise Since during pregnancy hormonal changes cause considerable loosening or laxity of the ligaments, care must be taken with regard to stretching exercises. The latter should be practiced daily but must be personalized according to the needs and abilities of each woman while maintaining a wide range of movements [36].

Table 3 Target heart rate zones during pregnancy, based on age, fitness level, and BMI

Age (years)	20–29	30–39
BMI < 25 kg/m^2		
Unfit	129–144	128–144
Active	140–155	130–145
Fit	145–160	140–156
BMI ≥ 25 kg/m^2	102–124	101–120

Heart rate is expressed in beats per minute (bpm); source: [20] modified

BMI, body mass index

Aerobic exercise Every exercise that mobilizes large muscle groups in one continuous, rhythmic movement can be considered aerobic exercise. Characteristic examples are walking, running, jogging, dancing, swimming, bicycling, rowing, skiing, skating, and climbing [36]. Aerobic exercise is safe during pregnancy, but pregnant women must avoid sports requiring physical contact between players to minimize the risk of falls and blows to the abdomen [15].

Walking is one of the safest and most popular kinds of aerobic exercise during pregnancy and is the only form of exercise that does not need to be reduced during this period. In fact, during the third trimester, it can be increased as it helps to maintain and improve aerobic abilities without having any negative impact on the pregnant woman or her fetus [37].

Exercise in water is considered safe during pregnancy. Due to buoyancy, any musculoskeletal burdens due to weight gain are considerably decreased. Care must be taken as to the cleanliness and the temperature of the water, which should not be above 32 °C. In the case of a swimming pool, pregnant women should move slowly from the deep to the shallow end before coming out to avoid a sudden drop in blood pressure [19].

Table 2 Evaluation methods of exercise intensity during pregnancy, according to organizations' guidelines

Country	Methods				
	Heart Rate	MET	VO_{2max}	Borg's Scale	Talk test
Canada	Target heart rate zones			√	√
Japan	≥ 150 beats/min				
Spain	≥ 140 beats/min		50%		
UK	Fit 60–90% HRmax Active 60–70% HRmax			√	√
Norway			70–75%	√	√
France					
USA (ACOG)		16–28		√	√
USA (ACSM)	13–33% of HRR			√	
Australia				√	

Sources: [10, 11, 15, 20, 24–29] modified

ACOG, The American College of Obstetricians–Gynecologists; *ACSM*, American College of Exercise Medicine; *HRmax*, maximum heart rate; *HRR*, heart rate reserve; *MET*, metabolic energy equivalents; *VO_{2max}*, maximum oxygen consumption

Synthesis of guidelines

- All organizations agree that approval of the physician in charge is a prerequisite for a pregnant woman intending to start an exercise program.
- All organizations agree that activities involving physical contact with other players, risk of falling, risk of injury, and sports at high altitude, or such water sports as diving should be avoided during pregnancy.
- Clinical organizations emphasize that pregnant women should be informed about warning signs that will alert them to abandon exercising promptly.
- Adequate information on the recommended exercise program during pregnancy is vital. Women who are correctly informed have greater chances of continuing exercising after pregnancy.
- All organizations suggest aerobic training from 60 to 150 min/week, with an upper limit of 30 min/day (type of exercise). This type of exercise is safe, even on a daily basis (frequency of exercise). Resistance exercise is recommended by five organizations (Australia, Canada, Denmark, Norway, and the UK).
- Differences exist among organizations regarding the advised intensity of exercise. Canada, Japan, Spain, and the UK use objective (heart rate, maximum oxygen consumption) and subjective criteria (Borg's Scale, talk test) to determine the effectiveness and safety of exercise. Only Canada provides specific recommendations, taking into consideration the individual's age and level of physical condition. By contrast, the USA, Australia, France, and Denmark do not apply objective criteria to define the intensity of exercise.
- Exercise during pregnancy should be adapted to the needs of the pregnancy and be personalized to the needs of each woman. For this to be achieved, a holistic approach is required by different health professionals (physician, midwife, nutritionist, trainer, and psychologist).
- A series of questionnaires, such as the PARmed-x, constitute valuable tools in the design of the exercise program for all those involved, including health professionals and the pregnant woman herself [39].

Exercise in pregnancies complicated with gestational diabetes mellitus

General recommendations

GDM is an endocrine disorder that complicates approximately 16% of all pregnancies, with adverse consequences for the pregnant woman, the fetus, and the neonate [40]. Exercise, along with pharmaceutical and nutritional intervention, can play a vital role in the management of GDM. However, there are very few recommendations concerning efficacious and safe physical exercise programs for women whose pregnancy has been complicated by GDM [41, 43].

As a general consideration, women with GDM need to take extra precautions during exercise. That is, because of their high blood sugar levels (hyperglycemia), they must comply with the recommendation issued for women with type 2 diabetes [41]. The prescription and supervision of exercise should be carried out according to the principles outlined above, as is the case for pregnant women without complications. The physician in charge must assess the woman's capacity to exercise [41, 42].

Better pregnancy outcomes in the setting of GDM may be expected when exercise has been started before pregnancy as compared with exercise started during pregnancy [30]. Nevertheless, with the exception of very few contraindications, it is safe to start exercise for the first time during pregnancy [44, 45]. In women with GDM with coexisting obesity, high-intensity exercise can reduce the chances of excessive weight gain [44, 45]. In addition, the position statement of the American Diabetes Association is that GDM should first be managed with diet and exercise, with medication being administered afterwards if needed [2, 3].

Exercise training parameters

Frequency and duration Regarding the frequency and duration of exercise, both the Society of Obstetricians and Gynecologists of Canada (SOGC) and the CSEP suggest that pregnant women with GDM should follow the same guidelines as other pregnant women [20]. Exercise at a frequency of three to four times a week, with a 50% intensity of VO_{2max}, totaling 45 min with 5-min breaks every 15 min is considered safe and effective [45].

Regarding the frequency of aerobic exercise, the ACSM and ESSA (Exercise and Sports Science Australia) suggest that exercising should not exceed two consecutive days due to the temporary improvement in insulin action and passive glucose uptake after exercise for up to 48 h. Regarding resistance exercise, the ACSM and ESSA recommend at least two training sessions per week and, ideally, three on non-consecutive days. Each training session should include 5–10 (ACSM) or 8–10 (ESSA) exercises involving major muscle groups (upper, lower, and core), 10–15 (ACSM) or 8–10 repetitions (ESSA), and one (ACSM) or two (ESSA) sets [11, 14, 15, 20, 32, 41, 46].

Intensity Exercise intensity should be carefully adapted for women using insulin. Overweight or obese women with GDM should follow the target heart rate guidelines for overweight and obese pregnant women without GDM [20].

The ACSM proposes that overweight and obese pregnant women could take part in aerobic exercise programs at 20 to 39% of the reserve aerobic capacity (VO_2 reserve) [47]. These rates of VO_2 reserve correspond to 102 to 124 b/min for ages 20–29 years and 101 to 120 b/min for ages 30–39 years [34].

Table 4 Exercise recommendations for GDM

	Aerobic	Resistance	Flexibility–balance
Frequency	3–4 times/week	At least 2	2–3/week
Intensity	50–60% VO_{2max}	12–13 Borg's Scale	Stretch till slight discomfort Balance workout light to moderate
Time	45 min with 5-min breaks every 15 min	ACSM 5–10 exercises 10–15 repetitions (1 set) ESSA 8–10 exercises 8–10 repetitions (2 sets)	Stretch 10–30 s, 2–4 repetitions/exercise
Type	Walking, jogging, running, elliptical machine, cycling, swimming, aqua-aerobics	Sitting position exercises, pilates, yoga, exercises with free weights, elastic band exercises, weight-bearing exercises	Yoga, pilates, tai chi, dynamic stretch, static stretch

Sources: [3, 11, 14, 15, 20] modified

ACSM, American College of Exercise Medicine; *ESSA*, Exercise and Sport Science Australia

Low-intensity aerobic exercise seems to have a better effect on glucose control than moderate-intensity aerobic exercise. More specifically, studies performed at < 60% of VO_{2max} have shown favorable effects on glucose control and prevention of insulin use [34, 48, 49]. In contrast, aerobic exercise at 70% of VO_{2max} showed fewer desirable results [50]. Indeed, when two different intensities of aerobic exercise were compared at 30% and 70% of HRR on a static bike with women at a low risk of developing GDM, during the last trimester of pregnancy, the biopsies of the vastus lateralis muscle showed that glucose transporter 4 (GLUT4) increased in women who performed exercise at low intensity as compared with those who exercised at moderate intensity.

Even better results were recorded when aerobic exercise was combined with nutritional intervention. In the Nutrition and Exercise Lifestyle Intervention Program (NELIP), exercise was carried out at walking intensity (30% of HRR) combined with a nutritional intervention of 8350 kJ/day and 200 g of carbohydrate/day [51]. Women at high risk of developing GDM maintained the same insulin sensitivity as compared to those at low risk, while none of them developed GDM [52]. Overweight women at high risk of developing GDM who followed the NELIP program from the 16th week of pregnancy had HbA_{1c} levels well below the range of diabetes. Table 4 illustrates the most important exercise guidelines issued by the international organizations for GDM [53].

Type Most pregnant women with or without GDM can safely participate in moderate-to-intense sports. They can engage in bodyweight activities, such as walking, jogging, and running, and use of functional and fixed machines, such as elliptical trainers, but also in non-bodyweight transfers, such as cycling,

Table 5 Suggested carbohydrate intake or other actions based on blood glucose levels at the start of exercise

Pre-exercise blood glucose	Carbohydrate intake or other actions
< 90 mg/dl (< 5.0 mmol/l)	• Ingest 15–30 g of fast-acting carbohydrate before the start of exercise, depending on the size of the individual and intended activity; some activities that are brief (< 30 min) or at a very high intensity (weight training, interval training) may not require any additional carbohydrate intake. • For prolonged activities at moderate intensity, consume additional carbohydrate, as needed (0.5–1.0 g/kg body mass/h of exercise), based on blood glucose testing results.
90–150 mg/dl (5.0–8.3 mmol/l)	• Start consuming carbohydrate at the onset of most exercise (0.5–1.0 g/kg body mass/h of exercise), depending on the type of exercise and the amount of active insulin.
150–250 mg/dl (8.3–13.9 mmol/l)	• Initiate exercise and delay consumption of carbohydrate until blood glucose concentrations are < 150 mg/dl (< 8.3 mmol/l)
250–350 mg/dl (13.9–19.4 mmol/l)	• Test for ketones. Do not perform any exercise if moderate-to-large amounts of ketones are present. • Initiate mild-to-moderate intensity exercise. Intense exercise should be delayed until glucose concentrations are < 250 mg/dl. Intense exercise may exaggerate the hyperglycemia.
≥ 350 mg/dl (≥ 19.4 mmol/l)	• Test for ketones. Do not perform any exercise if moderate-to-large amounts of ketones are present. • If ketones are negative (or trace), consider conservative insulin correction (e.g., 50% correction) before exercise, depending on active insulin status. • Initiate mild-to-moderate exercise and avoid intense exercise until glucose concentrations decrease.

Source: [2]

swimming, aqua-aerobics, sitting position exercises, or rowing [48]. Resistance exercise is considered a safe and effective option for women with GDM, as it can reduce the need for exogenous insulin delivery and control hyperglycemia. Even after the diagnosis of GDM, aerobic or resistance exercise can help to improve insulin action.

Specific recommendations

Pregnant women who are treated for insulin should be aware of the effects of exercise, which may increase insulin sensitivity and induce hypoglycemia, particularly during the first trimester [54]. Given the lack of large cohort studies on exercise in the management of GDM, women with this condition, and especially those on insulin therapy, should follow the same recommendations as those for pregnant women with type 1 diabetes, even though the responses are likely to be different. Table 5 provides practical suggestions that women with GDM need to follow.

Summary of recommendations

Due to their lack of knowledge as to the risks and benefits of exercise, most women tend to avoid exercise during pregnancy. However, under appropriate supervision, exercise regulates glucose levels, increases insulin sensitivity, and is both safe and beneficial for the treatment of GDM. According to the ADA, GDM should be managed first with exercise and diet, and medications should only be added if needed [44]. It is vital that exercise be integrated into the overall treatment plan. It is essential to promote research in the field of exercise for women with GDM and develop guidelines based on the research results [11, 14, 20, 32, 40].

Conclusion

All scientific organizations strongly support the involvement of pregnant women in regular exercise programs. Recent studies have reported the multiple benefits of exercise during pregnancy for both the mother and the fetus/newborn. Exercise during pregnancy with or without GDM is safe when the required precautions are taken into consideration and should be prescribed according to the international guidelines to achieve the maximum effectiveness and benefit of the exercise-induced, health-related adaptations.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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Title: Acute responses to structured aerobic and resistance exercise in women with gestational diabetes mellitus

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Abstract
Research on the acute responses to exercise in pregnancy is scarce, especially for women affected by gestational diabetes mellitus (GDM). The aim of this study was to investigate responses to a single bout of exercise performed multiple times throughout the pregnacy in women diagnosed with GDM. Data from 18 pregnant women (aged: 32.8 ± 3.8) diagnosed

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with GDM, treated with diet only, were analysed. Participants' pre-pregnancy body mass index was 24.4 ± 4.9 kg/m^2, 50% of them were nullipaorus, and 50% of the sample regularly exercised before the pregnany. The exercise intervention consisted of an individual structured aerobic and resistance exercise program performed twice per week from the time of diagnosis until at least the 36^{th} week of pregnancy. The exercise program included 20 minutes of aerobic exercise, 20-25 minutes of resistance exercise, and 10 minutes of cool down. Maternal heart rate, systolic and diastolic blood pressure, temperature and fetal heart rate were measured at every exercise session, along with blood glucose on three occasions. In total, 365 exercise sessions were analysed (85 in the 2^{nd} trimester and 280 in the 3^{rd} trimester), on average 20.3 ± 7.7 per participant. Heart rate and fetal heart rate were elevated during both the aerobic and resistance parts of the exercise session ($p<0.01$) in comparison to the baseline while systolic and diastolic blood pressure did not change in the total sample. There was a slight elevation in tympanic membrane temperature during the aerobic part of the session ($p<0.01$). All parameters returned to baseline levels by the end of the session. Glucose levels dropped from the baseline, from 4.7 ± 0.6 to 3.9 ± 0.4 mmol/L ($p<0.01$). There were no differences in responses to exercise between the 2^{nd} and 3^{rd} trimesters, nor between pre-pregnancy exercisers and non-exercisers. The combination of aerobic and resistance exercise for women diagnosed with GDM does not have harmful short-term effects if performed according to guidelines. Likewise, exercise can be considered useful for controlling hyperglycemia in pregnancy for women affected by GDM.

Keywords: pregnancy, exertion, heart rate, blood pressure, temperature, glucose

Introduction

Moderate-intensity exercise lasting at least 20-30 minutes per day on most or all days of the week is recommended to all pregnant women without contraindications to exercise[1]. Despite the challenges of exercising during pregnancy, reports from the literature have confirmed the safety of moderate-intensity exercise in pregnancy for both the mother and the fetus[2].

Gestational diabetes mellitus (GDM) is defined as any carbohydrate intolerance first diagnosed during pregnancy[3]. The primary therapeutic strategies are diet and lifestyle changes, supplemented by pharmacological treatment if necessary. It is also recommended to continue or initiate moderate-intensity exercise[4,5]. Recent meta-analyses[6,7] on the effects of diet and exercise interventions in pregnancy reported on benefits in reducing gestational weight gain and GDM. Furthermore, exercise interventions in pregnant women diagnosed with GDM are associated with reduced fasting and postprandial blood glucose concentration[8]. However, available data on the effects of exercise on GDM are still limited, including the acute effects of exercise on the wellbeing of pregnant women and their fetuses.

Randomized controlled trials to determine the optimal frequency, intensity, type and duration of exercise during pregnancy for women with GDM are yet to be conducted in order to determine an optimal exercise regime to obtain both long-term and short-term results. Aerobic and resistance exercises, especially in combination, had beneficial effects in patients with type 2 diabetes but this is yet to be investigated in the pregnant population affected by GDM[9].

Research into the acute effects of exercise on parameters such as body temperature, maternal and fetal hemodynamic responses, and blood glucose levels is scarce, especially for specific populations of pregnant women such as those affected by GDM. Data on body temperature changes during exercise is limited, but guidelines still advise caution regarding overheating[1]. This is despite it being shown in previous trials that moderate-intensity exercise did not cause dangerous levels of overheating[10-13]. Data on maternal and fetal hemodynamic responses regarding maternal heart rate (HR), fetal heart rate (FHR), and maternal systolic and diastolic blood pressure is also scarce, and conflicting, and almost non-existent for women affected by GDM. Previous research has shown that maternal blood pressure levels slightly increased during aerobic and resistance exercise, but remained within safe limits[13,14]. It is also suggested that prolonged exercise lasting in excess of 45 minutes can lead to hypoglycemia[11] with previous trials confirming a decline in blood glucose levels in women with GDM after exercise[15,16]. Previous reports consistently demonstrate that maternal exercise increases FHR but without harm to the fetus[17-19].

The aim of this study was to investigate acute maternal and fetal responses (HR, FHR, systolic and diastolic blood pressure, body temperature and glucose level) to a single session of exercise performed multiple times throughout pregnacy in women diagnosed with GDM. We also investigated whether there are any differences in acute responses between pre-pregnancy exercisers and non-exercisers. Furthermore, we compared acute responses to exercise sessions during the 2nd and 3rd trimesters of pregnancy in the subgroup of participants who attended exercise sessions in both trimesters of pregnancy. The secondary aim was to confirm the safety of the exercise regime. To the best of our knowledge, a study of this type has never been performed in this population of pregnant women.

Materials and methods

The study was designed as a secondary analysis of the data from a randomized controlled trial on the effects of a structured aerobic and resistance exercise program on the course and outcomes of GDM, registered with Clinicaltrials.gov (NCT 02196571). Participants gave their written informed consent and ethical approval was obtained from the University Hospital Centre Zagreb and the University Hospital Merkur, Zagreb, Croatia where pregnant women were recruited. The trial was conducted between July 2014 and January 2015. The inclusion criteria were: an established diagnosis of GDM and age between 20 and 40 years. The exclusion criteria were: diabetes diagnosed before pregnancy, pharmacological treatment for GDM, existing comorbidities and contraindications for exercise according to the American College of Obstetricians and Gynecologists[20]. Pregnant women included in the trial were randomized to either the control group, treated with medical nutrition therapy and lifestyle change, or the experimental group, which also included regular supervised exercise sessions. For the purpose of this study we used only the data gathered from the experimental group in the original trial.

Baseline information was taken at the initial interview and included demographic data, medical and obstetric history, pre-pregnancy regular exercise, body height, body mass, and body mass index, both at the start of the pregnancy and at the time of inclusion in the study. The Pregnancy Physical Activity Questionnaire[21] was used to assess physical activity levels at the time of inclusion in the study.

The exercise intervention consisted of an individual supervised structured aerobic and resistance exercise program performed twice per week, which started within one week from an established diagnosis of GDM and continued until at least the 36th week of pregnancy. It was developed according to official guidelines at that time[20]. Each exercise session consisted of aerobic exercise (20 minutes) performed on a treadmill (Axos Runner, Heinz Kettler GmbH, Ense-Parsit, Germany), resistance exercises (20-25 minutes), pelvic floor and stretching exercises and a short period of relaxation at the end of the session (10 minutes). Aerobic and resistance exercises aimed to reach target values of 13-14 on the Borg Rating of Perceived Exertion scale[22] and 65-75% of maximum HR. Target HR was calculated using

Karvonen's formula[23] and maximum HR was determined using the formula 220 – age. All exercise sessions were held indoors. The room was air-conditioned to 20-22˚C, and relative humidity was kept at 40-60%. The pregnant women wore standard sports clothing in which they felt comfortable, and sports footwear.

The aerobic part of the exercise session started with a warm-up lasting 5 minutes performed on the treadmill. After that, the women were able to adjust the velocity and incline of the treadmill, with the purpose of achieving the target intensity. Resistance exercises were performed to the same target intensity. Six different exercises, involving all major muscle groups, were performed in three sets of 10-15 repetitions in each set. Three resistance exercise protocols were developed and interchanged between exercise sessions, including exercises for the trunk, and upper and lower extremity muscles. Resistance exercises were performed using body weight, hand held weights of 0.5 and 1 kg (Aerobic Dumbbels, Heinz Kettler GmbH, Ense-Parsit, Germany) and elastic bands (TheraBand, The Hygenic Corporation, Akron, OH, USA).

The primary outcomes measured were maternal and fetal HR (beats per minute), systolic and diastolic blood pressure (mmHg), and tympanic membrane temperature (°C). Maternal HR was measured continuously (Mio Alpha, Mio Global, Vancouver, BC, Canada) during the exercise session. Baseline rate, average rate during the aerobic and resistance parts of the session, and rate at the end of the session were recorded. Fetal heart rate, maternal tympanic membrane temperature, and blood pressure were measured at baseline and immediately after the aerobic and resistance parts of the session. All outcomes were measured at every exercise session. Measurements before the start and at the end of the exercise session were taken at least 5 minutes before and after the session, respectively.

Blood pressure was measured using a mercury sphygmomanometer (Erkameter 300, ERKA, Kallmeyer Medizintechnik, Bad Tölz, Germany) using the first and fifth Korotkoff sound to identify systolic and diastolic values, respectively. Tympanic membrane temperature was measured with an infrared ear thermometer (ThermoScan 6023, Braun GmbH, Kronberg, Germany). Fetal heart rate was measured using an ultrasound device with doppler effect (MAS Baby Watcher, MAS Future Medical GmbH, Leibnitz, Austria).

Glucose and lactate levels (mmol/L) from capillary blood samples were also measured for every participant before the exercise session and at the end of the resistance exercises, three and two times, respectively during the study. Analysis was performed using a reliable and valid hand held device (Accutrend Plus, Roche Diagnostics, Basel, Switzerland) and test strips (Accutrend Glucose and BM-Lactate, Roche Diagnostics, Basel, Switzerland). All equipment was used and measurements taken according to the manufacturer's instructions. Measurements were taken in the sitting position.

Statistical methods

All statistical analyses were performed using SPSS 19.0 (IBM, Armonk, NY, USA). Descriptive statistics were used for baseline demographics which included age, parity, body mass index before pregnancy and at the time of inclusion in the study, oral glucose tolerance test results, and physical activity level. All data is presented as mean ± standard deviation. The Shapiro-Wilk test was performed to check for normality of data. The paired-samples t-test was used to perform pairwise comparisons between baseline parameters and parameters during or after aerobic and resistance parts of the session, as well as parameters at the end of the session for all data with a normal distribution. Wilcoxon signed-rank test was used for data without a normal distribution. All parameters were compared for the total duration of the intervention, and separately for the 2nd and 3rd trimesters of pregnacy. The same tests were also used to compare parameters from the 2nd and 3rd trimesters of pregnancy for the subgroup of women who exercised throughout the 2nd and 3rd trimesters. The independent samples t- test was used to compare the subgroups of pre-pregnancy exercisers and non-exercisers, and Mann Whitney test for non normal data. Confidence intervals (95% CI) were presented. The level of significance was set at $p < 0.05$.

Results

Eighteen women took part in the study and a total of 365 exercise sessions were performed. Participants' baseline characteristics are shown in Table 1. The average number of performed exercise sessions was 20.3 ± 7.7 per participant. The minimum number of exercise sessions per participant was 12, and the maximum 34. The average number of training sessions in the 2nd trimester was 4.7 ± 7.3, and in the 3rd trimester was 15.6 ± 3 per participant. The total number of analysed training sessions in the 2nd trimester was 85, and in the 3rd trimester was 280. Half of the participants (n = 9) in the study exercised throughout the 2nd and 3rd

trimesters of pregnancy and performed 85 training sessions in the 2nd trimester, and 151 in the 3rd trimester. The other half of the participants (n = 9) exercised only in the 3rd trimester.

The average intensity for both parts of the exercise session was 65.1 ± 4.4% of the maximum HR, and the average intensity for the aerobic and resistance parts of the exercise session was 68.3 ± 5.1%, and 62.3 ± 5% of the maximum HR, respectively. For the aerobic part of the session, the average velocity of the treadmill was 3.9 ± 0.5 km/h, and the incline was 2.9 ± 1.2°.

Acute physiological responses for the total number of exercise sessions are shown in Table 2. There were no differences in acute responses between subgroups of pre-pregnancy exercisers and non-exercisers. In both subgroups, maternal HR was elevated during the aerobic and resistance parts of the session (p<0.01) in comparison to baseline (Supporting Information Figure S1 & 2). Fetal heart rate was also elevated during both parts of exercise session for the total sample (aerobic exercise: p<0.01; resistance exercise: p<0.01) and pre-pregnancy non-exercisers (aerobic exercise: p=<0.01; resistance exercise: p=0.02) in comparison to the baseline values. Pre-pregnancy exercisers recorded a rise in FHR only in the aerobic part of the exercise session (p<0.01). The average baseline FHR for the total population was 141.2 ± 5.9 beats per minute, which increased by 6.3% (8.9 beats per minute) to 150.1 ± 5.8 following the aerobic part of the session. Fetal heart rate remained increased during the resistance part of the session. After this part of the session we recorded 145.2 ± 6.5 beats per minute, which is a 2.8% increase from baseline (4.1 beats per minute).

Neither systolic nor diastolic blood pressure changed in comparison to the baseline values in the total sample. However, in the subgroup of pre-pregnancy exercisers systolic blood pressure was higher during the aerobic part of the exercise (p<0.01) and at the end of the session (p=0.01), compared to baseline values. The subgroup of non-exercisers recorded a decrease in systolic blood pressure during resistance exercise (p=0.03). This subgroup also recorded a drop in diastolic blood pressure during aerobic (p=0.02) and resistance exercises (p=0.04). Blood pressure levels in both subgroups remained within healthy limits in the both subgroups.

There was a slight, but significant elevation in tympanic membrane temperature during the aerobic part of the session (p<0.01) in both subgroups, but this remained far from dangerous levels. There was no significant change in temperature during the resistance resistance part of the session. All abovementioned parameters had returned to baseline values by the end of the session.

Glucose levels dropped ($p<0.01$) from baseline values, by 17%, whilst lactate levels increased ($p<0.01$) following the exercise session in the total sample. This was observed in both subgroups, exercisers ($p<0.01$; $p=0.01$) and non-exercisers ($p<0.01$; $p=0.01$). The average blood glucose level after the session was 3.9 ± 0.4 mmol/L, with minimum values for exercisers and non-exercisers recorded as 3.5 mmol/L and 3.1 mmol/L, respectively.

There were no differences between acute responses to exercise during the 2nd and 3rd trimesters in the subgroup of women who exercised throughout both trimesters of pregnancy (Supporting Information Table S1). There were no symptoms of hypoglycemia or hyperthermia and there were no warning signs which would require terminating exercise during the sessions. No adverse effects were caused by exercise and none of the pregnant women developed relative or absolute contraindications to exercise.

Discussion

Data on the acute physiological responses to exercise in pregnancy is limited, especially for women affected by GDM. This study represents one of the largest collections of acute responses to exercise in pregnant women and is the first to offer comprehensive data for the population affected by GDM.

We have shown that exercise for pregnant women diagnosed with GDM induces changes in the maternal and fetal HR, as well as slight changes in the maternal blood pressure, but far from the levels that would cause concern. The recorded decrease in blood glucose levels post-exercise could be clinically worthwhile in the management of GDM and possibly reduce the need for insulin and/or oral glucose lowering agents. Furthermore, exercise elicits similar acute responses for both pre-pregnancy regular exercisers, and non-exercisers. Women should be advised to continue or start regular exercise in pregnancy if they have no contraindications, especially those affected by GDM.

Acute hemodynamic responses to aerobic and resistance exercise in pregnancy are similar to those observed in the general pregnant population, with an increased HR and little to no change in blood pressure[24]. Petrov Fieril et al.[13] conducted a similar study with a healthy population of pregnant women examining responses to aerobic and resistance exercise.

Whilst our results confirm a similar elevation in HR during exercise, Petrov Fieril et al.[13] also recorded an elevated HR five minutes following completion of the exercise which was not the case in our study. However, direct comparison is not possible because women in our study had a longer period of relaxation before assessment at the end of session (> 5 minutes).

We did not record elevations in systolic and diastolic blood pressure in the total sample. However, there were some changes in the subgroups, albeit minor. Whilst pre-pregnancy exercisers recorded slight elevation in systolic blood pressure during the aerobic part of the exercise, non-exercisers recorded decreases in both systolic and diastolic blood pressure during exercise sessions probably due to the decreased peripheral vascular resistance. Our results show that the combination of aerobic and resistance exercise in both the 2nd and 3rd trimesters of pregnancy does not induce unsafe changes in blood pressure. Furthermore, Bgeginski et al.[25,26] reported that blood pressure, together with FHR, stayed within normal limits during resistance exercise in pregnant women.

There were no differences in any of the parameters between the 2nd and 3rd trimesters of pregnancy in the subgroup of participants who exercised for the whole period. This is in contrast to a previous study performed by Baciuk et al.[12] in which HR during exercise decreased between the 2nd and 3rd trimesters of pregnancy.

We recorded a slight increase in tympanic membrane temperature during both the aerobic and resistance parts of the session, but this increase was significant only in the aerobic part of the session when compared to baseline. Still, this was not near dangerous levels and there was no overheating. Baciuk et al.[12] also found a significant increase in body temperature during strenouos exercise, but this did not affect the fetus. In contrast, Petrov Fieril et al.[13] recorded a slight decrease in orally measured body temperature following aerobic exercise, and no change following resistance exercise. Likewise, three previous studies[10,27,28] did not show a dangerous increase in body temperature during submaximal exercise in pregnancy.

Our recorded FHR values in response to exercise are in acccordance with those reported by Rieman & Kanstrup Hansen[17] showing that a small rise in FHR of 5-25 beats per minute is a common finding during physical exercise. Our results are also similar to the results from two previous studies[18,19], which showed an increase in the FHR over the pre-exercise baseline. Our results show a lesser increase in FHR than the study performed by Barakat et al.[29] where there was an increase of 11-36 beats per minute, with a mean increase of 24 beats per minute. Their study was based on a lower exercise intensity than our study.

Capillary blood glucose level dropped from the baseline value which was very useful effect of exercises for the population affected by GDM. This finding is in accordance with previous trials which reported that muscular uptake of blood glucose during moderate exercise exceeds hepatic glucose production, resulting in a decline in blood glucose level during the physical activity[30]. This result is also similar to previous trials performed on pregnant women with GDM[15,16] or at risk for GDM[31]. There were no symptoms of hypoglycemia, but some of the glucose level measurements post-exercise were below 3.5 mmol/L, similar to the results of Halse et al.[16] where the lowest value was 3.3 mmol/L. Soultanakis et al.[11] also found that 60 minutes of moderate-intensity exercise lowered circulating glucose concentration faster and to a greater extent than in a non-pregnant population.

The main limitation of this study was the small sample size. We compensated for the small number of participants by having a large number of individual exercise sessions. However, it is possible that the studied population is not representative of the general population affected by GDM. The sample consisted of women affected by mild GDM who were treated only with medical nutrition therapy and lifestyle changes. The results cannot be applied to pregnant women treated with insulin therapy or oral hypoglycemic agents. Also, all participating women had a normal pre-pregnancy body mass index and were normotensive and without comorbidities.

In conclusion, a combination of aerobic and resistance exercise for women affected by GDM does not cause concerns in the short-term and is without adverse effects if performed according to official guidelines. Maternal HR and FHR increase during exercise, and there are slight changes in the blood pressure values in comparison to baseline levels, but within healthy limits. Tympanic temperature is slightly elevated during aerobic exercise, but remains far from dangerous levels. All values return to baseline by the end of the exercise session. There is a significant decline in glucose levels which could be potentially useful for controlling hyperglycemia in pregnancy for women affected by GDM.

Perspectives

Moderate-intensity aerobic and resistance exercise for women diagnosed with GDM does not have harmful effects in the short-term and should be encouraged. Likewise, women should be advised of potentially beneficial effects of the exercise for treating hyperglycemia in pregnancy. Future research should aim to separately compare the acute responses to aerobic and to resistance exercise in women with GDM. There is also the need to investigate the acute effects and safety of exercise in women with GDM treated with insulin therapy or oral hypoglycemic agents, as well as other higher-risk pregnancies.

Conflict of interest statement:

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Table 1. Characteristics of the population

Variable	Total (N = 18)	Pre-pregnancy exercisers (N = 9)	Pre-pregnancy non-exercisers (N = 9)
Maternal age (years)	32.8 ± 3.8	31 ± 3.9	34.6 ± 3
Parity			
Nulliparous; N(%)	9 (50)	5 (56)	4 (44)
Parous; N(%)	9 (50)	4 (44)	5 (56)
Pre-pregnancy BMI (kg/m^2)	24.4 ± 4.9	24 ± 3.9	24.8 ± 5.9
BMI at inclusion in the study (kg/m^2)	26.7 ± 4.4	26.3 ± 3.4	27.2 ± 5.4
Week of pregnancy at inclusion in the study	25.6 ± 5.2	26 ± 4.9	25.1 ± 5.8
Duration of inclusion in the study (weeks)	12.2 ± 5.1	11.9 ± 4.9	12.6 ± 5.5
75 g OGTT (mmol/L)			
Fasting	5.2 ± 0.4	5.2 ± 0.4	5.2 ± 0.4
1h	9.6 ± 2.1	8.4 ± 1.9	11 ± 1.5
2h	7.3 ± 2.3	6.8 ± 2.5	7.8 ± 2.1
Total activity at inclusion in the study (MET-h*week^{-1})	158.2 ± 74.5	186.7 ± 90.9	129.7 ± 41.4
Total activity of light intensity and above (≥ 1.5 METs) at inclusion in the study (MET-h*week^{-1})	133.1 ± 74.8	156.6 ± 91.9	109.5 ± 46.9
Sport/exercise activities at inclusion in the study (MET-h*week^{-1})	3.2 ± 2	3.6 ± 2.2	2.7 ± 1.8

SD – standard deviation; BMI – body mass index; OGTT – oral glucose tolerance test; MET – metabolic equivalent.

Table 2. Acute responses to exercise

Variable	Total sample (N = 18)				Pre-pregnancy exercisers (N = 9)				Pre-pregnancy non-exercisers (N = 9)				Differences between pre-pregnancy exercisers and non-exercisers
	Mean values ± SD	Change from baseline (%)	p value	95% CI	Mean values ± SD	Change from baseline (%)	p value	95% CI	Mean values ± SD	Change from baseline (%)	p value	95% CI	p value
Heart rate (bpm)													
Baseline	91 ± 7.5				89.8 ± 5.8				92.2 ± 9.1				0.506
Aerobic exercise	127.9 ± 9.1	40.5	<0.001*	31.8 – 41	127 ± 9.6	41.4	<0.001*	31.9 – 42.4	128.8 ± 9	39.7	<0.001*	28.9 – 44.2	0.686
Resistance exercise	116.8 ± 8.4	28.4	<0.001*	21.6 – 30	115 ± 7.6	28.1	<0.001*	20.1 – 30.3	118.3 ± 9.5	28.3	<0.001*	19 – 33.2	0.420
End of Exercise	92.2 ± 5.9	1.3	0.195	-0.7 – 3	90.7 ± 5.2	1	0.398	-1.5 – 3.3	93.7 ± 6.5	1.6	0.357	-1.9 – 4.8	0.302
Systolic blood pressure (mmHg)													
Baseline	112.1 ± 7.1				110.7 ± 5.2				113.5 ± 8.8				0.423
Aerobic exercise	113 ± 6.8	0.8	0.137	-0.3 – 2	113 ± 4.7	2.1	0.004*	1 – 3.6	112.9 ± 8.7	-0.5	0.454	-2.2 – 1.1	0.988
Resistance exercise	111.7 ± 6.4	-0.4	0.571	-1.9 – 1.1	111.9 ± 5.2	1.1	0.272	-1.1 – 3.4	111.5 ± 7.7	-1.7	0.034*	-3.8 – 0.2	0.908

End of Exercise	112.4 ± 5.7	0.3	0.603	-1 – 1.6	112.6 ± 4.3	1.7	0.011*	0.6 – 3.2	112.3 ± 7.1	-0.7	0.163	-3.1 – 0.6	0.912
Diastolic blood pressure (mmHg)													
Baseline	71.2 ± 6				70.2 ± 6				72.2 ± 6.2				0.497
Aerobic exercise	70.4 ± 6.3	-1.1	0.408	-2.8 – 1.2	70.9 ± 7	0.1	0.671	-3 – 4.5	69.8 ± 5.9	-3.3	0.022*	-4.3 – 0.4	0.733
Resistance exercise	70.8 ± 5.5	-0.6	0.690	-2.1 – 1.4	71.2 ± 5.8	1.4	0.479	-2.2 – 4.3	70.5 ± 5.4	-2.4	0.039*	-3.3 – 0.1	0.782
End of Exercise	71.8 ± 4.6	0.8	0.400	-0.9 – 2.2	71.5 ± 4.7	1.9	0.290	-1.4 – 4.1	72.1 ± 4.8	-1.1	0.914	-2 – 1.8	0.808
Fetal heart rate (bpm)													
Baseline	141.2 ± 5.9				143.5 ± 5.8				138.9 ± 5.3				0.096
Aerobic exercise	150.1 ± 5.8	6.3	<0.001*	6.6 – 11.3	151.9 ± 7.7	5.9	0.001*	5.5 – 11.9	148.4 ± 2.5	6.8	<0.001*	5.6 – 13.4	0.209
Resistance exercise	145.2 ± 6.5	2.8	0.003*	1.6 – 6.5	146.7 ± 7.5	2.2	0.094	-0.7 – 7.1	143.8 ± 5.3	3.5	0.018*	1.1 – 8.9	0.361
End of Exercise	141.8 ± 4.7	0.4	0.290	-0.6 – 1.9	143.9 ± 4.8	0.3	0.575	-1.1 – 1.9	139.8 ± 3.7	0.7	0.398	-1.5 – 3.3	0.059
Temperature (°C)													
Baseline	36.5 ± 0.3				36.5 ± 0.3				36.6 ± 0.2				0.529
Aerobic	36.7 ±	0.6	<0.001*	0.1 –	36.7 ±	0.6	0.001*	0.1 –	36.8 ±	0.6	0.001*	0.1 – 0.3	0.197

exercise	0.3			0.3	0.3			0.2	0.2				
Resistance exercise	36.7 ± 0.4	0.6	0.010^{W}		36.7 ± 0.5	0.6	0.173^{W}		36.7 ± 0.2	0.3	0.050^{W}		0.772
End of Exercise	36.6 ± 0.2	0.3	0.009	0 – 0.2	36.6 ± 0.2	0.3	0.060	0 – 0.2	36.7 ± 0.2	0.3	0.070	0 – 0.3	0.226
Glucose (mmol/L)													
Baseline	4.7 ± 0.6				4.6 ± 0.5				4.8 ± 0.6				0.454
End of exercise	3.9 ± 0.4	-17	<0.001*	-1 – -0.5	3.8 ± 0.4	-17.4	<0.001*	-1 – - 0.6	4 ± 0.3	-16.7	0.007*	-1.3 – -0.3	0.248
Lactate (mmol/L)													
Baseline	1.5 ± 0.7				1.3 ± 0.3				1.7 ± 0.8				0.222^{MW}
End of exercise	3.2 ± 1.4	113.3	<0.001^{W}*		3.3 ± 1.5	153.9	0.012^{W}*		3.1 ± 1.3	82.4	0.011^{W}*		0.863^{MW}

SD – standard deviation; CI – confidence interval; bpm – beats per minute; ^{W}Wilcoxon signed-ranks test; ^{MW}Mann Whitney test; *statistically significant.

Supporting information (submitted separately):

Supporting Information Table S1. Differences between acute responses to exercise between 2nd and 3rd trimester and characteristics of exercise sessions

Supporting Information Figure S1. Hemodynamic parameters before the exercise session and during the aerobic part of the exercise session

Supporting Information Figure S2. Hemodynamic parameters before the exercise session and during the resistance part of the exercise session

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RESEARCH ARTICLE Open Access

The effect of exercise during pregnancy on gestational diabetes mellitus in normal-weight women: a systematic review and meta-analysis

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Abstract

Background: Gestational diabetes mellitus (GDM) is one of the most common complications during pregnancy, and it has both short- and long-term adverse effects on the health of mothers and fetuses. To investigate the effect of exercise during pregnancy on the occurrence of GDM among normal-weight pregnant women.

Methods: We searched for studies published between January 1994 and June 2017 that appeared in the Web of Science, Scopus, ClinicalTrials.gov or Cochrane library databases. Randomized controlled trials that investigated the preventive effect of exercise on GDM in normal-weight women were included. Interventions including any confounding factors (e.g., dietary) were excluded. We extracted maternal characteristics, the diagnostic criteria of GDM, and basic information for intervention and obstetric outcomes. The primary outcome was the occurrence of GDM, and the secondary outcomes included gestational weight gain, gestational age at birth, birth weight, and the odds of cesarean section. A meta-analysis was conducted based on calculations of pooled estimates using the random-effects model.

Results: Eight studies were included in this systematic review and meta-analysis. Exercise during pregnancy was shown to decrease the occurrence of GDM [RR = 0.58, 95% CI (0.37, 0.90), $P = 0.01$ and RR = 0.60, 95% CI (0.36, 0.98), $P = 0.04$ based on different diagnosis criteria, respectively] in normal-weight women. Regarding secondary outcomes, exercise during pregnancy can decrease gestational weight gain [MD = − 1.61, 95% CI (− 1.99, − 1.22), $P<0.01$], and had no significant effects on gestational age at birth [MD = − 0.55, 95% CI (− 1.57, 0.47), $P = 0.29$], birth weight [MD = − 18.70, 95% CI (− 52.49, 15.08), $P = 0.28$], and the odds of caesarean section [RR = 0.88, 95% CI (0.72, 1.08), $P = 0.21$], respectively.

Conclusions: Exercise during pregnancy can ostensibly decrease the occurrence of GDM without reducing gestational age at delivery and increasing the odds of cesarean section in normal-weight women.

Keywords: Exercise, Gestational diabetes mellitus, Systematic review, Meta-analysis

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Background

Gestational diabetes mellitus (GDM) is a common complication of pregnancy; based on the diagnosis criteria published by the International Association of Diabetes and Pregnancy Study Groups (IADPSG), the estimated prevalence of GDM worldwide is 17.8% [1]. In 2013, the World Health Organization (WHO) adopted the IADPSG evidence-based criteria as their standard for GDM diagnosis [2, 3]; these criteria use lower thresholds for several indices (i.e., a fasting glucose ≥5.1 mmol/l, or a one-hour result ≥10.0 mmol/l, or a two-hour result ≥8.5 mmol/l, using a 75 g oral glucose tolerance test) than previously accepted, therefore yielding more cases of GDM [4]. Gestational diabetes mellitus is more common among women who are overweight or of advanced maternal age, have a history of GDM and macrosomia, and who have a family history of diabetes [5–8].

Gestational diabetes mellitus can affect the health of mothers and their offspring due to transient abnormalities in carbohydrate metabolism [1, 5, 9, 10]. Women with GDM are at higher risk of experiencing fetal demise, fetal malformation, preterm birth, macrosomia, polyhydramnios, infection, and cesarean section than the general population [11–15]. Furthermore, both women with GDM and their infants are more likely to become overweight or obese [16, 17] and develop type 2 diabetes mellitus (T2DM) [10], cardiovascular diseases (CVD) and neuropsychological deficits later in life than the normal group [1, 17, 18].

Recent studies have demonstrated that GDM could be modified by lifestyle interventions such as exercise and diet control [19]. Exercise is characterized as planned, structured, repetitive movement that has a specific goal (e.g., health improvement). It is a subcategory of physical activity, which refers to any movement that involves energy expenditures and the use of skeletal muscles [20]. Exercise is deemed to be an important component of lifestyle intervention for GDM [21]. Regular exercise reduces the risk of T2DM, CVD, and metabolic syndrome in non-pregnant patients [22, 23]. The Royal College of Obstetricians and Gynecologists (RCOG) recommends that to accrue health benefits, healthy pregnant women should engage at least 30 min of moderate-intensity exercise at least four times per week [24]. However, only a small proportion of pregnant women achieve this goal.

Several meta-analyses support the evidence that exercise protects against GDM. Da Silva et al. concluded that leisure-time physical activity during pregnancy played a protective role against the development of GDM [25]; another meta-analysis of randomized controlled trials (RCTs) found that exercise prevents GDM in normal-weight and overweight women [26]; yet another meta-analysis of the association between exercise and preterm birth also showed that exercise lowers the occurrence of GDM in overweight or obese women [27].

Objectives

The majority of the GDM population comprises women of normal weights (based on pre-pregnant body mass index [BMI]). However, the existing systematic reviews and meta-analyses focused on the over-weight or obese population [28]. Exclusively on the normal-weight population, there are few reviews of pregnancy outcomes and one recent paper focused on the exercise during pregnancy in the normal-weight population and the risk of preterm birth [29]. To our knowledge, no published reviews have examined GDM in such population. Evidence of how exercise influencing GDM in normal-weight women could inform first-line treatments of GDM in clinical practice. Earlier meta-analyses of all-weight populations did not rule out the impact of maternal weight on GDM given that overweight and obese populations are at high risk of GDM and their status may be attributed to a variety of factors. Here, we synthesized available evidence of RCTs of exercise during pregnancy in preventing GDM in normal-weight women.

Methods

We conducted a systematic review and meta-analysis and reported our findings according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.

Search strategy

We searched Web of Science, Scopus (including Pubmed, MEDLINE and Embase), ClinicalTrials.gov and the Cochrane Library for articles published between January 1994 and June 2017, using the following combinations of keywords: ('activit*' OR 'fitness' OR 'exercise' OR 'sport*' OR 'physical activit*' OR 'physical exercise') AND ('pregnancy' OR 'wom*') AND ('trial*') AND ('diabetes' OR 'gestational diabetes' OR 'gestational diabetes mellitus' OR 'GDM' OR 'glucose'). The integrated search strategy is shown in Additional file 1: Textbox 1. These search terms were reviewed by a trained librarian and a physician. Reference citations for relevant articles were additionally screened to identify possible missing publications.

Study selection

Studies were included if they satisfied the following conditions: 1) they consisted of randomized controlled trials; 2) interventions used in the study included at least one type of exercise; 3) the occurrence of GDM was reported for both the intervention and control groups; 4) subjects were pregnant women with a pre-pregnancy BMI or a mean pre-pregnancy BMI ranging from 18.5–24.9 kg/m^2. Publications were excluded if they met any of the following conditions: 1) they integrated interventions of other factors (e.g., dietary) confounding the independent effects of exercise on the occurrence of GDM; 2) the pre-pregnancy BMI or the mean pre-pregnancy BMI of each group was less than 18.5 kg/m^2 or equal to or greater than 25 kg/m^2; 3) papers were literature reviews, case reports or protocols; 4) only the abstract or conference contents were published, or the studies lacked specific data.

Data extraction and outcome measures

Two reviewers (W.D., W.M.) independently searched the literature and extracted data from all eligible studies. Any discrepancy in crosschecks was resolved by a third reviewer and by discussion between all participating authors. The following data were extracted if available: 1) study characteristics (authors, publication year, country, affiliation of the authors, number of subjects, and gestational period); 2) exercise intervention (type, frequency, duration, and intensity); 3) pregnancy outcomes (GDM, gestational weight gain [GWG], caesarean section, gestational age, and birth weight). The primary outcome was the occurrence of GDM, and the secondary outcomes included gestational age at birth, cesarean section, birth weight, and GWG.

Assessment of risk of Bias

Quality assessment was based on the criteria outlined in the Cochrane Handbook for Systematic Reviews of Interventions and consisted of 1) randomization; 2) concealment of allocation; 3) blinding of the outcome assessment (blinding of participants and healthcare providers was impossible owing to the nature of exercise); 4) incomplete outcome data; 5) selective reporting and 6) other potential bias.

Data synthesis

Data analysis was conducted using Review Manager 5.3 (RevMan 5.3). Relative risks (RRs) or mean differences (MDs) with 95% confidence intervals (CIs) were used to calculate pooled effects. Relative risks were reported for dichotomous outcomes (i.e., the occurrence of GDM and cesarean section), and MDs were reported for continuous outcomes (i.e., gestational age at birth, gestational weight gain, and birth weight). Heterogeneity was assessed using the Cochran Q statistic ($P < 0.1$), qualified with Higgins I^2 statistics. A p-value less than 0.05 in the two-tailed tests was considered to be statistically significant.

Results

Study selection and characteristics

We identified 5077 publications in four databases. Upon screening the titles and abstracts, the full texts of 21 studies were reviewed. Of these studies, 13 were excluded due to the following reasons: the pre-pregnancy BMI of the patients did not meet the inclusion criteria (7 studies) [30–36], the patients underwent lifestyle interventions including dietary changes (3 studies) [37–39], there were no control groups (2 studies) [40, 41], or the studies were only observational (2 studies) [42, 43]. Eight RCTs [44–51], including a total of 3256 pregnant women, were eligible for this meta-analysis. The detailed selection procedure is shown in Fig. 1. The publication bias in the primary outcome was assessed by a funnel plot, and the results revealed that such bias existed (Fig. 2).

The general characteristics of the included RCTs are listed in Table 1. All trials were conducted in European countries. The sample sizes ranged from 83 to 962. With the exception of Stafne et al. [50], all of the interventions adopted comprehensive exercise programs of light-to-moderate intensity that were performed three times per week. The duration of each exercise period ranged from 35 to 60 min. Seven trials started in the first trimester and continued to the end of the third trimester [44–49, 51], and only one trial spanned the 20th through 36th weeks of gestation [50]. Pregnant women in the control group received regular antenatal care in all trials.

All studies reported the occurrence of GDM, gestational age at birth and birth weight; in addition, gestational weight gain was reported in five studies [45–47, 49, 51]; and the likelihood of caesarean section was reported in seven studies [44, 45, 47–51].

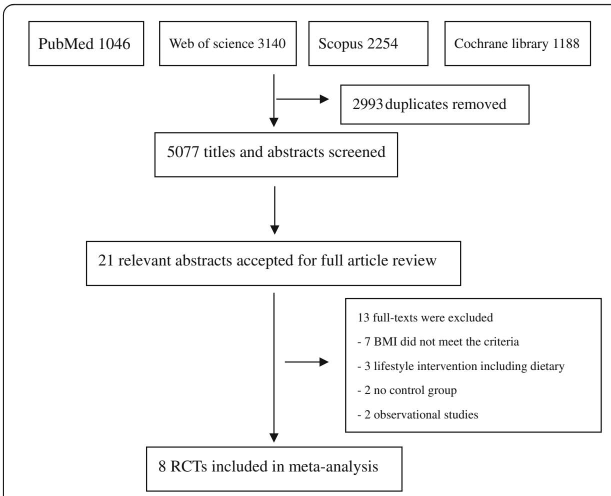

Fig. 1 Flow diagram of studies selection

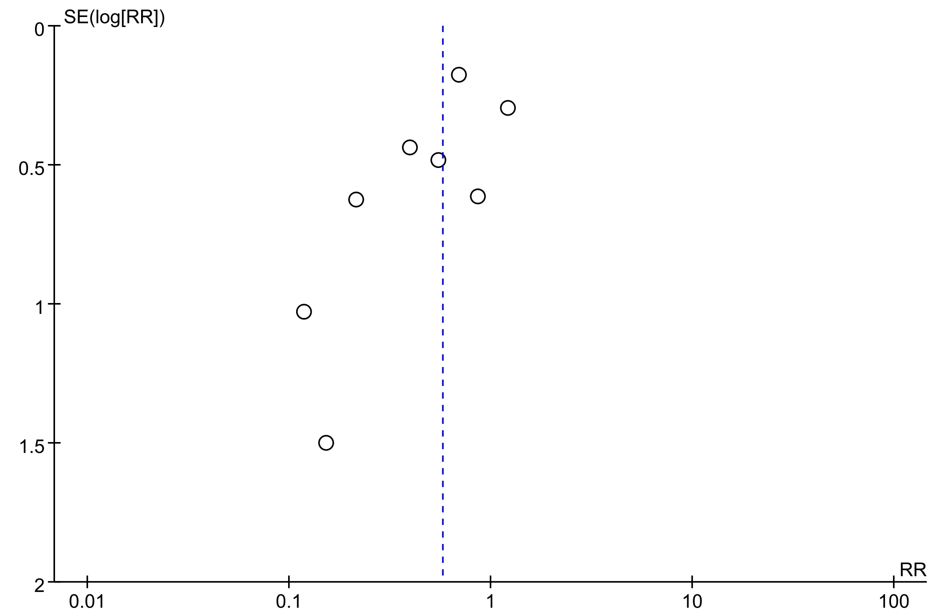

Fig. 2 Funnel plot for assessing publication bias SE: standard error; RR: relative risk

Risk of Bias in the included studies

Due to the nature of the exercise, blinding of personnel and participants was impractical. We accordingly excluded the blinding component from the bias assessment. Overall, the included trials displayed specific methodological bias (Fig. 3). Five trials showed a low risk of randomization based on the use of a computer random number generator [45–47, 50, 51], and one trial showed a high risk of bias (i.e., randomization is based on the sequence of entering study) [48], and two trials did not report this aspect. Three trials reported that the group allocation was concealed from the staff who conducted the assessment [45, 50, 51]. In terms of incomplete outcome data, three trials reported a full description of participants and follow-up status during the trial [45, 50, 51]. Only one trial was associated with a low risk of selective reporting bias of its outcomes [44].

Synthesis of results

Primary outcome: The occurrence of GDM

The diagnostic criteria for GDM varied among the eight RCTs (among these eight studies, one of the RCT with two criteria, as a result, we decided to did additional analysis as two RCTs): two were based on WHO criteria [50, 51], one was based on IADPSG criteria [51], one was based on National Diabetes Data Group (NDDG) criteria [44], one was based on criteria defined by the authors (self-reported criteria) [49]; and four studies did not report their diagnostic criteria [45–48]. Notably, one trial determined the occurrence of GDM based on the WHO criteria (before 2013) as well as the IADPSG criteria [denoted as "Barakat(a) 2013" and "Barakat(b) 2013," respectively] (Table 1).

The analysis included 1472 women in the intervention group and 1509 women in the control group. Barakat et al. [51] was analyzed as two separate trials due to different diagnosis criteria used. Exercise during pregnancy significantly decreased the occurrence of GDM [RR = 0.58, 95% CI (0.37,0.90), $P = 0.01$ and RR = 0.60, 95% CI (0.36, 0.98), $P = 0.04$ based on different diagnosis criteria, respectively] in normal-weight women. The absolute risk reduction was 3.66% and 2.53%, respectively. The heterogeneity across included studies was high ($I^2 = 46\%$ and 52%, $P = 0.07$ and 0.04) (Figs. 4 and 5).

Secondary outcomes

Exercise had no significant impact on gestational weight gain [MD = − 1.61, 95% CI (− 1.99, − 1.22), $P<0.01$; Additional file 2: Figure S1], gestational age at birth [MD = − 0.55, 95% CI (− 1.57, 0.47), $P = 0.29$; Additional file 3: Figure S2], birth weight [MD = − 18.70, 95% CI (− 52.49, 15.08), $P = 0.28$; Additional file 4: Figure S3], and the odds of caesarean section [RR = 0.88, 95% CI (0.72, 1.08), $P = 0.21$; Additional file 5: Figure S4].

Discussion

Main findings

This meta-analysis of eight studies that included 2981 pregnant women suggests that exercise during pregnancy has a significant protective impact on the occurrence of GDM, and decrease gestational weight gain. Exercise during pregnancy does not reduce the gestational age of

Table 1 Characteristics of randomized controlled trials included in the systematic review and meta-analysis ($n = 9$)

Authors	Year	Country	Subjects(*N*)		Intervention description					Parameters		Diagnosis criteria
			IG	CG	Type of exercise	Gestational period (weeks)	Duration (minutes)	Frequency (times/week)	Intensity	Maternal	Neonatal	
Barakat et al. [45]	2013	Spain	107	93	mobilization exercises, aerobic dance, and muscle training.	from 9 to 13 weeks to the end of the third trimester	50–60	3	Light-moderate	√	√	Not mentioned.
Barakat et al. (a) [51]	2013	Spain	210	218	aerobic exercises, muscle strength and flexibility	weeks 10 to 12 of pregnancy to the end of the third trimester	50–55	3	moderate	√	√	WHO
Barakat et al. (b) [51]	2013	Spain	210	218	aerobic exercises, muscle strength and flexibility	weeks 10 to 12 of pregnancy to the end of the third trimester	50–55	3	moderate	√	√	IADPSG
Barakat et al. [49]	2011	Spain	40	43	two land aerobic sessions and one aquatic activities session.	from week 6–9 to the end of the third trimester	35–45	3	Light-moderate	√	√	Self-reported
Cordero et al. [44]	2014	Spain	101	156	two on land and one as an aquatic activity	weeks 10 and 14 to the end of the third trimester	50–60	3	Light-moderate	√	√	NDDG
Stafne et al. [50]	2012	Norway	375	327	aerobics, resistance, stretching	between 20 and 36 gestation weeks	60	1	Moderate	√	√	WHO
Tomić et al. [48]	2013	Croatia	166	168	aerobic exercise	From 6 to 8 gestation week till the week of delivery	50	3	Moderate	√	√	WHO
Ruiz et al. [47]	2013	Spain	481	481	aerobics exercise and resistance exercises	From week 9 to week 38–39	50–55	3	Light-moderate	√	√	Not mentioned
Barakat et al. [46]	2014	Spain	152	138	toning and joint mobilization exercises and resistance exercises	From week 8–10 to week 38–39	55–60	3	Moderate	√	√	Not mentioned

IG intervention group, *CG* control group
Barakat et al. (a) = analysis with World Health Organization criteria; Barakat et al. (b) = analysis with International Association for Diabetes in Pregnancy Study Group criteria

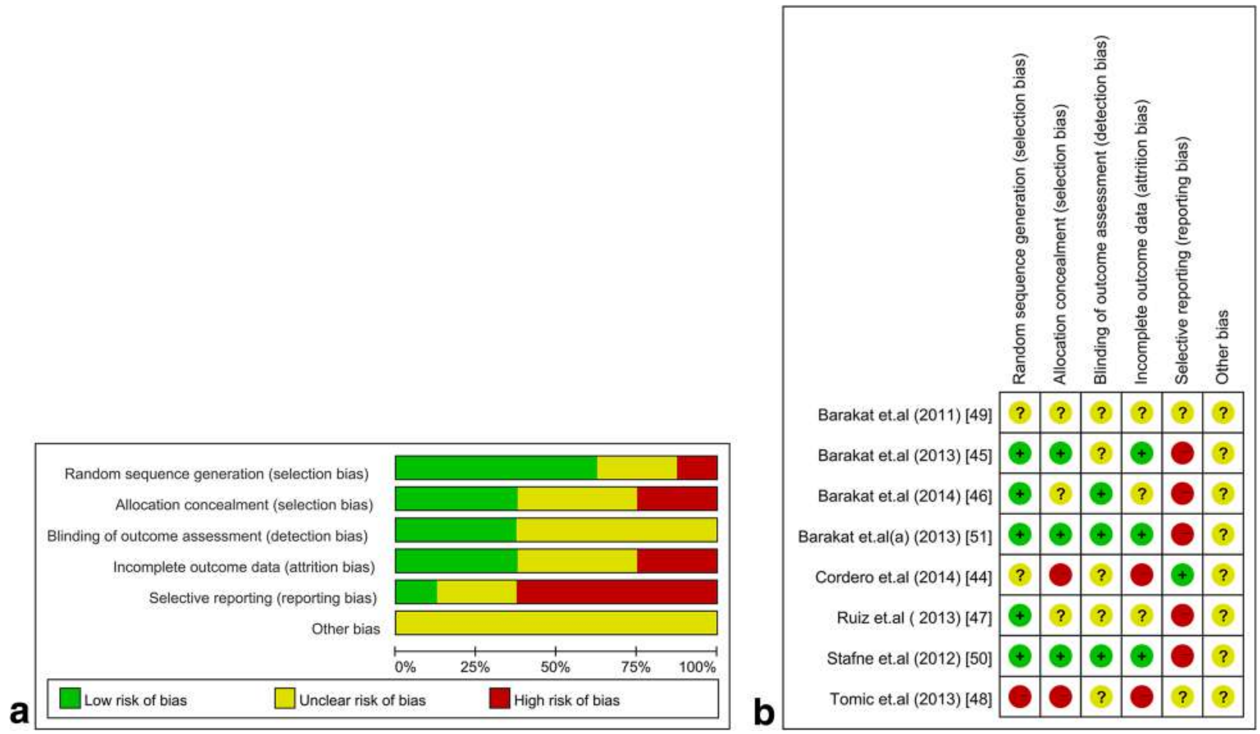

Fig. 3 Assessment of risk of bias. (**a**) Risk of bias graph about each risk of bias item presented as percentage across all included studies. (**b**) Summary of risk for bias for each trial; Plus sign: low risk of bias; minus sign: high risk of bias; question mark: unclear risk of bias

delivery or increase the odds of cesarean section in mostly normal-weight pregnant women. The mean gestational age at delivery, birth weight, and the odds of cesarean section are similar in women who exercise regularly and women who receive routine prenatal care. Summary of findings was shown in Additional file 6: Table S1.

Comparisons with the existing literature

Recently, Shepherd et al. described the effect of combined exercise and diet intervention on preventing GDM in detail, and suggested that combined diet and exercise interventions can reduce risks of GDM [52]. The meta-analysis conducted by Sanabria-Martinez et al., which included all BMI categories, showed that structured exercise during pregnancy could prevent GDM and prevent excessive weight gain [28]. Another meta-analysis performed by Magro-Malosso et al. demonstrated that aerobic exercise during pregnancy, with or without dietary intervention, could reduce the incidence of GDM in overweight and obese women [27].

Study or Subgroup	Intervention Events	Intervention Total	Control Events	Control Total	Weight	Risk Ratio M-H, Random, 95% CI
Barakat et.al (2011) [49]	0	40	3	43	2.1%	0.15 [0.01, 2.88]
Barakat et.al (2013) [45]	5	107	5	93	9.4%	0.87 [0.26, 2.91]
Barakat et.al (2014) [46]	6	138	12	152	12.9%	0.55 [0.21, 1.43]
Barakat et.al(a) (2013) [51]	41	210	61	218	27.2%	0.70 [0.49, 0.99]
Cordero et.al (2014) [44]	1	101	13	156	4.1%	0.12 [0.02, 0.89]
Ruiz et.al (2013) [47]	7	335	18	352	14.5%	0.41 [0.17, 0.97]
Stafne et.al (2012) [50]	25	375	18	327	20.6%	1.21 [0.67, 2.18]
Tomic et.al (2013) [48]	3	166	14	168	9.2%	0.22 [0.06, 0.74]
Total (95% CI)		**1472**		**1509**	**100.0%**	**0.58 [0.37, 0.90]**
Total events	88		144			

Heterogeneity: Tau² = 0.15; Chi² = 12.90, df = 7 (P = 0.07); I² = 46%
Test for overall effect: Z = 2.44 (P = 0.01)

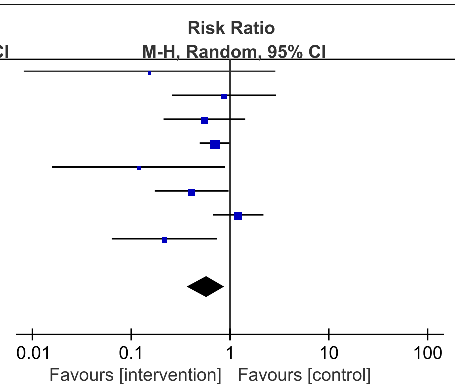

Fig. 4 Forest plot for the meta-analysis of the occurrence of gestational diabetes mellitus (1)

Study or Subgroup	Intervention Events	Intervention Total	Control Events	Control Total	Weight	Risk Ratio M-H, Random, 95% CI
Barakat et.al (2011) [49]	0	40	3	43	2.6%	0.15 [0.01, 2.88]
Barakat et.al (2013) [45]	5	107	5	93	10.5%	0.87 [0.26, 2.91]
Barakat et.al (2014) [46]	6	138	12	152	13.8%	0.55 [0.21, 1.43]
Barakat et.al(b) (2013) [51]	29	210	32	218	22.6%	0.94 [0.59, 1.50]
Cordero et.al (2014) [44]	1	101	13	156	4.9%	0.12 [0.02, 0.89]
Ruiz et.al (2013) [47]	7	335	18	352	15.2%	0.41 [0.17, 0.97]
Stafne et.al (2012) [50]	25	375	18	327	20.2%	1.21 [0.67, 2.18]
Tomic et.al (2013) [48]	3	166	14	168	10.3%	0.22 [0.06, 0.74]
Total (95% CI)		**1472**		**1509**	**100.0%**	**0.60 [0.36, 0.98]**
Total events	76		115			

Heterogeneity: Tau² = 0.22; Chi² = 14.55, df = 7 (P = 0.04); I² = 52%
Test for overall effect: Z = 2.06 (P = 0.04)

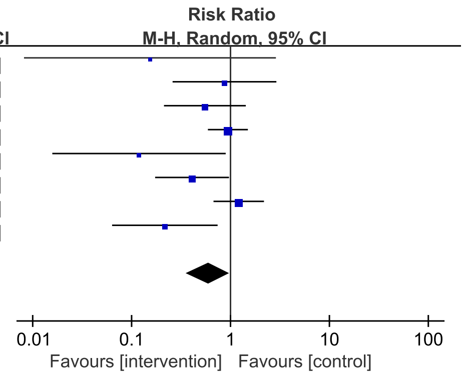

Fig. 5 Forest plot for the meta-analysis of the occurrence of gestational diabetes mellitus (2)

Recently, Di Mascio et al., in a meta-analysis of nine trials—including 2059 normal-weight women—showed that exercise during pregnancy was not associated with an increased risk of preterm birth. However, these authors found that exercise was correlated with a significantly lower incidence of GDM, cesarean delivery, and hypertensive disorders [29]. All of these studies support our findings. On the other hand, a meta-analysis conducted in 2014 suggested that physical exercise had no significant effect on lowering the occurrence of GDM. However, this study included only 947 pregnant women. In addition, exercise during pregnancy can also decrease the risk of gestational hypertension, preterm birth, cesarean delivery and macrosomia, which can significantly decrease the perinatal morbidity and mortality [53, 54].

Strengths and limitations

To the best of our knowledge, this study is the first meta-analysis focused on normal-weight women to examine the relationship between exercise/physical activity and the occurrence of GDM. This meta-analysis included all eight RCTs on the topic that have been published so far, with a larger sample size (2981 women) than earlier meta-analyses. Individual studies did not affect the overall results because of the similar sample size of each included study. These key factors are essential for assessing the validity of a meta-analysis.

However, our analysis has some limitations. The baseline characteristics (e.g., maternal age, occupation, educational level, household income, etc.) of the participants across the included studies were not balanced. Furthermore, compliance with the intervention and the effect of exercise might have varied due to differences in maternal education levels, parity, residence, and lifestyle habits before pregnancy; no included study reported adherence and compliance with the exercise regimens. Only one trial was stratified by pre-pregnancy BMI when assessing outcomes [47]; therefore, the mean BMI of the women included in all of the RCTs was in the normal range, but some of the studies might have included a small proportion of underweight, overweight, or obese women. The result of funnel plot suggested possible publication bias, which indicated the effect of exercise during pregnancy on decreasing the risks of GDM was likely reported in published studies, yielding over-estimation of the true effect. Moreover, the method for objectively monitoring physical activity is needed. Cordero et al. [44] used a heart rate monitor to modulate the intensity of exercise, but such set-up has not yet proofed as the best site for pregnant women.

Conclusions and interpretation

Over a decade, healthcare professionals have mainly focused on overweight/obese women's exercise during pregnancy related to GDM. However, there is a considerable proportion of GDM women having a normal pre-pregnancy BMI. Also, the majority group in the whole pregnancy population is those with normal pre-pregnancy BMI. From a cost-effectiveness perspective, we need to be more concerned about those women with a normal pre-pregnancy BMI. Our study shows light-to-moderate exercise for 30–60 min, three times a week, during pregnancy is safe and worthy of promotion in normal-weight women with uncomplicated, single pregnancies. This type of exercise could significantly decrease the occurrence of GDM and gestational weight gain, which is associated with adverse outcomes like gestational hypertension, preeclampsia. Besides, exercise during pregnancy is not associated with a reduction of mean gestational age at delivery or an increase in the odds of cesarean delivery. Therefore, our findings support the RCOG recommendations that women with uncomplicated pregnancies should engage in 30 min of moderate physical activity at least four times per week in all trimesters. Our finding indicates that the physical activity intervention in normal pre-BMI women could be a cost-effective or cost-saving management among the pregnancy population with normal pre-pregnancy BMI. Future studies should include larger cohorts to examine the association between exercise pattern (frequency and intensity) and glucose level, and to identify exercise amount and intensity that are suitable for the pregnancy population.

Additional files

Additional file 1: Textbox 1. Search terms used to identify articles related to exercise and gestational diabetes mellitus. (DOCX 12 kb)

Additional file 2: Figure S1. Forest plot for the meta-analysis of the gestational weight gain (kg). (PDF 400 kb)

Additional file3: Figure S2. Forest plot for the meta-analysis of the gestational age at birth (days). (PDF 514 kb)

Additional file 4: Figure S3. Forest plot for the meta-analysis of the birth weight (g). (PDF 593 kb)

Additional file 5: Figure S4. Forest plot for the meta-analysis of the odds of caesarean section. (PDF 438 kb)

Additional file 6: Table S1. Summary of findings. (PDF 88 kb)

Abbreviations
BMI: Body mass index; CI: Confidence interval; CVD: Cardiovascular diseases; GDM: Gestational diabetes mellitus; GWG: Gestational weight gain; IADPSG: The International Association of Diabetes and Pregnancy Study Groups; NDDG: National Diabetes Data Group; OR: Odds risk; PRISMA: Preferred reporting items for systematic reviews and meta-analyses; RCOG: Royal College of Obstetricians and Gynecologists; RCT: Randomized controlled trials; SMD: Standard mean differences; T2DM: Type 2 diabetes mellitus; WHO: World Health Organization

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Availability of data and materials
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Authors' contributions
ZW contributed to discussion and reviewed and edited the manuscript. WM and WD designed the study, searched the published work, extracted articles, analysed data, and drafted the manuscript. CJPZ interpreted the data, and reviewed and edited the manuscript. LZ selected articles, extracted data, and commented on drafts. YL, ZL, CS, YW, HC1 and HC2 commented and edited the manuscript. HC2 would correspond to the author furthest up on the author list.

Competing interest
The authors declare that they have no competing interests.

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EXERCISE FOR PREVENTION AND TREATMENT OF GDM

Prescribing exercise for prevention and treatment of gestational diabetes: review of suggested recommendations

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Abstract

Exercise has been proved to be safe during pregnancy and to offer benefits for both mother and fetus; moreover, physical activity may represent a useful tool for gestational diabetes prevention and treatment. Therefore, all women in uncomplicated pregnancy should be encouraged to engage in physical activity as part of a healthy lifestyle. However, exercise in pregnancy needs a careful medical evaluation to exclude medical or obstetric contraindications to exercise, and an appropriate prescription considering frequency, intensity, type and duration of exercise, to carefully balance between potential benefits and potential harmful effects. Moreover, some precautions related to anatomical and functional adaptations observed during pregnancy should be taken into consideration. This review summarized the suggested recommendations for physical activity among pregnant women with focus on gestational diabetes.

Keywords

Exercise, gestational diabetes, pregnancy

History

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Introduction

Gestational Diabetes Mellitus (GDM) is the most common metabolic complication of pregnancy. Its prevalence is increasing worldwide accordingly with increasing obesity and obese pregnant women [1]. Overweight and obesity are the major modifiable risk factors for GDM and should be taken into consideration by health professionals for preventing or at least delaying the onset of GDM [2]. Increasing evidences suggest that physical activity may represent a simple, inexpensive and useful tool for GDM prevention and treatment [3]. However, exercise in pregnancy needs a careful evaluation and appropriate prescription. To implement a proper prescription of exercise during pregnancy, we examined the published international guidelines for exercise in pregnancy [4–10] complicated or not by diabetes and summarizes in this review the suggested recommendations for physical activity among pregnant women with focus on GDM. The quality of evidence reported for the recommendations has been described using the International Evaluation of Evidence criteria.

Gestational diabetes: screening, diagnosis and management

GDM is defined as a carbohydrate intolerance of varying degree of severity with first diagnosis during pregnancy and a natural dispelling of the hyperglycemic condition after child birth [5]. GDM, when undiagnosed or inadequately treated, has many detrimental consequences for woman, fetus and child [11–16].

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Since 2011, the Italian National Health System guidelines recommended a selective screening for GDM based on risk factors (Figure 1), using a 75 g OGTT and IADPSG/WHO 2013 criteria for diagnosis: Fasting plasma glucose $\geq$5.1 mmol/l (92 mg/dl) and/or 1-h plasma glucose $\geq$10.0 mmol/l (180 mg/dl) and/or 2-h plasma glucose $\geq$8.5 mmol/l (153 mg/dl) [17].

The primary aim of GDM treatment is blood glucose control in order to reduce the elevated risk for short- and long-term complications for both mother and offspring. The approach for GDM includes: maternal education, diet modifications, exercise, drug treatment and fetal surveillance. If adequate glycemic control is not been achieved with lifestyle modifications, drug treatment is prescribed with the aim to reach the target maternal blood glucose levels [16–19].

Physical activity during pregnancy: benefits and risks

Exercise has been proved to be a beneficial therapeutic tool during pregnancy. It is safe and advantageous for cardiovascular functions (fitness, blood pressure, peripheral edema), preeclampsia, varicose veins and deep vein thrombosis, decreased lower back pain and had benefits on mood and psychological wellbeing; decreased risk of preterm delivery, length of labor and delivery complications; furthermore, exercise has an important role on limitation in weight gain and fat retention after delivery with improving self-image [20,21]. Moreover, observational studies support physical activity as useful tool to reduce the risk of GDM, and a recent meta-analysis of 10 eligible intervention trials showed a 28% risk reduction (95% CI 9–42%) in the intervention compared with the control group ($R^2 = 0.72$, $p = 0.005$), providing a protective effect against the development of GDM [22]. In the management of women with GDM, there is evidence that exercise, particularly structured aerobic and/or resistance training, is a beneficial adjunctive therapy. A recent meta-analysis of seven eligible randomized, controlled trials found that exercise as an adjunct to standard care significantly improved postprandial control of glycemia and lowered fasting blood glucose for women with GDM compared with standard care alone, while there was no increase in adverse events in the exercise groups [23]. Lower postprandial blood glucose levels are associated with fewer perinatal complications [24].

Maternal exercise has also been shown to provide significant benefits to the fetus health: increased amniotic fluid, increased in placenta viability and volume, increase vascular function, faster placenta growth and greater villous tissue, lower birth weight and risk of preterm birth, improved neurodevelopment and lower fetal body fat percentage [25–28]. Finally, children born from women who engaged in regular physical activity during pregnancy had higher behavior regulatory ability and orientation, a better understanding and, at age of five, had less body fat, higher general language intelligence and oral expression [29]. Therefore, considering the benefits of exercise during pregnancy, it is necessary that it becomes an integral part of treatment strategies in women during pregnancy and particularly in case of pregnancy complicated by GDM. However, studies evaluating type, timing, duration, and compliance of physical activity regimens are warranted to best inform obstetric guidelines.

Exercise prescription requires knowledge of the potential risks and assessment of the physical ability to engage in various activities. Absolute and relative contraindications to exercise should be evaluated, and anatomical and physiological change occurring during pregnancy should be taken into account in prescribing exercise. Therefore, clinical evaluation of each pregnant woman should be conducted before physical activity is recommended and exercise programs should be tailored by appropriately trained and qualified practitioners.

Pregnant women with GDM do not need suggestions or special precautions for physical activity other than those recommended in women with normal glucose tolerance but, considering the presence of hyperglycemia, they need to take into account the recommendations for the physical activity outlined for the pre-gestational diabetes especially when GDM requires a pharmacological treatment that could cause hypoglycemia. Considering the lack of large cohort studies implementing exercise as treatment of GDM, the suggested recommendations have been derived from exercise guidelines in pregnancy and exercise in type 2 diabetes guidelines [30–35]. Although currently there is only a GDM-specific exercise prescription guideline published [36], we suggest to develop Italian recommendations to allow proper application of physical activity practice as an effective tool in glucose control to prevent, delay or treat GDM.

Indication and contraindications to physical activity during pregnancy

All women in uncomplicated pregnancy should be encouraged to engage in physical activity as part of a healthy lifestyle [Level of evidence II, Recommendation B]

Women with complicated pregnancy have been discouraged from the practice of physical activity to avoid a worsening of the

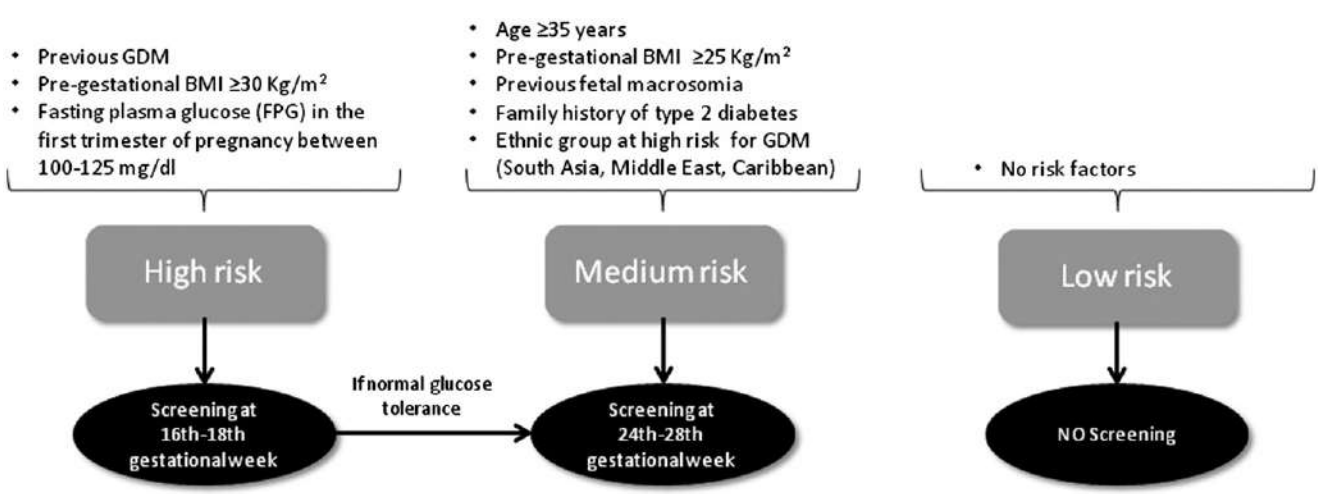

Figure 1. Recommendation for the screening of GDM according with Italian National Health System guidelines 2011.

underlying disease or negative impact on both maternal and fetal outcomes. The absolute contraindications represent conditions where exercise is not recommended, while relative contraindications are conditions where the risks may outweigh the benefits of regular physical activity and should be individually evaluated (Table 1). Therefore, clinical evaluation of each pregnant woman should be performed before physical activity is recommended [Level of evidence V, Recommendation B]

Starting a new exercise program during pregnancy

Starting a new exercise program should be considered already in the pre-conceptional period, especially in women who are overweight-obese and/or have other risk factors for GDM (previous gestational diabetes, age >35 years, family history for diabetes, high-risk ethnic group) in order to avoid excessive weight gain during pregnancy and prevent GDM [37] [Level of evidence III, Recommendation B].

Previously active women can continue the regular practice of physical exercise, as long as the pregnancy is uncomplicated, and the activity practiced meets the safety criteria in terms of type, intensity and frequency of exercise as suggested below [38] [Level of evidence III, Recommendation B].

In sedentary women, especially those in which the gestational diabetes is diagnosed, an exercise program could be initiated in the second trimester, when the nausea, vomiting, and fatigue (sometimes intense in the first trimester) have passed and before the physical limitations of the third trimester occur [Level of evidence VI, Recommendation C].

Exercise prescription during pregnancy

Consideration should be given to the frequency of exercise sessions, intensity of exercise, type of exercise and its duration to carefully balance between potential benefits and potential harmful effects. We identified in the FITT model (Frequency, Intensity, Time/duration and Type; Table 2) a valid tool to prescribe physical activity during pregnancy in order to prevent and treat GDM [39].

Frequency and duration

Aerobic exercise should go on for a minimum of 15 minutes per session, 3 times a week (according to an appropriate target heart rate), and should be increased gradually during the second trimester up to a maximum of approximately 30 minutes per session, 4 times to week (to the appropriate heart rate) [40] [Level of evidence IV, Recommendation C]. To optimize the metabolic benefits of physical activity, due to the transient improvement of insulin action and passive glucose uptake for up to 48 h, exercise should be conducted with no more than two consecutive days between sessions.

Aerobic activity should be preceded by a short (10–15 min) warming up and followed by a short (10–15 min) cool-down phase that includes stretching and relaxation exercises [Level of evidence VI, Recommendation C].

Intensity

The best way to prescribe and monitor the intensity of physical activity is evaluating the heart rate based on age and the rating of perceived exertion (RPE), simultaneously.

Heart rate

In pregnancy, at rest, there is a physiological increase in heart rate from 10 to 15 beats/minute [41]. The target heart rate during exercise, depending on the age of the woman (Table 3), representing about 60–80% of peak aerobic capacity for a pregnant woman [42] [Level of evidence VI, Recommendation C].

Classification of perceived physical activity

Choosing carefully the desirable heart rate, it is useful to compare it with the scale that assesses the individual's perception of

Table 1. Relative and absolute contraindications for the practice of physical activity during pregnancy.

Relative	Absolute
• Previous spontaneous abortion • Previous preterm birth • Mild/moderate cardio-respiratory disorders (chronic hypertension, asthma, etc.) • Eating disorder or malnutrition • Twin pregnancy after 28th week • Severe obesity (BMI >40 kg/m^2) • Mild/moderate anemia (Hb >10 g/dL) • Other significant mild/moderate medical conditions (thyroid disease, pre-gestational diabetes, etc.)	• Vaginal bleeding • Ruptured membranes • Premature contractile activity • Placenta praevia • Incompetent cervix/cerclage • Intrauterine growth restriction • Pre-eclampsia • Multiple gestation (>2) • Severe cardio-respiratory disorders • Severe anemia (Hb <10 g/dL) • Other significant severe or poorly controlled medical conditions (thyroid disease, pre-gestational diabetes, etc.)

Table 2. FITT (Frequency, intensity, time/duration and type) model.

F: FREQUENCY	Begin at 3 times per week and progress to 4 times per week
I: INTENSITY	Exercise to not excessively increase the heart rate. The proper intensity is one that lets you continue the conversation while exercising (Talk Test)
T: TIME	Start from a minimum of 15 minutes per session, 3 times a week (according to an appropriate target heart rate) to a maximum of about 30 minutes per session, 4 times a week (to the appropriate heart rate).
T: TYPE	Preferably use large muscle groups (such as those that are put in motion for walking, stationary bike, swimming, aquatic exercise, low impact aerobics). Avoid the exercises with use of weights or resistance; those that can cause falls; sports at high altitude and underwater.

physical activity (Borg's scale, Table 4) [43]. An interval between 12 and 14 is appropriate for most of the pregnant women [Level of evidence VI, Recommendation C].

Talk test

A simple, alternative or complement system for assessing the adequacy of physical exercise intensity is represented by the ''talk test'': if a woman is able to maintain a conversation during exercise means that the intensity of exercise is adequate; it should be reduced if the conversation is not possible [Level of evidence VI, Recommendation C].

Type

Exercise for the development and the maintenance of adequate physical fitness in pregnant women consists of activities that improve both the cardio-respiratory (aerobic exercise, consisting of any activity that uses large muscle groups rhythmically and continuously) and musculoskeletal status (strength and flexibility exercises; Table 5) [Level of evidence VI, Recommendation C]. However, some elements should be considered when prescribing physical activity during pregnancy.

A wide range of recreational activities appears to be safe for pregnant women. The safety of each sport is largely determined by the specific movements required by the exercise. Activities with a high risk of falling or abdominal trauma should be discouraged. Activity with a high potential for physical contact (such as ice hockey, football, and basketball) or falls (horseback riding, downhill skiing, etc.) can cause severe trauma to both mother and fetus and therefore should be discouraged. Scuba diving should be avoided during pregnancy because the fetus is at risk for decompression sickness. Caution should be also in the practice of physical exercise at high altitude (>2500 m). [Level of evidence VI, Recommendation C].

The most popular form of aerobic activity during pregnancy is walking; however, water exercise may also be an excellent choice of exercise during pregnancy.

Precautions for exercise during pregnancy

Although it is useful to exercise all muscle groups, precautions shall be taken, in part related to anatomical and functional adaptations that are observed during pregnancy (Table 6).

Musculo-skeletal adaptation

The most obvious physiological anatomical changes observed during pregnancy is the increase in weight which can increase the pressure on all the joints, especially hips and knees, causing discomfort for normal joints and increase in damage in previously unstable joints. Furthermore, due to the increase of weight and abdomen, pregnant women usually develop lumbar lordosis, which leads to changes in posture, predisposing them to the loss of balance and increased risk of falls. Finally, during pregnancy there is an increase of the laxity of the ligaments, due to higher levels of estrogen and relaxin. This could predispose pregnant women to a higher risk of tearing and distortions. Although there is no evidence of an increase in musculoskeletal injuries during pregnancy, this possibility should still be taken into account at the time of prescription of exercise in pregnancy.

Cardiovascular adaptation

Pregnancy induces an increase in maternal blood volume, frequency and cardiac output, and a reduction in systemic vascular resistance [44]. These hemodynamic changes seem to establish a reserve circulatory necessary to provide nutrients and oxygen to the mother and fetus at rest and during moderate physical activity [45]. Cardiovascular changes associated with posture should be taken into consideration both at rest and during exercise. After the first trimester, the supine position results in relative obstruction of venous return and therefore decreased cardiac output. For this reason, the supine position should be avoided as much as possible during both rest and exercise. [Level of evidence VI, Recommendation C]. Furthermore, the maintenance of the motionless standing should be avoided because it is associated with a significant decrease in cardiac output.

Table 3. Heart rate intervals useful for pregnant women.

Maternal age (years)	Fitness level	Heart rate range (beats/minute)
<20	–	140–155
20–29	Low	129–144
	Active	135–150
	Fit	145–160
30–39	Low	128–144
	Active	130–145
	Fit	140–156

Table 4. Borg's scale of perceived physical activity.

6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Very very light		Somewhat light		Light		Somewhat hard		Hard			Very hard		Very very hard	

Table 5. Examples of muscle strengthening exercises.

Category	Purpose	Example
Upper back	Promotion of good posture	Shoulder shrugs, shoulder blade pinch
Lower back	Promotion of good posture	Modified standing opposite leg & arm lifts
Abdomen	Promotion of good posture, prevent low-back pain, prevent diastasis recti, strengthen muscles of Labor	Abdominal tightening, abdominal curl-ups, head raises lying on side or standing position
Pelvic floor	Promotion of good bladder control, prevention of urinary incontinence	Sway, stay on her toes
Upper body	Improve muscular support for breasts	Shoulder rotations, modified pushups against a wall
Buttocks, lower limbs	Facilitation of weight-bearing, prevention of varicose veins	Buttocks squeeze, standing leg lifts, heel raises

Respiratory adaptation

Pregnancy is associated with increase of about 50% of the ventilation, increase in arterial oxygen tension, especially in the first trimester, increase uptake of oxygen and its baseline consumption [46]. Because of the increased requirement of oxygen at rest and increased work of breathing caused by the pressure exerted on the diaphragm by increased uterine volume, the availability of oxygen for the execution of aerobic exercise during pregnancy decreases.

Thermoregulation

During pregnancy, the basal metabolic rate, and thus heat production, has increased. Fetal temperature is usually 1 °C higher than the maternal one. The dissipation of excess heat generated during exercise can be a potential problem, since some studies suggest that hyperthermia (body temperature >39 °C) during the first 45–60 days of gestation can also be teratogenic in humans [47]. The increase in body temperature during exercise is directly related to the intensity of exercise, increasing on average by 1.5 °C during the first 30 minutes of exercise and then reaches a plateau if exercise is prolonged for another 30 minutes [48]. A constant ratio between production and heat dissipation is usually guaranteed by an increase of the heat conductance from the center towards the periphery, through the cardiovascular system, and the cooling by the evaporation of sweat. However, if the production of heat exceeds the heat dissipation capacity, for example during exercise in hot, humid conditions or during very high intensity exercise, the temperature may further rise. The exercise should, therefore, be preferably performed in a thermo-neutral environment or under controlled environmental conditions (conditioning) [Level of evidence VI, Recommendation C]. Moreover, since during prolonged exercise the loss of fluid through sweat can impair the dissipation of heat, it must be maintained a proper hydration.

In women with gestational diabetes, especially insulin-treated, it is necessary to minimize the risk of an episode, however rare, of hypoglycemia. Therefore, glucose self-monitoring before and after physical exercise should be recommend. If exercise is particularly long, glucose monitoring should also be performed during physical activity. Moreover, if glycemia before exercise is ≤70 mg/dl, it is useful to posticipate the exercise after the intake of glucose and the restoration of an adequate blood glucose levels. Finally, it may be important to perform physical activity after at least one hour of rapid acting insulin administration, in order to further reduce the risk of hypoglycemia.

Indication to the interruption of physical activity

Pregnant women should be asked to stop physical activity in case of occurrence of:

- Excessive shortness of breath, feeling short of breath or rapid heartbeat
- Chest pain
- Painful uterine contractions (more than 6-8 per hour)
- Vaginal bleeding
- Any ''gush'' of fluid from the vagina (suggesting premature rupture of membranes)
- Dizziness or weakness
  [Level of evidence VI, Recommendation C].

Healthy lifestyle during pregnancy: the role of nutrition

Pregnancy is a best time to positive change lifestyle. These changes include improved eating habits, abstinence from alcohol intake and smoking, and practice regular moderate physical activity. All these changes can be continued in the postnatal period and become a ''new'' style of life.

The quality of maternal eating during pregnancy is one of the factors that can significantly affect the health of the pregnant woman and her fetus. It is therefore appropriate to pay attention to nutrition of pregnant women, as early as the pre-conceptional period, until the baby will be breastfed [49].

In general, the pregnant woman must:

- provide a higher intake of calories (about 300 kcal/day) compared to pre-gestational period (not recommended low-calorie diet to lose weight). [Level of evidence III, Recommendation A]
- follow a diet as possible varied and contains all the nutrients
- have 3 meals and 3 snacks a day to avoid long periods of fasting
- *Skipping meals may lead to the activation of ketogenesis from fatty acids, the produced ketones may pass through the placenta and may be harmful to the fetus.*
- ensure caloric integration with complex carbohydrates, by prolonged physical activity
- eat slowly (swallowing air can give a sense of bloating)
- drink at least 2 liters of water a day, preferably mineral, non-carbonated water.

To prefer

- fresh foods to maintain unchanged the content of vitamins and minerals
- well-cooked lean meats

Table 6. Precautions for exercise during pregnancy.

Variable	Effects of pregnancy	Precautions during exercise
Body position	In the supine position the increase in uterine volume can reduce both the return flow of blood from the lower half of the body (by applying pressure on the inferior vena cava) and the flow to the abdominal aorta.	After the fourth month of gestation, the exercises that are normally performed in the supine position should be performed in a lying position on the side or standing.
Joint laxity	The ligaments become more relaxed for the increase in hormone levels.The joints are most prone to damage.	Avoid sudden direction changes and bounce during exercise. The stretching exercises should be performed controlling movements.
Abdominal muscles	During exercises involving abdominal muscles the presence of an alteration of the connective tissue along the midline may be present (diastasis recti).	If a diastasis abdomen recti developed exercises that involve the abdominal muscles should be avoided.
Posture	Breast and uterus enlargement can cause a forward shift in the center of gravity and increase the lumbar lordosis. This may cause shoulders to slump foward.	It should be encouraged good posture and neutral pelvic alignment (maintaining the neutral position of the pelvis in accordance with the natural curves of mild cervical lordosis, lumbar and mild kyphosis).

- roasted, baked, steamed or stewed fish (sole, cod, hake, trout, dogfish, red snapper, sea bream) low-fat cheese (mozzarella, ricotta, growth)
- preferably low-fat milk and yogurt
- well-washed vegetables and seasonal fruit, every day.
  To limit
- coffee and tea (or prefer decaffeinated)
- *Coffee, as all drinks containing so-called ''nervine'' substances (tea, cola drinks, chocolate), should be taken in moderation because caffeine crosses the placenta. Also, during this particular period caffeine metabolism it is slowed down 15 times and pregnant women are more sensitive to its effects.*
- salt (preferring iodized salt).
- *A high intake of salt increases the risk of cardiovascular disease and hypertension. Prefer the iodized salt because, during pregnancy and lactation iodine requirements are greater.*
- sugars: prefer complex carbohydrates such as pasta, bread, potatoes [Level of evidence I, Strength of recommendation A]
- eggs: no more than two a week, thoroughly cooked
- fats: prefer the extra virgin olive oil.
  To avoid
- Alcoholic beverages.
- *The alcohol ingested by the mother reaches after a few minutes in the blood of the fetus, but the fetus cannot metabolize it because it is devoid of enzymes suitable for this task, consequently the alcohol and its metabolites accumulate in the nervous system and other organs, damaging them and, in case of excessive ingestion, can cause a polymalformative syndrome with mental retardation (the so-called fetal alcohol syndrome) [Level of evidence II-III, Recommendation B].*

Declaration of interest

No potential conflicts of interest relevant to this article were reported.

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ORIGINAL RESEARCH

Exercise during pregnancy has a preventative effect on excessive maternal weight gain and gestational diabetes. A randomized controlled trial☆,☆☆

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Abstract
Background: Excessive gestational weight gain is associated with several adverse events and pathologies during pregnancy.
Objective: The purpose of this study was to examine the effects of an exercise program throughout pregnancy on maternal weight gain and prevalence of gestational diabetes.
Method: A randomized controlled trial was designed that included an exercise intervention group (EG) and standard care control group (CG). The exercise intervention included moderate aerobic exercise performed three days per week (50–55 minutes per session) for 8–10 weeks to 38–39 weeks gestation.
Results: 594 pregnant women were assessed for eligibility and 456 were included (EG $n = 234$; CG $n = 222$). The results showed a higher percentage of pregnant women gained excessive weight in the CG than in the EG (30.2% vs 20.5% respectively; odds ratio, 0.597; 95% confidence interval, 0.389–0.916; $p = 0.018$). Similarly, the prevalence of gestational diabetes was significantly higher in the CG than the EG (6.8% vs 2.6% respectively; odds ratio, 0.363; 95% confidence interval, 0.138–0.953; $p = 0.033$).
Conclusion: The results of this trial indicate that exercise throughout pregnancy can reduce the risk of excessive maternal weight gain and gestational diabetes.

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Introduction

Q2 Pregnancy and delivery are biological processes that can have a significant impact on maternal health and newborn wellbeing. Research has shown that events that occur during pregnancy may influence both maternal and fetal future health outcomes.[1,2]

The impact that gestational weight gain can have on health outcomes has been especially recognized by health care professionals as a potential factor that may influence maternal and fetal wellbeing. Excessive gestational weight gain is associated with several adverse events and pathologies. Many studies report complications related to the wellbeing of the mother, fetus and even the newborn and infant due to inappropriate maternal weight gain during pregnancy.[3–8]

Gestational diabetes mellitus (GDM) is defined as ''carbohydrate intolerance with onset or first recognition during pregnancy''[9] and it is among many problems that are highly related to excessive maternal weight gain.[10] Indeed the prevalence of GDM is increasing in parallel with overweight and obesity in the obstetric population.[11,12] Current trends for weight gain among women of reproductive age are alarming.[13,14]

Precise estimates of GDM prevalence are not clear. A recent meta-analysis reported that the prevalence of GDM in Europe is 5.4%.[15] According to the American Diabetes Association (ADA), GDM complicates approximately 7% of all pregnancies.[16] Regardless of the variability presented in available studies, data from western countries suggests that the prevalence of GDM is increasing.[17–19] Women diagnosed with GDM have a higher risk for future diabetes, with approximately 50% of women developing type 2 diabetes within 5 years of delivery.[20]

Many studies support the association of GDM with several adverse maternal and fetal outcomes.[21–23] Additionally, there are some data that suggest an increase in fetal malformation and perinatal mortality.[24–26]

Although research supports that healthy lifestyle modifications may have a positive impact on metabolic factors among overweight and obese pregnant women, evidence for specific effective approaches to prevent GDM are needed.[27] Research to identify modifiable factors that might help prevent excessive maternal weight gain and abnormal glucose tolerance or GDM, in the pregnant population is needed and has urgent public health importance.[28,29] One such modifiable factor may be exercise performed during pregnancy.

The existing literature suggests that physical activity before and during pregnancy may be an effective public health and clinical strategy for GDM prevention and treatment.[30] This effect might be explained by the widely accepted influence that physical activity has on preventing weight gain.[31]

Research has supported exercise during pregnancy as an effective intervention to prevent excessive gestational weight gain.[32] Furthermore, exercise during pregnancy has been identified as an effective approach to control blood sugars to help prevent and manage GDM.[33] Previous studies carried out with pregnant women however have conducted physical activity programs using small sample sizes and/or lacking supervision.[34,35]

The main aim of this randomized controlled trial (RCT) was to examine the influence of a supervised exercise program throughout pregnancy on maternal weight gain and incidence of GDM. As a secondary objective, the effect of the exercise program on other maternal and neonatal outcomes was also examined. We hypothesized that maternal physical exercise would be associated with a reduction of both excessive maternal weight gain and prevalence of GDM without adverse effects on other maternal and newborn outcomes.

Methods

The present RCT (clinical trial registration number NCT02109588) was conducted between March 2014 and January 2017 following the ethical guidelines of the Declaration of Helsinki, last modified in 2000. The research protocol was reviewed and approved by the Hospital Severo Ochoa (Madrid, Spain) ethics review board (240-09). Participants enrollment began in April 2014.

Participants and randomization

A total of 594 Spanish-speaking (Caucasian) healthy pregnant women from two primary care medical centers (*Centro de Salud Los Pedroches, Centro de Salud Leganés Norte*, Madrid, Spain) were recruited during their first prenatal visit (Fig. 1). They were informed about the nature of the study and assessed for eligibility. Women with singleton and uncomplicated pregnancies (no type 1, 2 or gestational diabetes at baseline), with no history or risk of preterm delivery (i.e. ≥1 previous preterm delivery) and not participating in any other trial were invited to participate. Women not planning to give birth in the same obstetric hospital, or with no medical follow-up throughout pregnancy were not included in the study. Women having any serious medical conditions (contraindications) that prevented them from exercising safely were also not included.[36]

A computer-generated list of random numbers was used to allocate the participants into the study groups following other previous studies. Allocation ratio was 1:1. The randomization blinding process (sequence generation, allocation concealment and implementation) was performed by three different researchers. The treatment allocation system was set up so that the researcher who was in charge of randomly assigning participants to each group did not know in advance which treatment the next person would receive (i.e. concealed allocation).

Women who were randomly allocated to the Exercise Group (EG) received similar standard care and performed an exercise program throughout pregnancy. Women randomly allocated to the Control Group (CG) received obstetric standard care from health professionals. Women were excluded if they did not conform to the specifications of the allotted group. All the participants signed an informed consent.

Exercise intervention[37,38]

Pregnant women in the intervention group received standard care and all aspects of a structured and supervised

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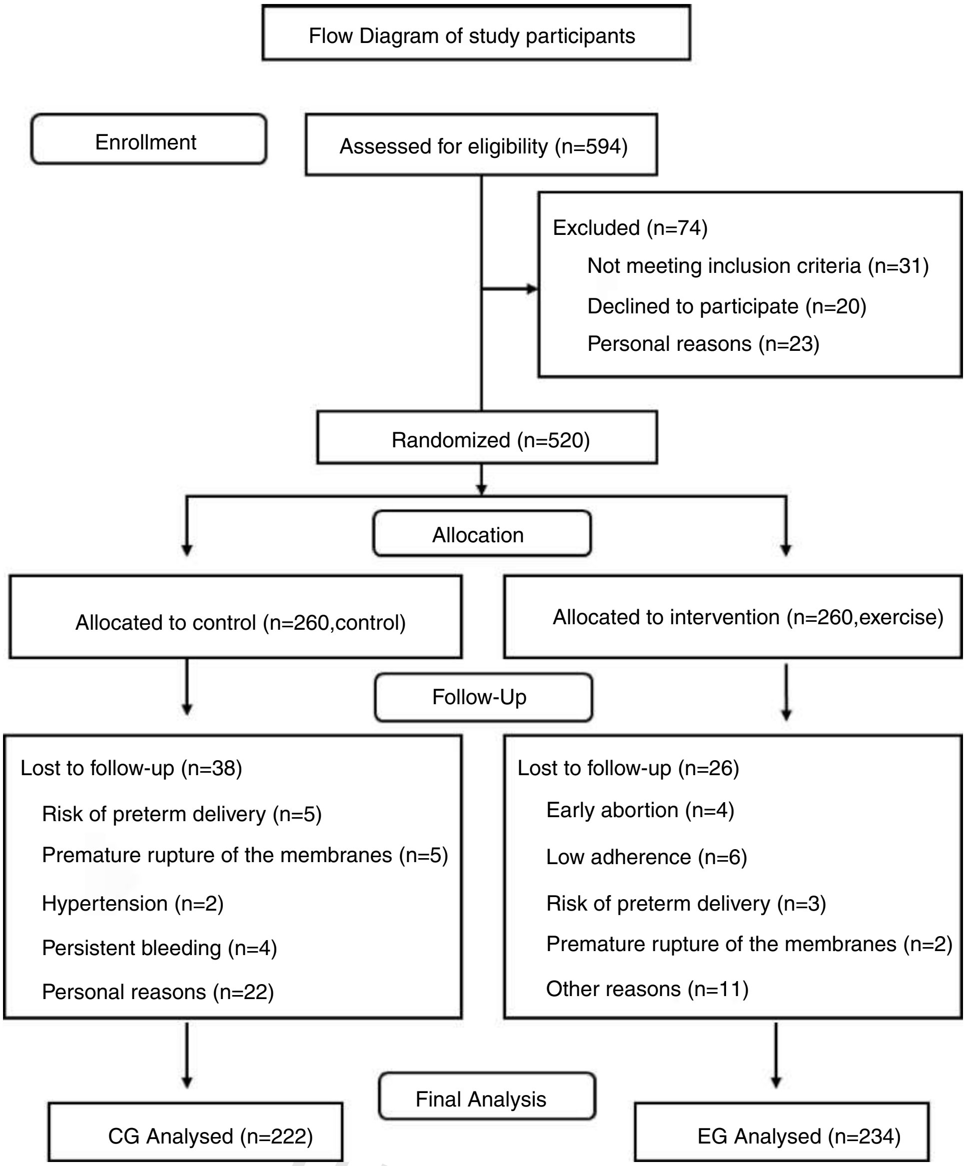

Figure 1 Flow chart of study participants.

moderate exercise intervention program three days per week (55–60 min per session) from the 8–10th week of pregnancy (immediately after the first prenatal ultrasound) to the end of the third trimester (weeks 38–39). The exercise protocol was supervised by a qualified of physical activity and sport science professional (ten years of experience). A total of 83–85 group training sessions were originally planned for each participant in the event of no preterm delivery. The exercise program met the standards of the American College of Obstetricians and Gynecologists[36] and included the following seven sections:

i. Gradual warm-up
ii. Aerobic exercises
iii. Light muscle strengthening
iv. Coordination and balance exercises
v. Stretching exercises
vi. Pelvic floor strengthening
vii. Relaxation and final talk

Women used a heart rate (HR) monitor (Accurex Plus, Finland) during the training sessions (HR was consistently under 70% of age-predicted maximum) and the rating of perceived exertion scale ranged from 12 to 14 (Somewhat Hard).[39]

The exercise session started with a light-intensity, 10-min warm-up consisting of walking and static stretching (avoiding muscle pain) of most muscle groups (upper and lower limbs, neck and trunk muscles). Similarly, the exercise session finished with a light-intensity, 10-min cool-down including the same exercises as the warm-up period plus relaxation and pelvic floor muscle training. As a motivational strategy, a final talk was done to promote extensive counseling and provide information to ensure that the participants received clear instructions on how to have an active

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pregnancy and emphasizing the importance of regular (not occasional) exercise throughout pregnancy.

The main section of the exercise session after the warm-up was 30–35 min in length and included moderate-intensity aerobic exercises and resistance exercises. Aerobic exercises consisted of low-impact aerobic dance, involving the upper and lower limbs. Aerobic dance bouts were approximately 3–4 min long and included stretching and relaxation followed by a one minute break.

Light muscle strengthening was also included in each session. Strengthening exercises engaged major muscle groups (pectoral, back, shoulder, upper and lower limb muscles) to promote good posture, prevent low back pain and strengthen the muscles used in labor and the pelvic floor (third trimester). Exercises were performed using the full range of motion and involved barbells (3 kg/exercise) and low-medium-resistance elastic bands (Therabands). The exercises included biceps curls, arm extensions, arm side lifts, shoulder elevations, bench presses, seated lateral row, lateral leg elevations, leg circles, knee extensions, knee (hamstring) curls, ankle flexions and extensions. Exercises involving extreme stretching and joint over-extension, ballistic movements or jumps were avoided, and exercises in the supine position on the floor were not performed for more than 2 min.

As pregnancy progresses, women may experience difficulty with balance therefore all coordination and balance exercises consisted of easy activities using sport equipment (foam balls, cords, etc.) for support.

To maximize program safety, adherence and efficacy, all sessions were: (i) supervised by a qualified fitness specialist (ten years of experience) and with an obstetrician's assistance; (ii) accompanied by music; and (iii) performed in the Health Care Center in a spacious, well-lit room under favorable environmental conditions (altitude 600 m; temperature 19–21 °C; humidity 50–60%). An adequate intake of calories and nutrients was confirmed before the start of each exercise session.

The intervention involved group sessions of 12–15 participants.

Adherence to the training program was ≥80% in the intervention group that was measured by a qualified fitness specialist using a checklist of attendance for each session.

Standard-care (CG)

The women assigned to the standard care CG attended regular scheduled visits to their obstetricians and midwives (according to Hospital protocol), usually every 4–5 weeks until the 36–38th week of gestation and then weekly until delivery. They received general nutrition and physical activity counseling from their health-care provider.

Women were not discouraged from exercising during pregnancy on their own. However, similar to our previous studies women in the CG were asked about exercise habits once each trimester using a ''Decision Algorithm'' (by telephone).[37]

Participant demographics

Information about demographics, including pre-pregnancy Body Mass Index (BMI), parity, educational level, previous physical activity habits, smoking status, previous pre-term birth and previous miscarriage was obtained at the first prenatal visit either by reviewing the medical records or by a telephone interview. The inclusion/exclusion criteria was determined at this initial visit by the attending obstetrician.

Outcomes

Primary outcomes

Total maternal weight gain (kg) and excessive gestational weight gain (yes/no) were recorded. Total gestational weight gain was calculated on the basis of the pregravid weight (first prenatal consult) and weight at the last clinic visit before delivery (week 36–38). Excessive gestational weight gain was defined according to the recommendations of the 2009 Institute of Medicine (IOM) guidelines[40] categorized by pre-pregnancy BMI for each woman: >18 kg for underweight; >16 kg for normal weight; >11.5 kg for overweight; and >9 kg for obese women. Cases of gestational diabetes and 1 h Oral Glucose Tolerance Test (OGTT) information was collected from hospital records (week 24–26).

Secondary outcomes

Maternal gestational age at delivery, type of delivery and birth weight were collected from hospital records. Newborns were classified as having macrosomia when birth weight was >4000 × *g* and low birth weight was defined as <2500 × *g*.[41] Primary and secondary outcomes were assessed by health-care professionals.

Statistical analyses

Sample size was determined based on a priori widely accepted power calculation.[42] In total, 340 subjects were needed to achieve 80% power to detect a statistically significant difference in maternal weight gain taking into account previous data on this variable. The sample size was intentionally increased to account for patient withdrawal and possible problems for follow-up.

A Kolmogorov–Smirnov test was performed to verify the normality of the data in the study variables and showed that it was non-parametric ($p < 0.05$). Thus, Mann–Whitney tests were performed to analyze possible differences between the groups for continuous variables (maternal weight gain, oral glucose tolerance test (OGTT), maternal age, gestational age, pre-pregnancy BMI and birthweight). The Pearson χ^2 test was completed with the observation of standardized adjusted residuals and was used to assess differences between categorical variables (excessive weight gain, gestational diabetes, parity, mode of delivery). Statistical tests used a 2-sided 0.05 alpha level and SPSS 24.0 was used to analyze the data. All analyses were done on an intention-to-treat basis.

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Table 1 Maternal characteristics.

	CG ($n = 222$)	EG ($n = 234$)
Maternal age[*] *(mean ± SD)*	31.04 ± 3.78	31.75 ± 4.68
Pre-pregnancy BMI (mean ± SD)	23.66 ± 3.81	23.50 ± 3.79
Pre-pregnancy BMI categories (n/%)		
<18	6 (2.7%)	5 (2.1%)
18–24.9	157 (70.7%)	160 (68.4%)
25–29.9	45 (20.3%)	54 (23.1%)
>30	14 (6.3%)	15 (6.4%)
Parity (n/%)		
No previous birth	162 (73%)	142 (60.7%)
One previous birth	54 (24.3%)	77 (32.9%)
More than one previous birth	6 (2.7%)	15 (6.4%)
Previous miscarriage (n/%)		
None	162 (73%)	173 (73.9%)
One	53 (23.9%)	51 (21.8%)
Two or more	7 (3.2%)	10 (4.3%)
Study levels (n/%)		
Primary school	76 (34.2%)	30 (12.3%)
Secondary school	97 (43.7%)	87 (37.4%)
Tertiary education	49 (22.1%)	117 (50.0%)
Smoking (*n*/%)	49 (22.1%)	44 (18.8%)

[*] Years.

Results (Fig. 1)

Baseline characteristics

Baseline characteristics for both groups are listed in Table 1 and were similar between groups for most of the variables.

Main outcomes

Differences in main outcomes (maternal weight gain, OGTT and cases of GDM) are presented in Table 2. Maternal weight gain was significantly lower in the EG compared to the CG (12.19 vs 13.33 kg respectively, $U = 22044$, $p = 0.005$). In line with these results, standardized adjusted residuals in Pearson χ^2 suggested that the ratio of women that gained excessively was higher in the CG than the EG (30.2% vs 20.5% respectively; odds ratio, 0.597; 95% confidence interval, 0.389–0.916; $p = 0.018$). A significant difference was also found for the OGTT results (EG = 116.56 vs CG = 121.63 mg/dL, $U = 23{,}158$, $p = 0.045$). Finally, standardized adjusted residuals in Pearson χ^2 suggested that the ratio of women diagnosed with GDM was higher in the CG than the EG (6.8% vs 2.6% respectively; odds ratio, 0.363; 95% confidence interval, 0.138–0.953; $p = 0.033$).

Other maternal and neonatal outcomes

Other outcomes of interest analyzed in the study are presented in Table 3. Among maternal outcomes, no differences were found for gestational age, number of preterm deliveries or mode of delivery. In regards to newborn outcomes, no differences were found for birthweight between study groups. Our results showed that, although the χ^2 test was not significant, the ratio of neonate macrosomia was slightly higher in the CG than in the EG (7.2% vs 3.4% respectively; odds ratio, 0.456; 95% confidence interval, 0.191–1.087).

Discussion

The aim of the present study was to examine whether regular and supervised physical exercise during pregnancy can influence prevention of excessive maternal weight gain, and GDM, which are both closely related factors. Similar to our previous work, the main strength of the current study is the combination of light resistance, toning, aerobic dance, coordination, stretching and pelvic floor muscle training in the same program throughout pregnancy and examining the resultant effects on outcomes. The main finding of this study is that the exercise program reduced the total (mean) maternal weight gain as well as the cases of excessive weight gain and GDM.

Our results are relevant from a clinical and health care point of view due to the increasing prevalence of these two parameters in recent years, in parallel with the alarming rise of worldwide overweight and obesity.[11,12] Furthermore the interpretation of our results promote the use of moderate and supervised physical exercise throughout pregnancy as a method to increase prevention of pregnancy complications and improve quality of life for pregnant women without adverse effects on maternal and fetal well-being.

Regarding the external validity and generalizability of our findings the high adherence (≥80% attendance) of this large RCT for all pre-pregnancy BMI categories strongly supports the extension of the present results to the healthy pregnant population.

In regards to the newborn health outcomes, although birth weight was similar in neonates between the CG and the EG, the percentage of newborns with macrosomia was lower in the EG. We had previously observed[37,38] this effect, and therefore this study provides additional evidence that physical exercise may improve perinatal outcomes by preventing excessive accumulation of weight during fetal development.

Other authors have previously investigated the impact of prenatal exercise on excessive gestational weight gain and GDM.[43–55] Among the great variety of study designs used, RCTs are the most reliable as they allow management of independent variables (exercise program design). Current literature available on RCTs includes a great variety of exercise programs used. It might explain the difficulty in determining the exact type and frequency of exercise during pregnancy that is required to prevent and treat GDM.

From a methodological point of view the more adaptive/desirable outcomes are reported by those studies in which a supervised intervention (exercise program) including a large variety of exercises (aerobic, resistance, pelvic floor and muscle strengthening, stretching, etc.) have been provided throughout the pregnancy.[46–51]

Regardless of the variability among exercise interventions, most researchers agree that prenatal exercise is an excellent way for controlling maternal weight gain

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Table 2 Maternal weight gain, oral glucose tolerance test and gestational diabetes.

	CG (*n* = 222)	EG (*n* = 234)	*P* value	Between group differences	95% CI
Maternal weight gain* (mean ± SD)	13.33 ± 4.08	12.19 ± 3.70	.005	1.14 ± 0.37	0.42–1.86
Maternal excessive weight gain (*n*/%)	67 (30.2%)	48 (20.5%)	.018		
OGTT** (mean ± SD)	121.63 ± 29.56	116.56 ± 29.69	.045	5.43 ± 2.70	0.12–10.74
Gestational diabetes (*n*/%)	15 (6.8%)	6 (2.6%)	.033		

* Kilograms (kg).
OGTT: oral glucose tolerance test.
** Milligrams per deciliter (mg/dL).

Table 3 Other maternal and newborn outcomes.

	CG (*n* = 222)	EG (*n* = ± 234)	*P* value	Between group differences	95% CI
Mother					
Gestational age* (mean ± SD)	277.18 ± 9.75	277.21 ± 12.81	.45	−0.04 ± 1.07	−2.14 to 2.07
Preterm delivery (>37 weeks) (*n*/%)	7 (3.2%)	10 (4.3%)	.53		
Mode of delivery (*n*/%)					
Normal	138 (62.2%)	156 (66.7%)	.41		
Instrumental	38 (17.1%)	30 (12.8%)			
Cesarean	46 (20.7%)	48 (20.5%)			
Newborn					
Birthweight** (mean ± SD)	3256.34 ± 465.94	3266.58 ± 451.52	.60	−10.23 ± 43.00	−94.74 to 74.28
Macrosomia (*n*/%)	16 (7.2%)	8 (3.4%)	.07		

* Days.
** Grams (g).

during pregnancy. Our results are in consensus with many authors,[43–46] and with our previous studies on this health outcome.[47,48]

However, as we mentioned previously the relationship between exercise and GDM has been unclear. While some evidence suggests a high efficacy in the use of exercise as a preventive method,[49–51] literature has been inconsistent on the effect of prenatal exercise when used as a treatment method for reducing risk factors for GDM.[42–55] Differences in exercise programs may explain this. In our opinion the variance in the duration of the programs, length of the sessions, adherence and especially the type of exercises used, contribute to the differences observed in the results of studies.

Strengths and limitations

The major strengths of our study include the large number of participants in this RCT, the high adherence to intervention (>80% attendance) and the identification of those women in the CG who did not remain sedentary. In our opinion, the present results provide healthcare practitioners with evidence-based information that can be used to recommend supervised physical exercise throughout pregnancy to maintain or improve the quality of life of pregnant women including labor and birth.

One limitation of the current study was that nutrition or energy intake was not assessed, however, all pregnant women had (by their obstetricians and midwives) standard care which included regular information about a healthy lifestyle during pregnancy including nutrition information. Therefore the supervised exercise program was the only difference between study groups. In addition, we found differences between the study groups for parity and educational level of participants which could potentially influence the results.

The impracticality of instituting this type of a supervised activity program for pregnant women on a mass scale may be another potential limitation of the present study. Furthermore, our study focused on a Spanish population and was conducted in two tertiary care hospitals in Madrid, which may lower the external validity of our findings.

Conclusion

We conclude that a supervised physical exercise program initiated early and maintained throughout pregnancy can reduce the risk of excessive maternal weight gain and GDM.

Conflicts of interest

The authors declare no conflicts of interest.

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Effect of relaxation exercise on fasting blood glucose and blood pressure in gestational diabetes

Abstract

Background Gestational diabetes is a growing problem worldwide, with risks for both the woman and the baby. Stress has been shown to be linked with diabetes, and therefore research is examining the effect of relaxation on blood pressure.

Aim To assess the effect of relaxation on blood glucose and blood pressure in women with gestational diabetes mellitus.

Methods This quasi-experimental study was performed with a sample of 80 participants. Fasting blood glucose and systolic and diastolic blood pressure were measured before and after the intervention, which was a 10-week programme of home mind-body and relaxation.

Findings Both systolic blood pressure and fasting blood glucose in the control group were significantly higher ($P<0.001$). Diastolic blood pressure in both groups was not found to be significantly different ($P=0.151$).

Conclusions Relaxation exercises reduce fasting blood glucose and systolic blood pressure in women with gestational diabetes mellitus.

Keywords

Relaxation exercises | Fasting blood glucose | Blood pressure | Gestational diabetes | Pregnancy

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Gestational diabetes is one of the most common complications of pregnancy (Spaight et al, 2016). The prevalence of gestational diabetes in developed and developing countries is increasing (Donovan et al, 2016). It has been reported to occur in 1–14% of pregnancies globally (Schwarz et al, 2015) and 3.4% of pregnancies in Iran (Jafari-Shobeiri et al, 2015). Gestational diabetes results in adverse outcomes in pregnancy and childbirth, including development of type 2 diabetes, gestational hypertension, and increased risk of childbirth and congenital anomalies due to impairments in blood glucose control (Shang and Lin, 2014; Ekhtiari et al, 2016).

Knowledge of the risks of gestational diabetes can increase women's fear, anxiety and depression, and women who have gestational diabetes mellitus have been shown to worry more than other women (Byrn and Penckofer, 2015). Despite the fact that diabetes has a strong link with stress and tension, physical and mental stress also leads the body to diabetes (Çakir et al, 2014; Kaviani et al, 2014). The effect of daily stress on diabetes control is less recognised. Endocrinologists have found that stress and psychoactive stimuli cause hyperglycaemic conditions and increase blood pressure in women with diabetes (Zare et al, 2013; Khani et al, 2017). Decreasing stress in people with diabetes is therefore important (Seidi et al, 2016).

Relaxation is one of many complementary treatments and is harmless during pregnancy. It includes mental imagery, music therapy and massage (Rahimi et al, 2014). Relaxation has an effect on the sympathetic system, which can increase calm and reduce mental stress in pregnant women (Limsanon and Kalayasiri, 2015; Shojaie et al, 2017). It can increase the secretion of endorphin hormones, reduce the secretion of adrenaline hormones, reduce cortisol levels, and reduce heart rate and blood pressure among pregnant women (Rahimi et al, 2014). There are several methods for relaxation including mind-body techniques, which are led by three factors: respiratory training, progressive relaxation and guided imagery. These aim to improve mental, physical and patient's abilities. Given the effect of relaxation on decreasing depression, anxiety and stress, this method can be used to improve women's mental health during pregnancy (Seyed Ahmadi Nejad et al, 2015; Howland et al, 2017; Unger et al, 2017).

Women with gestational diabetes are considered to be high-risk, and their care is important. There are few studies on the effects of mind-body relaxation techniques on fasting blood glucose, systolic and diastolic blood pressure. Therefore, this study was conducted with the aim of investigating the effect of relaxation on fasting blood glucose and blood pressure in women with gestational diabetes mellitus.

Methods

This was a quasi-experimental study with two groups with the aim of examining the effect of relaxation on fasting blood glucose and hypertension in women with gestational diabetes mellitus.

Study participants

Participants included 80 women with gestational diabetes mellitus who were referred to the antenatal clinic at Imam Khomeini Hospita, Tehran. Women were divided into two groups, each with 40 participants. After confirmation of the researcher's skills in relation to relaxation by a senior midwifery practitioner, subjects were recruited using a convenience sampling method. Participants were screened using the depression, anxiety and stress scales (DASS) and were selected based on the inclusion and exclusion criteria shown in *Table 1*. During the study, five women in the control group and two women in the intervention group were excluded from the study due to the need for insulin injections. Two participants were excluded from the study before the fifth week. They could attend intervention sessions but were not included in the sample size. These participants were replaced with new ones.

The researcher explained the purpose of the study and asked particpants to sign the written consent form during face-to-face interviews. To prevent contamination between samples, the control group was recruited first.

Table 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
• Gestational age of 24–26 weeks • Diagnosis of gestational diabetes by a physician • Controlling gestational diabetes using diet • Ability to speak and understand Farsi	• History of psychological disorders • History of asthma, chronic blood pressure, or renal and cardiac diseases • History of miscarriage, stillbirth, newborn deaths or infertility • Use of medications affecting blood sugar and pressure • Use of insulin injections • Disruption of pregnancy • Stressful events, such as death of a relative, severe family disputes, accidents or surgery during the study period • Failure to complete relaxation exercises for more than 3 consecutive days • Unwillingness to participate • Pregnancy complications, such as third trimester bleeding and severe infection • Need for psychiatric interventions, including psychiatrist visits • Use of medications

Intervention

The intervention group was taught mind-body relaxation techniques for 10 weeks. Groups of 1–4 participants were taughts at weekly 45-minute sessions using a role-playing technique and educational pamphlet. At the beginning of sessions 1–2, the researcher laid on the bed in a lateral position and performed respiratory techniques and exercise. Participants were asked to do the exercises in the presence of researcher and then at home twice a day with the help of educational CDs. Performance of the techniques at home was recorded in the appropriate checklist: the first checklist was used to record relaxation exercises at home, while the second was for weekly checkups, questions related to exercise, relaxation problems, dietary observation, and a reminder of the next visit.

At the end of each week, the researcher followed up with participants in the intervention group by telephone to emphasised the importance of performing the exercises regularly. The educational content of each session covered important and common issues in pregnancy, the mechanism and causes of diabetes, the nature of stress and its impact on the body, stressors in pregnancy, and vaginal birth. The researcher provided an overview of the educational materials provided and the exercises performed in the previous session. In addition, exercise checklists were collected, questions were answered, and the appropriateness of conducting exercises was monitored.

The control group received routine education in clinic, with information on disease, self-care, diet, and exercises for pregnancy. It must be noted that the participants in control group also had high-risk pregnancies and for this reason, they had more frequent antenatal sessions than low-risk pregnancies. During the study period, they were also visited once every 10–14 days but did not receive a phone call. At the end of the study, the educational pamphlets were given to the control group.

Table 2. Mean and standard deviation of fasting blood sugar in the groups before and after the intervention

	Intervention group Mean ± SD	Control group Mean ± SD	*P* value†
Before intervention	5.45 ± 0.13	5.47 ± 0.12	0.484*
After intervention	5.22 ± 0.28	5.53 ± 0.21	<0/001*
P value	<0/001*	0.051*	

† t-paired and independent t-test. *Statistically significant at $P<0.05$

Table 3. Mean and standard deviation of systolic and diastolic blood pressure in the groups before and after the intervention

	Intervention group Mean ± SD	Control group Mean ± SD	*P* value†
Systolic blood pressure			
Before intervention	109.7 ± 9.604	111.1 ± 11.237	0.558*
After intervention	101.0 ± 8.181	117.8 ± 10.675	<0/001*
P value	<0/001*	<0/001*	
Diastolic blood pressure			
Before intervention	69.2 ± 8.664	68.3 ± 12.163	0.712*
After intervention	68.2 ± 5.723	65.6 ± 9.883	0.151*
P value	0.461*	0.020*	

† t-paired and independent t-test. *Statistically significant at $P<0.05$

Data collection

Fasting blood glucose, systolic blood pressure and diastolic blood pressure were measured in both groups before the start of the study and immediately after the experimental group had finished their last session. A third checklist was used by the researcher to record systolic and diastolic blood pressure and fasting blood glucose before and after the study.

Data gathering tools included a mercury sphygmomanometer; scales and a meter rule to measure weight and height, respectively; a demographic data questionnaire; the DASS instrument for measuring anxiety and depression and the three checklists.

Demographic data were collected by a questionnaire is including questions on personal and medical data. The DASS questionnaire was designed by Lovibond and Lovibond (1995) and included 21 questions on depression (7 questions), anxiety (7 questions) and stress (7 questions). Questions were scored on the Likert scale from 0 (low) to 3 (very high), with a higher score indicating the worse condition. Women with moderate and severe stress levels were not included in the study for homogeneity of samples. Validity and reliability of this instrument were confirmed by Henry and Crawford (2005). The scale also was validated for the Iranian population with coefficients of 0.72, 0.84, and 0.87 for anxiety, depression and stress, respectively (Shafaie et al, 2018).

The questionnaires were given to 10 faculty members, and necessary amendments were incorporated into the questionnaires after collecting their comments. The booklet of relaxation techniques that was provided to the intervention group was prepared after reading books and articles and consultations with experts in the field of relaxation. For content validity, the booklet was provided to 10 faculty members. For face validity, it was given to 5 women, who reviewed and corrected it in terms of ease of comprehension.

Data analysis

Data were analysed using SPSS version 21. Descriptive (mean, percentage and standard deviation) and inferential statistics (Chi-square (χ^2) test, Fisher's exact test, paired-t test) were used for data analysis and $P<0.05$ was considered statistically significant.

Results

In this study, 80 women undergoing dietary treatment were divided into the groups of 40 and were compared before and after the study. The groups were homogenous in terms of education, family history of diabetes, place of residence, employment and income adequacy ($P>0.05$). The results of the independent t-test showed that the two groups had no statistically significant differences in terms of age, number of pregnancies, number of living children, number of abortions, gestational age, weight, height, mean systolic and diastolic blood pressure and fasting blood glucose. Therefore, the groups were homogenous in terms of midwifery and demographic characteristics ($P>0.05$), systolic blood pressure ($P=0.558$), diastolic blood pressure ($P=0.712$) and fasting blood glucose ($P=0.484$) before the study.

No statistically significant difference between the mean fasting blood glucose score before and after the study was observed in the control group ($P=0.051$). Fasting blood sugar in the control group showed no changes before and after the study period, but in the intervention group, this difference was statistically significant and reduced ($P<0.001$) (*Table 2*).

There was a statistically significant difference between the mean systolic blood pressure before and after the study in both groups ($P<0.001$)—this was increased in the group control and reduced in the intervention group. There was also a statistically significant reduction in the mean diastolic blood pressure before and after the study in the control group ($P=0.02$). There was a small reduction in the intervention group, although this was not statistically significant ($P=0.461$) (*Table 3*).

The independent t-test showed that systolic blood pressure and fasting blood glucose were significantly different between the groups ($P<0.001$). The intervention group showed lower mean scores in systolic blood pressure, but the mean score of diastolic blood pressure did not show any significant difference after the study in both groups ($P=0.151$).

Discussion

Fasting blood glucose levels

The mean post-study fasting blood glucose was 99.60 mg/dl (5.53 mmol/l) in the control group and 94.10mg/dl (5.22mmol/l) in the intervention group. Changes in fasting blood glucose levels in the control and intervention groups were +1.05 and -4.08, respectively. This means that participants in the control group saw an increase in fasting blood glucose levels after 10 weeks. In the intervention group, the relaxation practices, educational pamphlets and phone call follow-ups contributed to significant decrease in fasting blood glucose levels. At the second measurement (10 weeks after the first), there was a significant difference in fasting blood glucose levels between the control (5.53 ± 0.21) and the intervention groups (5.22 ± 0.28) ($P<0.001$).

This confirms findings in the study by Kaviani et al (2014) in Shiraz. In another study, Asaadi et al (2013) compared the effectiveness of muscle relaxation education on reducing anger and blood glucose in patients with type 1 and type 2 diabetes, and found that the mean blood glucose in both groups was significantly decreased. A study by Seidi et al (2016) on the effectiveness of bioavailability feedback on depression, anxiety and blood glucose in patients with type 1 diabetes showed that relaxation reduced anxiety and blood glucose, but had no effect on their depression. Stress and anxiety can increase the long-term survival of hormones such as cortisol, epinephrine, norepinephrine, glucagon, growth hormone, prolactin and leptin by activating the hypothalamus-pituitary-adrenal axis, resulting in an increase in blood glucose (Zare et al, 2013; Mahajan, 2014). The physiological effect of relaxation in reducing the activity of the sympathetic nervous system and consequently, reducing plasma cortisol, improves blood glucose level (Seidi et al, 2016).

Systolic blood pressure

The mean score of systolic blood pressure before and after the intervention in the groups was statistically significant ($P<0.001$), indicating a reduction of systolic blood pressure in the intervention group. During pregnancy, the circulation system undergoes significant physiological adaptations, whereby the arterial blood pressure decreases and reaches its lowest level in the 24-26 week period and then increases. During the study, the systolic blood pressure was expected to rise due to the increase of gestational age. This was observed in the control group (mean +6.76 mmHg), but in the intervention group it decreased.

Previous studies have reported the effect of stress and relaxtion on blood pressure in pregnancy (Kaviani et al, 2014; Khani et al, 2014) also reported the effect of relaxation on the reduction of systolic blood pressure, while a review study by Chauhan and Sharma (2017) on the effect of advanced muscle relaxation exercises on blood pressure also showed a positive and beneficial effect of exercise on the reduction of blood pressure. Similarly, in a study by BasiriMoghadam et al (2014) on the effect of the Jacobson relaxation technique on blood pressure and dialysis adequacy in patients undergoing haemodialysis, relaxation reduced blood pressure and increased dialysis adequacy. Azimian et al (2017) studied the effect of relaxation and mental imagery on hypertension in pregnancy and found a significant reduction in systolic and diastolic blood pressure. Relaxation exercises increase the secretion of endorphins and decrease the secretion of adrenaline hormone, cortisol levels, and heart rate and blood pressure in pregnant women (Rahimi et al, 2014). These exercises can also reduce blood pressure and pulse by muscle relaxation, reducing vascular resistance and sympathetic activity, and controlling breathing. However, in a study by Fink (2012) on the effect of relaxation and mental imagery on the cardiovascular function of pregnant women, no change in systolic blood pressure was observed. In explaining this contradiction, Fink et al (2012) used a quick relaxation exercises in each session, which differed from the technique used in this study.

Diastolic blood pressure

The mean diastolic blood pressure after the intervention in both groups was not statistically significant ($P=0.151$), indicating that by performing relaxation techniques, diastolic blood pressure showed limited reduction in the control group (-2.76 mmHg) and in the intervention group (-1 mmHg). In the first half of pregnancy, diastolic

Key points

- Endocrinologists have found that stress and psychoactive stimuli can cause hyperglycaemic conditions and can increase blood pressure in women with diabetes
- Relaxation has an effect on the sympathetic system, which can increase calm and reduce mental stress in pregnant women
- In this study, relaxation exercises reduced fasting blood glucose and systolic blood pressure in women with gestational diabetes mellitus
- Diastolic blood pressure was not significantly reduced after relaxation
- Mind–body relaxation can improve maternal and neonatal outcomes in diabetic pregnant women

CPD reflective questions

- What is the effect of stress in control of diabetes?
- Which hormones reduce after relaxation in pregnant women?
- Why does diastolic blood pressure reduce in the first half of pregnancy?

pressure is reduced due to the dilation of the peripheral vasculatures, which returns to normal during the third trimester. No changes were reported in diastolic blood pressure in the control and intervention groups in studies by Fink et al (2012) or Kaviani et al (2014). Similarly, Jafarnejad et al (2016) found that respiratory control exercises for gestational hypertension showed a greater reduction in systolic pressure than diastolic pressure. In a further study, Abedi Amiri et al (2018) examined the effect of 6 weeks of pranayama breathing exercises on serum cortisol levels and blood pressure in pregnant women in the third trimester of pregnancy. Serum cortisol levels and diastolic blood pressure were found to be reduced, but systolic blood pressure did not show statistically significant changes. This contradiction may be due to different ways of relaxation, and the time and duration of the intervention.

Conclusion

This study has reported the positive effect of relaxation exercises on the reduction of fasting blood glucose levels and systolic blood pressure in women with gestational diabetes. Considering the impact of gestational diabetes on maternal and fetal health, and as there is less emphasis on investigating women's mental health, a comprehensive relaxation exercise programme can be devised to reduce the risks of gestational diabetes by reducing stress.

Limitations

The particular life habits, cultural backgrounds, interests, and motivations of the samples may have impacted the implementation of the intervention, which were factors beyond the researcher's control. BJM

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A randomized clinical trial of exercise during pregnancy to prevent gestational diabetes mellitus and improve pregnancy outcome in overweight and obese pregnant women

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BACKGROUND: Obesity and being overweight are becoming epidemic, and indeed, the proportion of such women of reproductive age has increased in recent times. Being overweight or obese prior to pregnancy is a risk factor for gestational diabetes mellitus, and increases the risk of adverse pregnancy outcome for both mothers and their offspring. Furthermore, the combination of gestational diabetes mellitus with obesity/overweight status may increase the risk of adverse pregnancy outcome attributable to either factor alone. Regular exercise has the potential to reduce the risk of developing gestational diabetes mellitus and can be used during pregnancy; however, its efficacy remain controversial. At present, most exercise training interventions are implemented on Caucasian women and in the second trimester, and there is a paucity of studies focusing on overweight/obese pregnant women.

OBJECTIVE: We sought to test the efficacy of regular exercise in early pregnancy to prevent gestational diabetes mellitus in Chinese overweight/obese pregnant women.

STUDY DESIGN: This was a prospective randomized clinical trial in which nonsmoking women age >18 years with a singleton pregnancy who met the criteria for overweight/obese status (body mass index $24 \leq 28$ kg/m^2) and had an uncomplicated pregnancy at $<12^{+6}$ weeks of gestation were randomly allocated to either exercise or a control group. Patients did not have contraindications to physical activity. Patients allocated to the exercise group were assigned to exercise 3 times per week (at least 30 min/session with a rating of perceived exertion between 12-14) via a cycling program begun within 3 days of randomization until 37 weeks of gestation. Those in the control group continued their usual daily activities. Both groups received standard prenatal care, albeit without special dietary recommendations. The primary outcome was incidence of gestational diabetes mellitus.

RESULTS: From December 2014 through July 2016, 300 singleton women at 10 weeks' gestational age and with a mean prepregnancy body mass index of 26.78 ± 2.75 kg/m^2 were recruited. They were randomized into an exercise group (n = 150) or a control group (n = 150). In all, 39 (26.0%) and 38 (25.3%) participants were obese in each group, respectively. Women randomized to the exercise group had a significantly lower incidence of gestational diabetes mellitus (22.0% vs 40.6%; $P <$ .001). These women also had significantly less gestational weight gain by 25 gestational weeks (4.08 ± 3.02 vs 5.92 ± 2.58 kg; $P <$ .001) and at the end of pregnancy (8.38 ± 3.65 vs 10.47 ± 3.33 kg; $P <$ .001), and reduced insulin resistance levels (2.92 ± 1.27 vs 3.38 ± 2.00; $P =$ .033) at 25 gestational weeks. Other secondary outcomes, including gestational weight gain between 25-36 gestational weeks (4.55 ± 2.06 vs 4.59 ± 2.31 kg; $P =$ .9), insulin resistance levels at 36 gestational weeks (3.56 ± 1.89 vs 4.07 ± 2.33; $P =$ .1), hypertensive disorders of pregnancy (17.0% vs 19.3%; odds ratio, 0.854; 95% confidence interval, 0.434–2.683; $P =$ .6), cesarean delivery (except for scar uterus) (29.5% vs 32.5%; odds ratio, 0.869; 95% confidence interval, 0.494–1.529; $P =$ .6), mean gestational age at birth (39.02 ± 1.29 vs 38.89 ± 1.37 weeks' gestation; $P =$ .5); preterm birth (2.7% vs 4.4%, odds ratio, 0.600; 95% confidence interval, 0.140–2.573; $P =$ .5), macrosomia (defined as birthweight >4000 g) (6.3% vs 9.6%; odds ratio, 0.624; 95% confidence interval, 0.233–1.673; $P =$ .3), and large-for-gestational-age infants (14.3% vs 22.8%; odds ratio, 0.564; 95% confidence interval, 0.284–1.121; $P =$ .1) were also lower in the exercise group compared to the control group, but without significant difference. However, infants born to women following the exercise intervention had a significantly lower birthweight compared with those born to women allocated to the control group (3345.27 ± 397.07 vs 3457.46 ± 446.00 g; $P =$ .049).

CONCLUSION: Cycling exercise initiated early in pregnancy and performed at least 30 minutes, 3 times per week, is associated with a significant reduction in the frequency of gestational diabetes mellitus in overweight/obese pregnant women. And this effect is very relevant to that exercise at the beginning of pregnancy decreases the gestational weight gain before the mid-second trimester. Furthermore, there was no evidence that the exercise prescribed in this study increased the risk of preterm birth or reduced the mean gestational age at birth.

Key words: adverse pregnancy outcome, exercise, gestational diabetes mellitus, obesity, overweight, pregnant women

Introduction

The global epidemics of overweight and obesity are leading health burdens worldwide; moreover, the proportion of overweight and obese women of reproductive age is increasing.[1,2] Overweight and obesity are widely accepted to affect the entire pregnancy process and to constitute major risk factors for perinatal complications, such as gestational diabetes mellitus (GDM), hypertensive syndrome, fetal growth disorders, cesarean delivery, postoperative complications, wound infections, and deep vein thrombosis.[3-7] Among them, GDM is a particular concern because of its own effects on other adverse pregnancy outcomes, such as preeclampsia, macrosomia, or cesarean delivery.[8] Our previous study showed that overweight and obese pregnant women have a >2-fold increased risk of developing GDM compared with nonobese women.[4]

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Related editorials, pages 335 and 338.

Furthermore, the combination of GDM and overweight or obesity aggravates the adverse pregnancy outcomes caused by either factor alone.[9] Importantly, these poor outcomes also potentially impact the long-term health of both the mothers and their offspring.[10-12] Thus, focusing on women who are overweight or obese before pregnancy and seeking ways to decrease their risk of GDM and other adverse pregnancy outcomes are of great importance.

As an important part of lifestyle interventions, exercise has received increasing attention from investigators worldwide. In nonpregnant subjects, the value of regular exercise for reducing the risk of type 2 diabetes and cardiovascular disease is well established.[13,14] However, whether exercise is effective in reducing the risk of GDM and other adverse pregnancy outcomes is not clear because the few randomized controlled trials (RCTs) that investigated these topics showed conflicting results.[15-21] Moreover, most of the current correlative researches were carried out on Caucasian women and few focus on overweight and obese pregnant women. In particular, most exercise training interventions are implemented in the second trimester. However, a recent meta-analysis including 29 RCTs with 11,487 pregnant women addressed that exercise could only play a role in preventing GDM in women with intervention <15 gestational weeks, whereas, among women with intervention afterward, it did not work.[22] In addition, a quasiexperimental study of Chinese pregnant women pointed out that lifestyle intervention including exercise, diet, and weight-gain counseling from 8-12 gestational weeks could lower the risk of GDM.[23]

Therefore, the objective of this study was to determine whether a program of regular exercise begun in early pregnancy could reduce the frequency of GDM in Chinese overweight/obese women.

Materials and Methods

Study design and participants

We conducted a RCT at Peking University First Hospital from December 2014 through July 2016. A flow chart of the protocol is shown in the Figure. Overweight and obesity were determined based on body mass index (BMI) recommendations of the Group of China Obesity Task Force of the Chinese Ministry of Health[24] accounting for interracial differences: overweight BMI $\geq$24-<28 kg/m^2 and obese BMI $\geq$28 kg/m^2. Singleton, nonsmoking pregnant women with a prepregnancy BMI (p-BMI) of $\geq$24 kg/m^2 at <12^{+6} weeks' gestation were eligible for the study. The exclusion criteria were the following: (1) age <18 years; (2) women unwilling to provide informed consent; (3) women with cervical insufficiency (historical painless cervical dilation leading to recurrent second-trimester births in the absence of other causes; dilated cervix on manual or speculum examination; transvaginal ultrasound cervical length <25 mm at <24 weeks of gestation in singleton gestations with $\geq$1 prior spontaneous preterm births at 14-36 weeks)[25]; (4) women on any medication for preexisting hypertension, diabetes, cardiac disease, renal disease, systemic lupus erythematosus, thyroid disease, or psychosis; and (5) women who were currently being treated with metformin or corticosteroids.

This study was reviewed and approved by the Institutional Review Board of Peking University First Hospital (reference number: 2014[726]) and registered at www.clinicaltrials.gov (NCT02304718). All participants provided written informed consent, and the ethics committee approved the consent procedure.

Randomization and masking

Eligible women were randomly allocated (ratio 1:1) into either an exercise intervention group or a control group following an allocation concealment process using an automatic computer-generated random number table. The 3 parts of the randomization process, that is, sequence generation, allocation concealment, and implementation, were conducted by 3 different individuals. Due to the nature of the intervention, all participants and research staff were aware of the allocations.

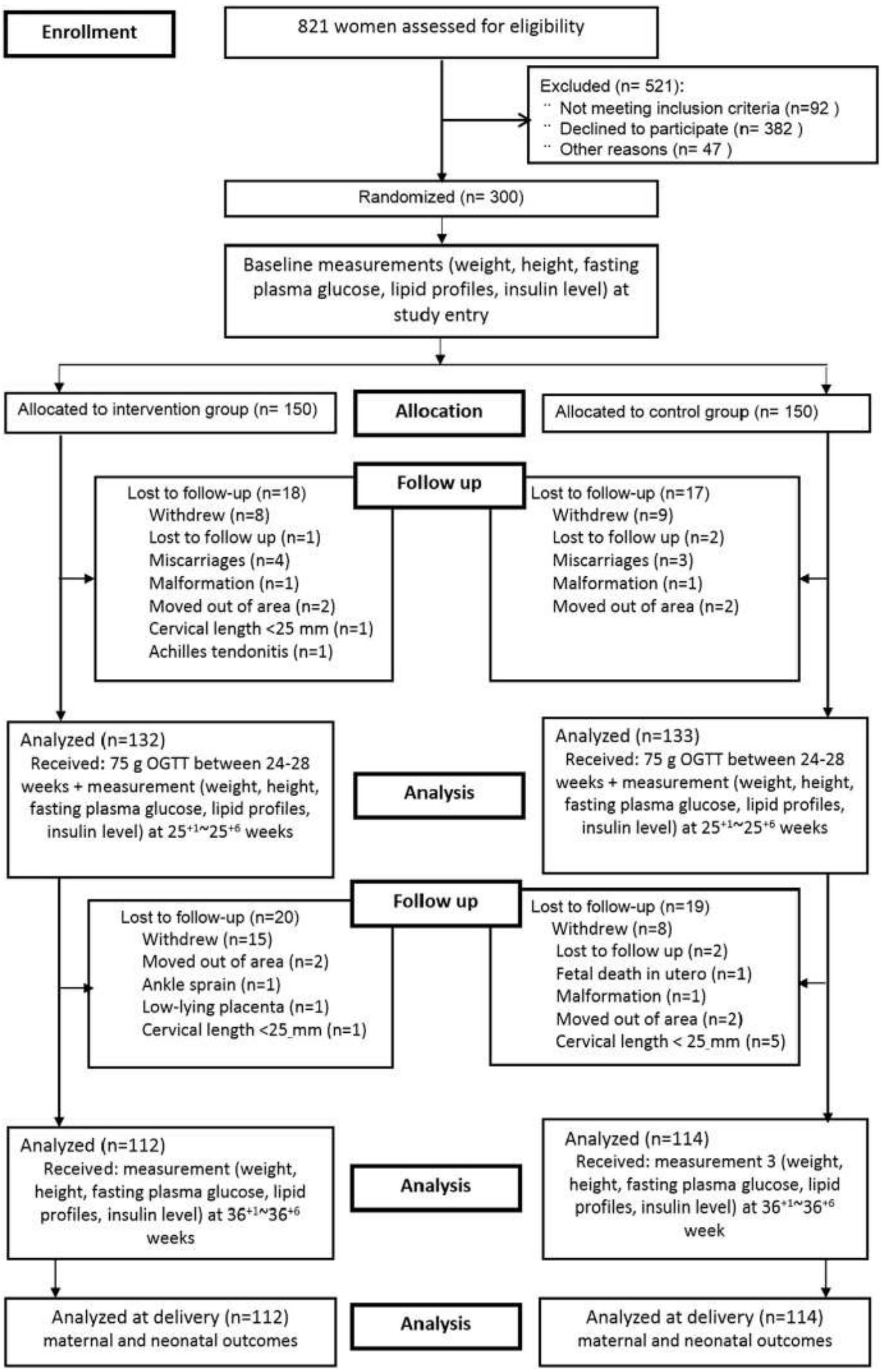
Research procedures

Eligible pregnant women were approached by research staff at a prenatal care class specifically for women in early pregnancy at the Department of Obstetrics and Gynecology, Peking University First Hospital, and provided the project details. Those who were willing to participate were asked to complete a questionnaire to assess demographic information, medical and family history, and current pregnancy information. Qualified participants were then asked to sign informed consent and randomly allocated into a group. Provided permission was granted, and demographic information was collected from women who declined participation.

Participants allocated to the control group continued with their usual daily activities and were not discouraged from participating in exercise sessions on their own. In contrast, the participants randomized to the exercise group engaged in a supervised cycling program involving at least 3 sessions per week. The intervention was initiated within 3 days of randomization and continued to the end of the third trimester (weeks 36-37). All women received standard prenatal care throughout the intervention period, and they had equal numbers of usual visits with their obstetricians during pregnancy. All women received general advice about the positive effects of physical activity during pregnancy, and no special dietary recommendation were given.

The exercise protocol was based on a previous study[26] showing the benefits of regular stationary cycling exercise for blood glucose control in women with GDM. All the exercise sessions occurred at Peking University First Hospital under supervision. Sessions were conducted on alternate days with the supervisor maintaining detailed records regarding the participants' physiological indexes and compliance. At the start of the intervention, each exercise session consisted of stationary cycling for 30 minutes, beginning with a 5-minute warm-up at low intensity, which was 55-65% of the age-predicted heart rate maximum (HRmax) and a rating of perceived exertion (RPE) according to Borg[27] scale between 9-11. RPE is the perceived score of difficulty when

FIGURE
Trial profile



Consolidated standards of reporting trials (CONSORT) 2010 flow diagram of study participants.

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exercising, and is frequently used to subjectively monitor the exercise intensity based on individual perception.[26,28] The Borg[27] scale is the most frequently used method to evaluate individual RPE. This scale ranges from 6-20, where exercise is perceived to be "no exertion at all" to "very very hard," respectively.[27] Subsequently, 5 minutes of continuous moderate-intensity cycling (65-75% of the age-predicted HRmax; RPE 12-14) ensued. Next, the participants completed a period of interval cycling consisting of 30 seconds of rapid pedaling (sprints, higher intensity efforts) at 75-85% of the age-predicted HRmax and RPE 15-16 every 2 minutes for 3-5 intervals. This sprinting was followed by 5 minutes of continuous cycling at low-to-moderate intensity (60-70% of the age-predicted HRmax; RPE 10-12) before beginning another period of interval cycling. During this interval phase, continuous moderate-intensity cycling at 65-75% of the age-predicted HRmax (RPE 12-14) was interspersed with 1-minute periods of pedaling against increased resistance (hill climb) at 75-85% of the age-predicted HRmax (RPE 13-15); these periods alternated every 2 minutes for 3 repeats. Each session ended with a 5-minute cool down of easy cycling. At the start of the intervention, the women exercised at the lower end of the calculated heart rate ranges, with progressive increases as the program continued. Additionally, the exercise duration was progressively increased to 45-60 minutes by adding 5 minutes to the intervals or the continuous moderate-intensity cycling phases according to individual ability. The inclusion of periods of interval cycling was based on a previous study showing benefits for energy expenditure and exercise enjoyment in pregnant women.[29]

All pregnant women who receive standard prenatal care at Peking University First Hospital have 4 routine ultrasound examinations throughout pregnancy at $11\text{-}13^{+6}$, $20\text{-}23^{+6}$, $30\text{-}30^{+6}$, and $36\text{-}36^{+6}$ gestational weeks. Cervical length was measured at each examination. Due to the possibility of an increased risk of preterm birth caused by cycling-induced shortening of cervical length, to ensure and evaluate the safety of exercise during pregnancy, we recorded and reviewed cervical length at each examination and excluded those women with a cervical length <25 mm at any time during the intervention because uterine cervix length is an accurate predictor of the risk of preterm birth.[30] For consistency, we also excluded those participants in the control group with a cervical length <25 mm.

Furthermore, at study entry, we measured each participant's height to the nearest 0.5 cm without shoes and weight accurate to 0.1 kg with light clothing. BMI was calculated as maternal weight divided by height (kg/m^2). Additionally, blood was drawn from the antecubital vein after the participant had fasted for at least 8 hours but not >14 hours and was collected in sterile vacutainer tubes preloaded with heparin. There was at least 24 hours between the last exercise bout and the time of blood draw. Blood was centrifuged at 1800*g* at 4°C for 10 minutes within 4 hours of collection; subsequently, the plasma was separated and glucose was measured immediately. The remaining plasma was stored at −80°C for later analysis of insulin and lipid parameters (triglyceride, total cholesterol, and low- and high-density lipoprotein cholesterol). Insulin was measured using radioimmunoassay commercial kits (Beifang Institute of Biochemical Technology, Beijing, China). The insulin resistance index was calculated according to the homeostasis model of assessment: fasting plasma insulin (μU/mL) × fasting glucose (mmol/L)/22.5.[31] Fasting lipid profiles were measured using an automatic analyzer (7600; Hitachi High-Technologies Corp, Tokyo, Japan) in the Department of Clinical Laboratory, Peking University First Hospital. Maternal body weight measurement and biochemical tests were repeated at 25 and 36 gestational weeks.

To assess the participants' physical activity levels during pregnancy, the International Physical Activity Questionnaire[32] was used at study entry and at 25 and 36 weeks' gestation. The questionnaire included questions about the number of days per week and the time spent sitting, walking, and doing moderate and vigorous activities, and then a score, which is expressed as metabolic equivalents of task min/wk, can be calculated using the formula 8.0 × vigorous activity + 4.0 × moderate activity + 3.3 × light activity (walking) for the different activity categories.[33]

At 24-28 weeks' gestation, all participants underwent a 75-g oral glucose tolerance test (OGTT) after an overnight fast to diagnose GDM. Similarly, at least 24 hours elapsed between the last exercise session and the OGTT. According to the new criteria amended in August 2014 in China, GDM was diagnosed when any 1 value was ≥5.1 mmol/L at 0 hours, ≥10.0 mmol/L at 1 hour, or ≥8.5 mmol/L at 2 hours. Values of 7.0 mmol/L at 0 hours or 11.1 mmol/L at 2 hours were diagnosed as diabetes mellitus, regardless of pregnancy stage.[34]

Outcomes

The primary outcome was the incidence of GDM (this has been reported as a letter in *Diabetes Care*,[35] but this article includes a number of other important outcomes). The secondary outcomes included physical activity levels; gestational weight gain; biochemical outcomes, including insulin resistance and lipid profiles; maternal outcomes, such as gestational hypertension (defined as blood pressure elevation [systolic blood pressure ≥140 mm Hg or diastolic blood pressure ≥90 mm Hg] >20 weeks' gestation in the absence of proteinuria),[36] preeclampsia (defined as new-onset hypertension [systolic blood pressure ≥140 mm Hg or diastolic blood pressure ≥90 mm Hg] and new-onset proteinuria [300 mg of protein in 24 hours or a urine protein/creatinine ratio of 0.3 mg/dL] >20 weeks' gestation or, in the absence of proteinuria, new-onset hypertension with new-onset thrombocytopenia, renal insufficiency, impaired liver function, pulmonary edema, or cerebral or visual disturbances),[36] and mode of delivery (vaginal, operative vaginal, or cesarean); and neonatal outcomes, including gestational age at delivery, preterm birth (<37 and <34 weeks), Apgar score, birthweight, macrosomia (birthweight >4000 g), large-for-gestational-age (LGA) infants (birthweight >90th percentile for gestational age), and small-for-gestational-age (SGA) infants (birthweight <10th percentile for gestational age), both LGA and SGA were defined in accordance with international standards for sex-specific newborn size for each gestational age based on data from the Newborn Cross-Sectional Study subpopulation.[37]

Statistical analysis

We calculated that a sample size of 121 participants in each group was sufficient to detect a 50% reduction in the incidence of GDM with an α of 0.05 and a statistical power (1-β) of 0.8 based on our previous study.[4] Assuming a dropout rate of 10-15%, the target sample size was 150 in each group.

Data were analyzed using statistical software (SPSS, 17.0, IBM Corp, Armonk, NY). Continuous variables are presented as mean ± SD, and categorical variables are presented as numbers and percentages. Differences in the means between groups were evaluated using independent sample *t* tests and analysis of variance. Pearson χ^2 test was used for categorical variables. Analysis was by intention to treat. The level of statistical significance was set at .05.

Results

From December 2014 through July 2016, 821 pregnant women with a BMI ≥24 kg/m^2 were screened for eligibility. Among those individuals, 300 singleton women at 10 weeks' gestational age and with a mean p-BMI of 26.78 ± 2.75 kg/m^2 were recruited. They were randomized to either the exercise group (n = 150) or the control group (n = 150). In all, 39 (26.0%) and 38 (25.3%) participants were obese in each group, respectively. The baseline characteristics of these individuals are summarized in Table 1, and the 2 groups were well matched at baseline, with no significant differences in age, p-BMI, gestational age, family history of diabetes, personal history of GDM, or fasting plasma glucose at study entry. Compared with women who declined to participate but agreed to the use of their routine data, the participants had a fasting plasma glucose that was 0.08 mmol/L higher and were more likely to have a family history of diabetes mellitus ($P < .05$).

As shown in the Figure, a total of 38 and 36 participants did not complete the follow-up in the exercise group and the

TABLE 1
Baseline characteristics of participants

Characteristics	Exercise group n = 150	Control group n = 150	P
Age, y	32.14 ± 4.57	32.50 ± 4.91	.5
Weight, kg	70.83 ± 8.49	70.44 ± 8.55	.7
Height, cm	162.64 ± 5.07	161.97 ± 4.87	.2
p-BMI, kg/m^2	26.75 ± 2.74	26.82 ± 2.76	.8
Obese, BMI ≥28 kg/m^2	39 (26.0)	38 (25.3)	.9
Maternal birthweight, g	3302.38 ± 432.38	3244.46 ± 561.66	.3
≥College/university, %	119 (79.3)	110 (73.3)	.7
Gestational age, wk	10 ± 2	10 ± 2	.8
Primiparous	120 (80.0)	121 (80.7)	.9
Family history of diabetes, %	49 (32.7)	47 (31.3)	.8
Personal history of GDM, multiparous only, %	4 (13.33)	3 (10.34)	.7
Fasting plasma glucose at study entry, mmol/L	5.04 ± 0.37	5.04 ± 0.41	1.0

Continuous variables presented as mean ± SD; categorical variables presented as n (%).

BMI, prepregnancy body mass index; *GDM*, gestational diabetes mellitus; *p-BMI*, prepregnancy body mass index.

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control group, respectively, and the main reason was their unwillingness to participate further. The frequency of potential adverse events associated with exercise, such as miscarriage and fetal death in utero, did not differ between the exercise and control groups. Furthermore, the number of participants excluded due to a cervical length <25 mm was comparable between the groups. The 7 women with a cervical length <25 mm in our study were followed up for adverse events; however, none of them experienced a miscarriage or fetal loss during their pregnancy. Notably, 3 of these women in the control group had a preterm birth (1 case at <34 weeks' gestation; 2 cases between 34^{+1} and 36^{+6} weeks' gestation).

The effect of exercise on the frequency of GDM

Overall, the total number (mean ± SD) of exercise sessions attended was 73 ± 10 (range 60-130) over a period of 27 ± 2 weeks; 90% of the participants in the exercise group were >80% compliant with the supervised cycling program, and the lowest attendance rate was 73%. The mean duration of each session was 35 ± 6 minutes at an RPE of 13 ± 1, equivalent to a perception of working out "somewhat hard."

In total, 132 participants (88.0%) in the exercise group and 133 (88.7%) in the control group underwent the 75-g OGTT, and their results were used for analysis of the primary outcome. The incidence of GDM was 22.0% (29/132) in the exercise group and 40.6% (54/133) in the control group (odds ratio [OR], 0.412; 95% confidence interval [CI], 0.240−0.705; $P < .001$). This represents a clinically important 45.8% reduction in the incidence of GDM. Furthermore, the exercise group had lower blood glucose levels at 0, 1, and 2 hours on the postintervention 75-g OGTT compared to the control group ($P = .001$, $P = .009$, and $P = .009$, respectively).

Physical activity

Physical activity levels preintervention and at 25 and 36 gestational weeks based on the International Physical Activity Questionnaire are shown in Table 2. The main form of physical activity in the control group was walking. The exercise group had higher total physical activity levels than the control group at 25 weeks' gestation (1741 ± 798 vs 1327 ± 1300 metabolic equivalents of task min/wk; $P = .010$) and at 36 weeks' gestation (1642 ± 862 vs 1388 ± 1044 metabolic equivalents of task min/wk; $P = .123$) and this was attributed to greater levels of moderate-intensity exercise at 25 weeks' gestation (484 ± 220 vs 64 ± 360 metabolic equivalents of task min/wk; $P < .001$) and at 36 weeks' gestation (436 ± 177 vs 81 ± 239 metabolic equivalents of task min/wk; $P < .001$). The levels of vigorous physical activity and walking were similar between and within groups at 25 and 36 gestational weeks.

Secondary outcomes

Following the intervention, the women randomized to the exercise group had significantly less gestational weight gain compared with those in the control group by 25 gestational weeks (4.08 ± 3.02 vs 5.92 ± 2.58 kg; $P < .001$) and at the end of pregnancy (8.38 ± 3.65 vs 10.47 ± 3.33 kg; $P < .001$). However, the 2 groups exhibited no significant difference in gestational weight gain between 25-36 weeks' gestation (4.55 ± 2.06 vs 4.59 ± 2.31 kg; $P = .896$). Furthermore, following the intervention, insulin resistance was significantly lower in the exercise group than in the control group

TABLE 2
Physical activity levels in overweight and obese pregnant women randomized to exercise intervention or control groups

	Exercise group	Control group	*P*
Vigorous exercise, metabolic equivalents of task min/wk			
At study entry	0, n = 150	0, n = 150	
At 25 wk gestation	34 ± 1630, n = 132	0, n = 133	.04
At 36 wk gestation	8 ± 48, n = 112	0, n = 114	.1
Moderate exercise, metabolic equivalents of task min/wk			
At study entry	33 ± 146, n = 150	11 ± 71, n = 150	.1
At 25 wk gestation	484 ± 220, n = 132	64 ± 360, n = 133	<.001
At 36 wk gestation	436 ± 177, n = 112	81 ± 239, n = 114	<.001
Walking, metabolic equivalents of task min/wk			
At study entry	1141 ± 1107, n = 150	1113 ± 1167, n = 150	.8
At 25 wk gestation	1224 ± 722, n = 132	1263 ± 1116, n = 133	.9
At 36 wk gestation	1198 ± 839, n = 112	1307 ± 996, n = 114	.5
Total, metabolic equivalents of task min/wk			
At study entry	1195 ± 1154, n = 150	1124 ± 1183, n = 150	.6
At 25 wk gestation	1741 ± 798, n = 132	1327 ± 1300, n = 133	.01
At 36 wk gestation	1642 ± 862, n = 112	1388 ± 1044, n = 114	.1

Data presented as mean ± SD unless otherwise specified.

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at 25 weeks' gestation (2.92 ± 1.27 vs 3.38 ± 2.00; *P* = .033). No differences were noted between the groups in the preintervention or postintervention levels of plasma triglycerides, total cholesterol, and low- and high-density lipoprotein cholesterol. The frequency of hypertensive disorders of pregnancy, including both gestational hypertension and preeclampsia (17.0% vs 19.3%; OR, 0.854; CI, 0.434−2.683; *P* = .649), and cesarean delivery (except for scar uterus) (29.5% vs 32.5%; OR, 0.869; 95% CI, 0.494−1.529; *P* = .627) did not differ significantly between the exercise and control groups. Similarly, no significant differences were observed between the 2 groups with regard to the gestational age at birth (39.02 ± 1.29 vs 38.89 ± 1.37 weeks' gestation; *P* = .486), the percentage of preterm births (2.7% vs 4.4%; OR, 0.600; 95% CI, 0.140−2.573; *P* = .487), or the Apgar score at 1 or 5 minutes. However, infants born to women following the exercise intervention had a significantly lower birthweight compared with those born to women allocated to the control group (3345.27 ± 397.07 vs 3457.46 ± 446.00; *P* = .049, *P* = .049). But, in the exercise group vs control group, there were no significant differences in the frequency of macrosomia (6.3% vs 9.6%; OR, 0.624; 95% CI, 0.233−1.673; *P* = .345) and LGA (14.3% vs 22.8%; OR, 0.564; 95% CI, 0.284−1.121; *P* = .100). Notably, 3 cases of SGA were observed in the exercise group with none in the control group (Table 3).

Comment

We conducted a prospective RCT to evaluate the efficacy of regular exercise begun in early pregnancy to prevent GDM in overweight and obese pregnant women. The main results of our study suggest the following. First, overweight/obese women allocated to the exercise group have a significantly lower frequency of gestational diabetes than those allocated to the control group. Second, the exercise group had significantly less gestational weight gain before mid-second trimester and at the end of pregnancy, and lower insulin resistance levels at 25 gestational weeks than the control group. Third, other pregnancy outcomes, including hypertensive disorders of pregnancy, cesarean delivery, mean gestational age at birth, macrosomia, and LGA infants, were also lower in the exercise group compared to the control group, but without significant difference. However, infants born to women following the exercise intervention had a significantly lower birthweight compared with those born to women allocated to the control group. Fourth, no increased exercise-related safety issues, such as miscarriage, fetal loss, short cervical length, or preterm birth, was observed in women allocated to the exercise group.

The role of exercise in preventing and treating diseases has been widely studied. In particular, various studies have confirmed that exercise is effective in delaying the progression of glucose

TABLE 3
Maternal and neonatal outcomes

	Exercise group	Control group	OR (95% CI)	*P*
GDM, %	29 (22.0), n = 132	54 (40.6), n = 133	0.412 (0.240–0.705)	<.001
75-g OGTT glucose level, mmol/L				
0 h	4.76 ± 0.41[b]	4.96 ± 0.51[c]	/	.001
1 h	7.99 ± 1.67[b]	8.57 ± 1.86[c]	/	.009
2 h	6.57 ± 1.18[b]	7.03 ± 1.62[c]	/	.009
Gestational weight gain, kg				
Study entry to 25^{+6} wk gestation	4.08 ± 3.02[b]	5.92 ± 2.58[c]	/	<.001
26^{+1} to 36^{+6} wk gestation	4.55 ± 2.06[d]	4.59 ± 2.31[e]	/	.9
Total	8.38 ± 3.65[d]	10.47 ± 3.33[e]	/	<.001
HOMA-IR				
At study entry	2.70 ± 1.33[a]	2.69 ± 1.25[a]	/	.9
At 25 wk gestation	2.92 ± 1.27[b]	3.38 ± 2.00[c]	/	.033
At 36 wk gestation	3.56 ± 1.89[d]	4.07 ± 2.33[e]	/	.1
Plasma triglycerides, mmol/L				
At study entry	1.33 ± 0.78[a]	1.34 ± 0.63[a]	/	.9
At 25 wk gestation	2.53 ± 1.14[b]	2.67 ± 0.85[c]	/	.3
At 36 wk gestation	3.39 ± 1.19[d]	3.50 ± 1.11[e]	/	.5
Plasma total cholesterol, mmol/L				
At study entry	4.27 ± 0.74[a]	4.30 ± 0.68[a]	/	.7
At 25 wk gestation	5.54 ± 1.03[b]	5.67 ± 0.90[c]	/	.3
At 36 wk gestation	5.82 ± 1.09[d]	5.81 ± 1.11[e]	/	.9
Plasma HDL-C, mmol/L				
At study entry	1.46 ± 0.32[a]	1.46 ± 0.31[a]	/	.9
At 25 wk gestation	1.79 ± 0.34[b]	1.77 ± 0.32[c]	/	.9
At 36 wk gestation	1.72 ± 0.32[d]	1.65 ± 0.30[e]	/	.1
Plasma LDL-C, mmol/L				
At study entry	2.32 ± 0.56[a]	2.30 ± 0.60[a]	/	.9
At 25 wk gestation	2.78 ± 0.78[b]	2.91 ± 0.72[c]	/	.2
At 36 wk gestation	2.94 ± 0.82[d]	2.93 ± 0.84[e]	/	.9
Hypertensive disorders of pregnancy	19/112 (17.0)	22/114 (19.3)	0.854 (0.434–1.683)	.6
PE	8/112 (7.1)	7/114 (6.1)	1.176 (0.412–3.359)	.8
Gestational hypertension	11/112 (9.8)	15/114 (13.2)	0.719 (0.315–1.642)	.4
Labor and delivery				
Unassisted vaginal delivery	59/112 (52.7)	50/114 (43.9)	1.425 (0.844–2.406)	.2
Operative vaginal delivery	7/112 (6.3)	15/114 (13.2)	0.440 (0.172–1.124)	.1
Cesarean delivery (except for scar uterus)	33/112 (29.5)	37/114 (32.5)	0.869 (0.494–1.529)	.6
Gestational age at birth	39.02 ± 1.29[d]	38.89 ± 1.37[e]	/	.5

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TABLE 3
Maternal and neonatal outcomes *(continued)*

	Exercise group	Control group	OR (95% CI)	*P*
Preterm birth				
<34 wk gestation	0	1/114 (0.9)	/	
34^{+1} to 36^{+6} wk gestation	3/112 (2.7)	4/114 (3.5)	0.757 (0.166–3.461)	.7
Total	3/112 (2.7)	5/114 (4.4)	0.600 (0.140–2.573)	.5
Apgar score				
At 1 min	9.95 ± 0.30[d]	9.80 ± 1.03[e]	/	.1
At 5 min	10[d]	9.93 ± 0.51[e]	/	.1
Birthweight, g	3345.27 ± 397.07, n = 112	3457.46 ± 446.00[e]	/	.049
Macrosomia	7/112 (6.3)	11/114 (9.6)	0.624 (0.233–1.673)	.3
LGA	16/112 (14.3)	26/114 (22.8)	0.564 (0.284–1.121)	.1
SGA	3/112 (2.7)	0	/	

Data are presented as n (%) or mean ± SD unless otherwise specified.

Acrosomia is defined as birthweight >4000 g; LGA and SGA are defined as birthweight >90th or <10th percentile for gestational age, respectively; furthermore, both LGA and SGA were defined in accordance with international standards for sex-specific newborn size for each gestational age based on data from Newborn Cross-Sectional Study subpopulation.[37]

CI, confidence interval; *GDM*, gestational diabetes mellitus; *HDL-C*, high-density lipoprotein cholesterol; *HOMA-IR*, homeostasis model assessment of insulin resistance index [fasting plasma insulin (μU/mL) × fasting glucose (mmol/L)/22.5][31]; *LDL-C*, low-density lipoprotein cholesterol; *LGA*, large for gestational age; *OGTT*, oral glucose tolerance test; *OR*, odds ratio; *PE*, preeclampsia; *SGA*, small for gestational age.

[a] n = 150; [b] n = 132; [c] n = 133; [d] n = 112; [e] n = 114.

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intolerance in type 2 diabetes.[38] Considering the similar pathogenesis of GDM and type 2 diabetes, recent research focused on the relationship between exercise and the incidence of GDM. However, the results of the few well-designed RCTs are inconsistent. Particularly, a recent meta-analysis including 10 RCTs of physical activity and GDM from 1966 through 2014 showed that exercise interventions had a 28% (95% CI, 9–42%) reduction in the incidence of GDM (relative risk, 0.72; $P = .005$) compared to controls.[39] However, only 2 of the 10 included studies showed a protective effect of exercise on GDM independently. This finding may be due to small sample size, low adherence, and loss to follow-up in some of these individual studies.

Cordero et al[15] showed that moderate exercise implemented 3 times per week from 10-12 weeks of gestation was effective in preventing the development of GDM. In contrast, Nobles et al[40] reported that an exercise intervention started in the second trimester did not reduce the relative odds for GDM in women at high risk (those with at least 1 of the following: p-BMI ≥25 kg/m^2, family history of diabetes, GDM in previous pregnancy). Recently, a study using a supervised stationary cycling exercise program similar to that used in the current study reported no effect on GDM incidence. However, it is important to point out critical differences between the studies, including the commencement of exercise earlier in pregnancy, as well as a focus on overweight and obese women in the present trial, rather than women with GDM in a previous pregnancy with higher background levels of physical activity in the prior study.[28]

These results suggest that preventing the development of GDM in women with risk factors might be challenging. Alternatively, they highlight the importance of seeking effective ways to reduce the incidence of GDM in high-risk populations.

Among the established risk factors for GDM, prepregnancy overweight and obesity are the main health care challenges.[41] Our previous study showed that the incidence of GDM was 29.55% and 35.88% in women with p-BMI ≥24-<28 kg/m^2 and ≥28 kg/m^2, respectively.[4] Moreover, the prevalence of overweight and obesity in recent decades is increasing worldwide. As shown in one study, the global number of overweight and obese individuals was 2.1 billion in 2013, accounting for 38% of the total population.[41] Similar trends were observed in China, with the prevalence of overweight and obesity increasing from 10.7-14.4% and 5.0-10.1%, respectively, from 1993 through 2009.[42] And one of our studies based on 15 hospitals in Beijing with 14,168 pregnant women showed that the prevalence of overweight and obesity in pregnant women was as high as 19.1% in 2013.[43] Therefore, an urgent need exists to address health issues surrounding GDM, overweight/obesity, and diabetes.

Our study targeted overweight/obese pregnant women and demonstrated the robust ability of regular exercise to reduce GDM risk. These positive results may be attributed, at least in part, to the supervision of the program, which ensured the exercise intensity and the high level of adherence. Moreover, starting the intervention early in pregnancy may have played an important role in the effectiveness of our protocol.

For example, 2 recent well-designed RCTs, The United Kingdom Pregnancies Better Eating and Activity Trial (UPBEAT)[16] and the pilot study of Vitamin D and Lifestyle Intervention for GDM Prevention,[18] focused on the role of lifestyle intervention in preventing GDM in women with obesity. Unfortunately, neither study proved the efficacy of exercise in reducing the incidence of GDM. However, the exercise was not supervised, and both trials initiated the interventions in the second trimester, which may be too late to prevent the development of GDM considering that endocrine and metabolic changes begin in the first trimester[44] and placental function may be programmed by this time.[45] Thus, early intervention may be more effective. This hypothesis is supported by a meta-analysis suggesting that prepregnancy exercise may have a greater role in reducing the risk of developing GDM than exercise started in early pregnancy. Moreover, prepregnancy exercise continued into early pregnancy had the strongest beneficial effect.[46]

Numerous studies suggest that excessive gestational weight gain is another vital independent risk factor for GDM; the risk of GDM increases as the rate of gestational weight gain increases.[47,48] This may be due to the reason that excess gestational weight gain is associated primarily with maternal adipose tissue, but not with lean body mass accrual.[49] Furthermore, studies have indicated that the association between the rate of gestational weight gain and GDM has been primarily attributed to the increased weight gain in the first trimester.[48,50] Importantly, in our study, women in the exercise group had significantly less gestational weight gain than women in the control group by 25 weeks' gestation and at the end of pregnancy. However, no significant difference in gestational weight gain was observed between the 2 groups between 25-36 weeks' gestation, perhaps because all the women with GDM initiated lifestyle interventions after their GDM diagnosis, and the proportion of women with GDM in the control group was as high as 40%. Nevertheless, our study is one of several other studies showing that physical exercise at the beginning of pregnancy decreases mean gestational weight gain and is associated with decrease of GDM incidence.[23,51]

Additionally, our study clearly shows that exercise attenuates the increase in insulin resistance in the population of overweight-obese pregnant women at 25 weeks of gestation, possibly revealing the underlying mechanism by which exercise prevents GDM. And this result was supported by other studies. Davenport et al[52] reported that walking intervention could significantly lower glucose concentrations in the fasted state and 1 hour after meals in women with GDM, moreover, women with walking intervention required fewer units of insulin per day and less injection frequency. Similarly, the RCT conducted by Brankston et al[53] showed that compared to GDM women treated with diet alone, women treated with diet plus resistance exercise were prescribed less insulin and had a longer delay from diagnosis to the initiation of insulin therapy. However, the exact pathogenesis for exercise on improving insulin sensitivity and subsequently reducing the frequency of GDM remains unclear. Several mechanisms, such as stimulating insulin sensitivity by muscle contraction, enhancing antioxidant defense mechanisms, and altering adipokine profiles, such as adiponectin, leptin, resistin, might be implicated.[54]

Besides, our results favored a significant reduction in neonatal birthweight in overweight and obese women following an exercise intervention, and the frequency of hypertensive disorders of pregnancy, cesarean delivery, macrosomia, and LGA was also lower than those of the control group, even though were not significant. These findings probably were because the sample size in our study was calculated on the incidence of GDM, and may be too small to demonstrate a positive result on these perinatal outcomes.

Decades ago, researchers began to focus on the relationship between exercise and maternal and neonatal outcomes. However, the results have been inconsistent due to the considerable variation in study design. The UPBEAT study showed no significant differences between groups in the frequency of LGA and other outcomes such as mode of delivery, preeclampsia, postpartum hemorrhage, and birthweight.[16] The Australian LIMIT RCT[19] also showed that lifestyle interventions addressing diet and exercise, which were similar to those used in the UPBEAT study, had no effect on reducing the proportion of LGA in overweight and obese pregnant women; however, the proportion of infants weighing >4 kg was lower in the women allocated to the intervention group. A recent meta-analysis[55] including 14 RCTs reported that an exercise program during pregnancy was effective at reducing neonatal birthweight, moreover, did not negatively affect gestational age at delivery. Barakat et al[56] showed that a 3 d/wk exercise program with sessions lasting 50-55 minutes from 9-11 gestational weeks until 38-39 weeks was effective in preventing the development of hypertension and reducing the incidence of macrosomia.

High birthweight is the top concerns of overweight and obese women, for it is well recognized to be associated with immediate birth consequences, such as shoulder dystocia and fetal asphyxia.[57] Furthermore, it may lead to a long-term increase in the risks of obesity and metabolic syndrome in childhood and adulthood,[58] Thus, according to the results of our study and those of other investigators, the modest reduction in neonatal birthweight caused by an exercise intervention during pregnancy may have positive health benefits not only during the perinatal phase but also in the long term.

Notably, even though not significant, 3 women in the exercise group gave birth to SGA infants in our study. The birthweights of their infants were 2470, 2605, and 2280 g at 40, 39, and 38 gestational weeks, respectively. The respective total gestational weight gain of these 3 mothers was 0.8 kg loss, 2.5 kg, and

3.6 kg, and all of them had high compliance with the cycling program (98%, 90%, and 85%, respectively). Therefore, we reasoned that these women additionally might have been strict with their diet, which together with exercise caused the development of SGA. Thus, when we provide exercise recommendations to pregnant women, we must comprehensively evaluate their diet and gestational weight gain and direct close attention to fetal development.

Generally, the amount of physical activity during pregnancy is low. Very few pregnant women meet the minimum American Congress of Obstetricians and Gynecologists recommendations regarding the amount of exercise during pregnancy.[59] Based on the International Physical Activity Questionnaire, the data in our study showed that only 10.7% and 9.1% of the subjects in the exercise group and the control group participated in moderate physical activity at study entry, and the predominant physical activity performed by pregnant Chinese women was walking. However, the exercise intervention was effective in providing an incremental increase in physical activity in the exercise group, whereas the level of physical activity in the control group remained stable.

We previously reported that excessive fatigue and concerns about the safety of exercise are the greatest barriers to exercise during pregnancy in Chinese women.[60] However, our study showed that moderate exercise will not cause the cervix to shorten; increase the risk of miscarriage, fetal loss, or preterm birth; or reduce the mean gestational age at delivery. In addition, a recent meta-analysis including 9 RCTs also showed that aerobic exercise (35-90 min/session, 3-4 times/wk) during pregnancy was not associated with increased risk of preterm birth.[61] Thus, considering the benefits and safety of exercise demonstrated in our study and other studies, increasing the physical activity level of pregnant women is important. However, specific recommendations on the type, form, frequency, intensity, duration, or starting time of exercise to prevent diseases during pregnancy are lacking. According to our study, regular moderate-intensity cycling at a frequency of at least 3 sessions per week with each session lasting at least 30 minutes begun in early pregnancy was safe and effective in preventing GDM in overweight and obese pregnant women.

Strengths and weaknesses

Our study is the first RCT performed in China to assess the effectiveness and safety of regular exercise in preventing GDM and improving adverse pregnancy outcomes in overweight and obese women. The major strength of our study is the supervised cycling exercise intervention we employed, which ensured the appropriate amount and intensity of exercise and high adherence to the intervention program. Furthermore, our intervention did not include a dietary component, which facilitated our ability to discern the effect of exercise itself on outcomes. Assuredly, this intervention was also a study weakness that restrained us from further analyzing and comparing the respective and combined roles of exercise and dietary interventions. However, women in the 2 groups all received standard care, which included information regarding how to maintain a healthy lifestyle during pregnancy. Notwithstanding, further studies with detailed descriptions of the different types of dietary interventions and physical activity are needed.

The impracticality of instituting this type of a supervised activity program for pregnant women on a mass scale may be another potential limitation of the present study. Furthermore, our study focused on a Chinese population and was conducted in a tertiary care hospital in Beijing, which may lower the external validity of our findings. Nonetheless, our study confirmed the safety and potential of thrice weekly cycling initiated early in pregnancy to improve the health of overweight and obese pregnant women. Large longitudinal prospective studies involving multiple centers or ethnicities remain warranted to fully address the ability of different types of interventions to diminish long-term and other complications associated with pregnancy and delivery.

In summary, we observed that cycling exercises initiated early in pregnancy and performed at least 30 minutes 3 times per week had a significant effect on lowering the risk of GDM in overweight and obese pregnant women and may affect their offspring size at birth. And the decrease of GDM is very relevant to the reduced gestational weight gain in pregnancy. Furthermore, such exercise does not increase the risk of preterm birth or reduce the mean gestational age at birth and should therefore be recommended. Thus, in the absence of contraindications, regular exercise should be recommended as an important part of antenatal care. ■

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Prenatal exercise for the prevention of gestational diabetes mellitus and hypertensive disorders of pregnancy: a systematic review and meta-analysis

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ABSTRACT

Objective Gestational diabetes mellitus (GDM), gestational hypertension (GH) and pre-eclampsia (PE) are associated with short and long-term health issues for mother and child; prevention of these complications is critically important. This study aimed to perform a systematic review and meta-analysis of the relationships between prenatal exercise and GDM, GH and PE.

Design Systematic review with random effects meta-analysis and meta-regression.

Data sources Online databases were searched up to 6 January 2017.

Study eligibility criteria Studies of all designs were included (except case studies) if published in English, Spanish or French, and contained information on the Population (pregnant women without contraindication to exercise), Intervention (subjective or objective measures of frequency, intensity, duration, volume or type of exercise, alone ["exercise-only"] or in combination with other intervention components [e.g., dietary; "exercise + co-intervention"]), Comparator (no exercise or different frequency, intensity, duration, volume and type of exercise) and Outcomes (GDM, GH, PE).

Results A total of 106 studies (n=273 182) were included. 'Moderate' to 'high'-quality evidence from randomised controlled trials revealed that exercise-only interventions, but not exercise+cointerventions, reduced odds of GDM (n=6934; OR 0.62, 95% CI 0.52 to 0.75), GH (n=5316; OR 0.61, 95% CI 0.43 to 0.85) and PE (n=3322; OR 0.59, 95% CI 0.37 to 0.9) compared with no exercise. To achieve at least a 25% reduction in the odds of developing GDM, PE and GH, pregnant women need to accumulate at least 600 MET-min/week of moderate-intensity exercise (eg, 140 min of brisk walking, water aerobics, stationary cycling or resistance training).

Summary/conclusions In conclusion, exercise-only interventions were effective at lowering the odds of developing GDM, GH and PE.

INTRODUCTION

In 2011, the *American Heart Association Effectiveness-Based Guidelines for the Prevention of Cardiovascular Disease in Women* listed pregnancy complications including pre-eclampsia (PE), gestational hypertension (GH) and gestational diabetes mellitus (GDM) as risk factors as strong as smoking for the future development of cardiovascular disease.[1] The strength of this relationship is supported by evidence of elevated risk for future type 2 diabetes (risk ratio (RR) 7.43), hypertension (RR 3.70), ischaemic heart disease (RR 2.26) and stroke (RR 1.8) in the 5–15 years following delivery.[2 3] Furthermore, GDM, GH and PE are also associated with adverse outcomes in the offspring, such as excessive or inadequate fetal growth, fetal growth restriction, preterm delivery, perinatal death and long-term metabolic and cardiovascular morbidity.[4–6] Prevention of these disorders during pregnancy is therefore essential for the future health of two generations.

Gestational diabetes is defined as 'glucose intolerance with onset or first recognition during pregnancy' and affects up to 6%–9% of the obstetric population.[7] Hypertensive disorders of pregnancy include GH and PE and affect 10% of women.[8] Although the disorders are distinct, GDM, GH and PE are often superimposed.[9] These disorders have similar risk factors (eg, obesity, insulin resistance, advanced maternal age, excessive gestational weight gain)[8 10] and are associated with inflammation, vascular dysfunction, oxidative stress and vascular disease.[6] Exercise is a cornerstone for prevention and treatment of hypertension and diabetes in general populations; however, the effectiveness of exercise in prevention during pregnancy is poorly understood.

International and national guidelines for exercise during pregnancy recommend that women without contraindications be physically active throughout pregnancy.[11 12] The present systematic review and meta-analysis was conducted as part of a series of reviews which will form the evidence base for the development of the *2019 Canadian guideline for physical activity throughout pregnancy* (herein referred to as *Guideline*).[13] The purpose of this review was to evaluate the effect of prenatal exercise on the odds of developing GDM, GH and PE.

METHODS

In October 2015, the Guidelines Consensus Panel assembled to identify priority outcomes for the

Guidelines update. The Panel included researchers, methodological experts, a fitness professional and representatives from the Canadian Society for Exercise Physiology (CSEP), the Society of Obstetricians and Gynaecologists of Canada (SOGC), the College of Family Physicians of Canada, the Canadian Association of Midwives, the Canadian Academy of Sport and Exercise Medicine, Exercise is Medicine Canada and a representative health unit (the Middlesex-London Health Unit). The Guidelines Consensus Panel identified 20 'critical' and 17 'important' outcomes related to prenatal exercise and maternal/fetal health. Three of the 'critical' outcomes (ie, GDM, GH and PE) are examined in this review. This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, and the checklist was completed.[14]

Protocol and registration

Two systematic reviews examining the impact of prenatal exercise on fetal and maternal health outcomes were registered a priori with PROSPERO, the International Prospective Register of Systematic Reviews (*fetal health*: Registration No CRD42016029869; *maternal health*: Registration No CRD42016032376). Since the relationships between prenatal exercise and GDM, GH and PE were examined in studies related to both fetal and maternal health, records retrieved from the searches for both of these reviews were evaluated for inclusion in the present study.

Eligibility criteria

The PICOS (population, intervention, comparison, outcome, study design) framework[15] was used to guide this review.

Population

The population of interest was pregnant women without absolute or relative contraindication to exercise as defined by the *2003 SOGC/CSEP Clinical Practice Guidelines for Exercise During Pregnancy*.[11 16] Absolute contraindications to exercise were defined as: ruptured membranes, premature labour, persistent second or third trimester bleeding, placenta previa, PE, GH, incompetent cervix, intrauterine growth restriction, high-order pregnancy, uncontrolled type 1 diabetes, hypertension or thyroid disease, or other serious cardiovascular, respiratory or systemic disorders. Relative contraindications to exercise were defined as: a history of spontaneous abortion, premature labour, mild/moderate cardiovascular or respiratory disease, anaemia or iron deficiency, malnutrition or eating disorder, twin pregnancy after 28 weeks or other significant medical conditions.[11 16]

Intervention (exposure)

The intervention/exposure was subjective or objective measures of frequency, intensity, duration, volume or type of exercise. Although exercise is a subtype of physical activity, for the purpose of this review we used the terms interchangeably. Exercise was defined as any bodily movement generated by skeletal muscles that resulted in energy expenditure above resting levels.[17] Acute (ie, a single exercise session) or habitual (ie, usual activity) prenatal exercise, as well as interventions including exercise alone (termed 'exercise-only' interventions) or in combination with other interventions (such as diet; termed 'exercise+co-interventions'), was considered. Studies were excluded if exercise was performed after the beginning of labour.

Comparison

Eligible comparators were: no exercise; different frequency, intensity, duration, volume or type of exercise; different intervention duration; or exercise in a different trimester.

Outcome

Relevant outcomes were GDM (as defined by individual study authors), GH (defined as diastolic blood pressure ≥90 mm Hg on at least two measurements at ≥20 weeks' gestation, or as pregnancy-induced hypertension without additional specification) and PE (defined as GH combined with proteinuria).[8]

Study design

Primary studies of any design were eligible, except case studies. Narrative or systematic reviews and meta-analyses were excluded.

Information sources

A structured search was created and run by a research librarian using the Ovid interface (MEDLINE, EMBASE, PsycINFO, Cochrane Database of Systematic Reviews, Cochrane Central Register of Controlled Trials), the EBSCO interface (CINAHL Plus with Full-text, Child Development & Adolescent Studies, ERIC, Sport Discus), Scopus, Web of Science Core Collection, ClinicalTrials.gov and the Trip Database up to 6 January 2017. See the online supplement for complete search strategies.

Study selection and data extraction

Titles and abstracts of all retrieved articles were independently screened by two reviewers. Abstracts that were judged to have met the initial screening criteria by at least one reviewer were retrieved as full-text articles. The article was reviewed for relevant PICOS information by at least one person. If it was deemed that the article did not meet the inclusion criteria, it was reviewed by MHD and/or SMR prior to exclusion. If agreement could not be reached by discussion, the study characteristics were presented to the *Guidelines Steering Committee* who oversaw the systematic reviews (MHD, MFM, SMR, CEG, VJP, AJG and NB) and a final decision regarding inclusion/exclusion was made by consensus. Studies that were selected were imported into DistillerSR (Evidence Partners, Ottawa, ON, Canada) for data extraction. At this point, studies from the maternal and fetal reviews that were included were deduplicated against one another in DistillerSR and were considered as one review from this point forward.

Data extraction tables were created in DistillerSR in consultation with methodological experts and the *Guidelines Steering Committee*. Data were extracted by one person; a content expert (MHD, MFM or SMR) then independently verified the extracted data. Reviewers were not blinded to study authors. For each single study, the most recent or complete version (publication) was selected as the 'parent' paper; however, relevant data from all publications related to each unique study were extracted. Study characteristics (ie, year, study design, country) and population characteristics (eg, number of participants, age, pre-pregnancy body mass index (BMI), parity and pregnancy complications), intervention/exposure (actual and/or prescribed exercise frequency, intensity, duration and type, duration of the intervention, measure of physical activity) and outcomes (GDM, GH and PE) were extracted (see online supplement table 1). If data were not available for extraction, the authors were contacted for additional information.

Quality of evidence assessment

The Grading of Recommendations Assessment, Development and Evaluation (GRADE) framework was used to assess the quality of evidence across studies for each study design and health outcome.

Evidence from randomised controlled trials (RCT) began with a 'high' quality of evidence rating and was graded down if there was a concern with the risk of bias, indirectness, inconsistency, imprecision or risk of publication bias because these factors reduce the level of confidence in the observed effects. Evidence from all non-randomised interventions and observational studies began with a 'low'-quality rating and, if there was no cause to downgrade, was upgraded if applicable according to the GRADE criteria (eg, large magnitude of effect, evidence of dose–response).[18]

Specifically, the risk of bias in RCTs and intervention studies was assessed following the Cochrane Handbook[19] and the risk of bias in observational studies was assessed using the characteristics recommended by Guyatt *et al*,[20] which has been used by other Physical Activity Guidelines.[21] All studies (RCTs, intervention studies and observational studies) were screened for potential sources of bias including selection bias (RCT/intervention: inadequate randomisation procedure; observational: inappropriate sampling), reporting bias (selective/incomplete outcome reporting), performance bias (RCT/intervention: compliance to the intervention; observational: flawed measurement of exposure), detection bias (flawed measurement of outcome), attrition bias (incomplete follow-up, high loss to follow-up) and 'other' sources of bias. Risk of bias across studies was rated as 'serious' when studies having the greatest influence on the pooled result (assessed using weight (%) given in forest plots or sample size in studies that were narratively synthesised) presented 'high' risk of bias. The greatest influence on the pooled result was determined as follows: the studies that had the greatest individual % contribution in the meta-analyses, when taken together, contributed to >50% of the weight of the pooled estimate. Serious risk of bias was considered when the sample size of studies that were narratively synthesised was similar to the total sample size of studies contributing to >50% of the weight of the pooled estimate in the meta-analyses. Given the nature of exercise interventions, it is not possible to blind participants to group allocation. Therefore, if the only source of bias was related to the blinding of allocation, the risk of bias was rated as 'low'. Performance bias was rated as 'high' when <60% of participants performed 100% of prescribed exercise sessions or attended 100% of counselling sessions (defined as low compliance) or when compliance to the intervention was not reported. Attrition bias was rated as 'high' when >10% of data were missing at the end of the study and intention-to-treat analysis was not used. Due to time constraints and feasibility, one reviewer evaluated the quality of the evidence across each health outcome using the protocol and a second person reviewed the GRADE tables as a quality control measure.

Indirectness was considered serious when exercise-only interventions and exercise+cointerventions were combined for analysis or when the effect of exercise+cointervention on odds of GDM, GH or PE was assessed. Inconsistency was considered serious when heterogeneity was high ($I^2 \geq 50\%$) or when only one study was assessed (I^2 unavailable). Imprecision was considered serious when the 95% CI crossed the line of no effect, and was wide, such that interpretation of the data would be different if the true effect were at one end of the CI or the other. When only one study was assessed, imprecision was not considered serious as inconsistency was already considered serious for this reason. Finally, in order to assess publication bias, funnel plots were created if at least 10 studies were included in the forest plot (see online supplement figures 25–39). If there were fewer than 10 studies, publication bias was deemed non-estimable and not rated down. Quality of evidence assessment is presented in online supplement tables 2–4.

Statistical analysis

Statistical analyses were conducted using Review Manager V.5.3 (Cochrane Collaboration, Copenhagen, Denmark). ORs were calculated for all dichotomous outcomes. Significance was set at $p<0.05$. Inverse-variance weighting was applied to obtain OR using a random effects model. Meta-analyses were performed separately by study design. For RCTs and non-randomised interventions, sensitivity analyses were performed to evaluate whether the effects were different when examining relationships between exercise-only interventions versus exercise+cointerventions and GDM, GH and PE. Exercise-only studies could include standard care. When possible, the following a priori determined subgroup analyses were conducted for exercise-only interventions and observational studies: (1) women diagnosed with diabetes (gestational, type 1 or type 2) compared with women without diabetes (named 'general population'); (2) samples of women with overweight or obesity (mean BMI $>25.0\,kg/m^2$) prior to pregnancy compared with samples of women who were of various BMI (mean BMI $<25\,kg/m^2$ but possibly with some individuals with BMI $>25.0\,kg/m^2$; named 'general population'); (3) women >35 years of age compared with women <35 years of age; (4) women who were previously inactive compared with those who were previously active (as defined by individual study authors). Tests for subgroup differences were conducted, with statistical significance set at $p \leq 0.05$. Only when statistically significant differences were found subgroup differences were interpreted. If a study did not provide sufficient detail to allow it to be grouped into the a priori subgroups, then a third group called 'unspecified' was created. The I-squared (I^2) was calculated to indicate the per cent of total variability that was attributable to between-study heterogeneity. In studies where there were no observed events in the intervention or control group, data were entered into forest plots, but were considered 'not estimable' and excluded from the pooled analysis as per the recommendation in the Cochrane Handbook.[22] In order to identify a clinically meaningful decrease in GDM, GH and PE, dose–response meta-regression[23–25] was carried out by weighted no-intercept regression of log OR with a random effects for study, using the *metafor*[26] package in R[27] V.3.4.1. It was determined that an accepted cut-point for a clinically meaningful decrease does not exist in the literature. As such, a reduction of 25% was chosen based on expert opinion. Models did not include an intercept term since the log OR is assumed to be zero when the exercise dose is zero. Restricted cubic splines with knots at the 10th, 50th and 90th percentiles of the explanatory variable[28] were used to investigate whether there was evidence for a non-linear relationship. Fitting was performed by maximum likelihood, and non-linearity was assessed using a likelihood ratio test. When the model was statistically significant at $p<0.05$, the minimum exercise dose to obtain a clinically significant benefit was estimated by the minimum value of the explanatory variable at which the estimated OR was less than 0.75. Finally, subgroup analyses were conducted for exercise-only RCTs to identify whether a specific type of exercise was associated with greater benefit.

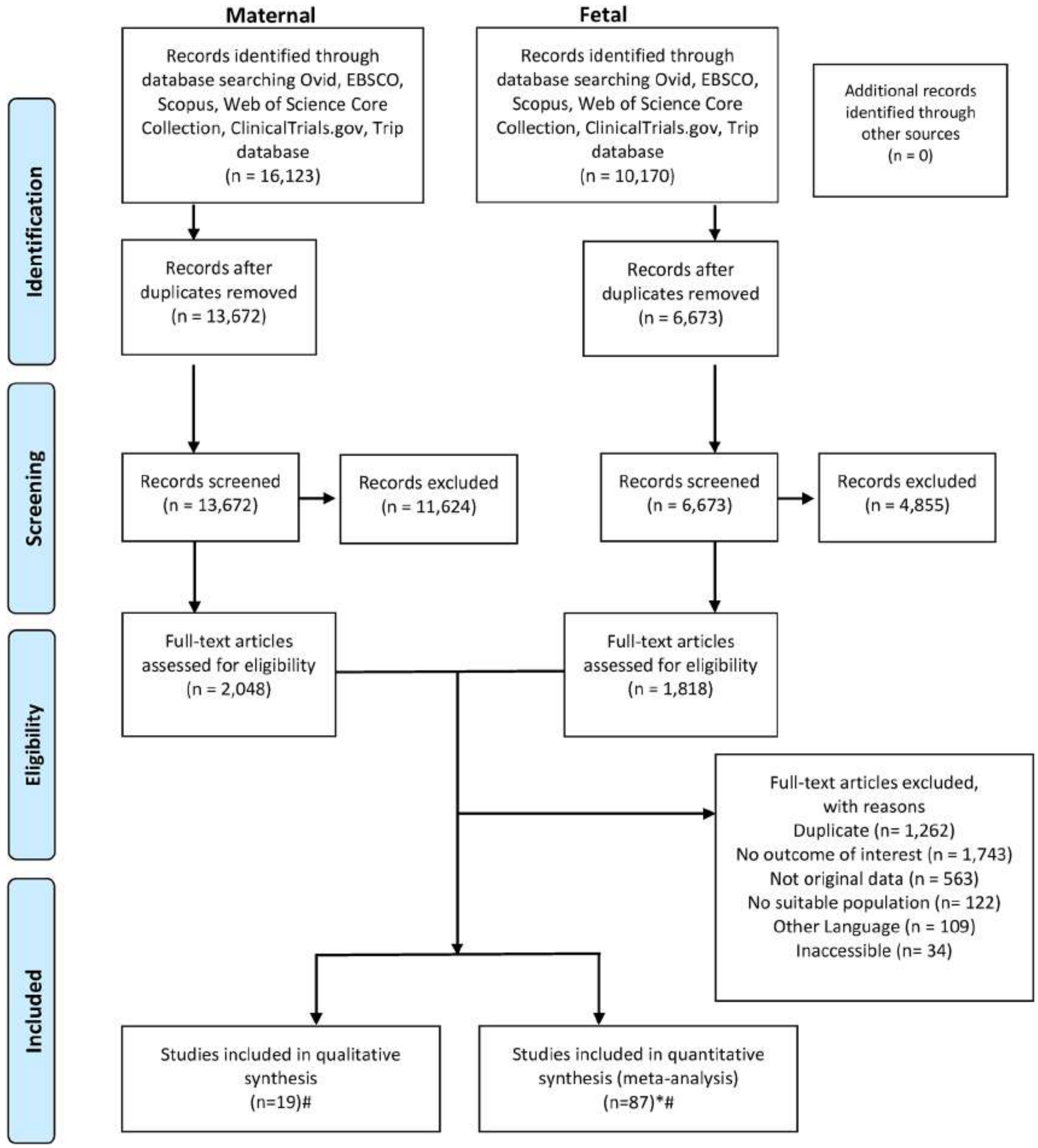

Figure 1 Flow diagram of studies selected for the present study. *Eighty-nine papers included in quantitative synthesis but three were from the same cohort study and counted as one unique study. #Five studies were included in both the qualitative and quantitative synthesis.

For outcomes or for subsets of studies where a meta-analysis was not possible, a narrative synthesis of the results was presented, organised around each outcome. Within each outcome, results were presented by study design. Unless otherwise specified, studies were not included in meta-analyses if data were incomplete (SD, SE or number of cases/controls not provided), if data were adjusted for confounding factors, or if the study did not include a non-exercising control group. In studies where data were included in the meta-analysis but additional information was available, the studies were included in both the meta-analysis and narrative synthesis.

RESULTS

Study selection

The initial search was not limited by language. However, the *Guidelines Steering Committee* decided to exclude studies published in languages other than English, Spanish or French for feasibility reasons. A PRISMA diagram of the search results, including reasons for exclusion, is shown in figure 1. A comprehensive list of excluded studies is presented in the online supplement. The results of the meta-regression analysis are presented in the online supplement (*Meta-regressions*).

Study characteristics

Overall, 106 unique studies (n=273 182 women) from 27 countries and five continents were included. There were 65 RCTs, 9 non-RCTs, 13 cohort, 11 cross-sectional and 8 case–control studies. Among the included exercise interventions, the frequency of exercise ranged from 1 to 7 days/week, the duration of exercise ranged from 10 to 90 min per session, and the types of exercise included walking, swimming, cycling, water gymnastics, resistance training, stretching, yoga or pelvic floor muscle training. Additional details about the studies can be found in the online supplement (*Study Characteristics* and online supplement table 1). No studies looked at the effect of exercising in different trimesters on the odds of developing GDM, GH or PE.

The results of the RCTs are presented below; the results of other study designs are presented in the online supplement.

Quality of evidence

Overall, the quality of evidence ranged from 'very low' to 'high' (see online supplement tables 2–4). The most common reasons for downgrading the quality of evidence were (1) serious risk of bias that reduced the level of confidence in the observed effects, and (2) indirectness of the interventions being assessed. Common sources of bias included poor or unreported compliance with the intervention and inappropriate treatment of missing data when attrition rate was high.

Synthesis of data

Gestational diabetes mellitus

Overall, there was 'low'-quality evidence from 46 RCTs (n=14 923) regarding the association between prenatal exercise and GDM.[29–74] The quality of evidence was downgraded from 'high' to 'low' because of serious risk of bias and serious indirectness of the interventions. Overall, prenatal exercise was associated with 24% lower odds of developing GDM compared with no exercise (pooled estimate based on 45 RCTs, n=14 823; OR 0.76, 95% CI 0.65 to 0.88, I^2=31%, figure 2).[29–73] The one additional study[74] that could not be included in the meta-analysis (no statistics provided) indicated there were no differences in GDM between women randomised to an intensive dietary and lifestyle counselling programme, including recommendations about physical activity (n=57), and those randomised to routine prenatal care (n=43) (online supplement table 1).

Sensitivity analysis

The pooled estimate for the exercise-only interventions was significantly different from the pooled estimate for the exercise+cointervention subgroups (p=0.007). Specifically, exercise-only interventions reduced the odds of developing GDM by 38% compared with no exercise (26 RCTs, n=6934; OR 0.62, 95% CI 0.52 to 0.75, I^2=0%; 'moderate'-quality evidence, downgraded due to serious risk of bias, figure 2).[29–54] There was no statistically significant difference for those participating in exercise+cointerventions (figure 2).

Subgroup analyses

The tests for subgroup differences performed for exercise-only interventions were not statistically significant (see online supplement figures 1–4).

Observational studies

Findings from non-randomised interventions,[75–80] cohort[81–95] and cross-sectional[96–102] studies were consistent with the findings from RCTs. The findings from case–control studies showed no significant relationship between prenatal exercise and GDM but had a point estimate similar to that from other study types[103–105] (see the online supplement for more details and online supplement figures 5–8).

Gestational hypertension

Overall, there was 'low'-quality evidence from 34 RCTs (n=9755) regarding the association between prenatal exercise and GH.[29 31–38 41–43 45 46 50 51 56 59 60 63 66 68–70 106–115] The quality of evidence was downgraded from 'high' to 'low' because of serious risk of bias and serious indirectness of the interventions. The pooled estimate based on 32 RCTs (n=9648) indicated 19% lower odds of GH with exercise compared with no exercise (OR 0.81, 95% CI 0.65 to 1.00, I^2=8%, figure 3).[29 31–38 41–43 45 46 50 51 56 59 60 63 66 68–70 106–111 113 114] Two superiority trials (n=107) could not be entered into the meta-analysis because they did not include a control group (online supplement table 1). In one of these studies, Yeo *et al*[112] reported GH incidence to be 22% (95% CI 8.7 to 35.2) in women randomised to a walking intervention (n=41) and 40% (95% CI 23.2 to 55.8) in those randomised to a stretching intervention (n=38). In the other study, McAuley *et al*[115] reported two cases of GH in each intervention group (aerobic and muscular exercise group (n=14) and muscular exercise group (n=14)).

Sensitivity analysis

The pooled estimate for the exercise-only interventions was significantly different from the pooled estimate for the exercise+cointervention subgroups (p=0.04). Specifically, exercise-only interventions reduced the odds of developing GH by 39% (22 RCTs, n=5316; OR 0.61, 95% CI 0.43 to 0.85, I^2=0%; 'high'-quality evidence, figure 3).[29 31–38 41–43 45 46 50 51 106–111] There was no statistically significant difference for those participating in exercise+cointerventions (figure 3).

Subgroup analysis

The tests for subgroup differences performed for exercise-only interventions were not statistically significant (see online supplement figures 9–12).

Observational studies

Findings from non-randomised interventions[78 79 116 117] were consistent with findings from RCTs. The findings from cohort[82 84 85 88 89 91 92 118] or cross-sectional[96 119–122] studies showed no significant relationship between prenatal exercise and GH but had a point estimate similar to that from other study types (see the online supplement for more details, and online supplement figures 13–16).

Pre-eclampsia

Overall, there was 'low'-quality evidence from 27 RCTs (n=10 256) indicating no association between prenatal exercise and PE.[30 36 38 42 43 45 46 50 52 56 58–60 63 64 68–71 107 110 112 123–127] The quality of evidence was downgraded from 'high' to 'low' because of serious risk of bias and serious indirectness of the interventions. The pooled estimate was based on 26 RCTs (n=10 177; OR 0.89, 95% CI 0.73 to 1.08, I^2=0%, figure 4).[30 36 38 42 43 45 46 50 52 56 58–60 63 64 68–71 107 110 123–127] The one superiority exercise-only trial could not be entered into the meta-analysis because it did not include a control group (see online supplement table 1). Yeo *et al*[112] reported that PE incidence was 14.6% (95% CI 5.6 to 29.2) among women in a walking group (n=41) and 2.6% (95% CI 0.07 to 13.8) among those in a stretching group (n=38).

Sensitivity analysis

The pooled estimate for the exercise-only interventions was not significantly different from the pooled estimate for the exercise+cointervention subgroups (p=0.05). However, exercise-only interventions reduced the odds of developing PE by 41% (16 studies, n=3401; pooled estimate based on 15 studies, n=3322; OR 0.59, 95% CI 0.37 to 0.94, I^2=0%; 'moderate'-quality evidence, downgraded due to serious risk of bias, figure 4).[30 36 38 42 43 45 46 50 52 107 110 123–126] There was no statistically significant difference for those participating in exercise+cointerventions (figure 4).

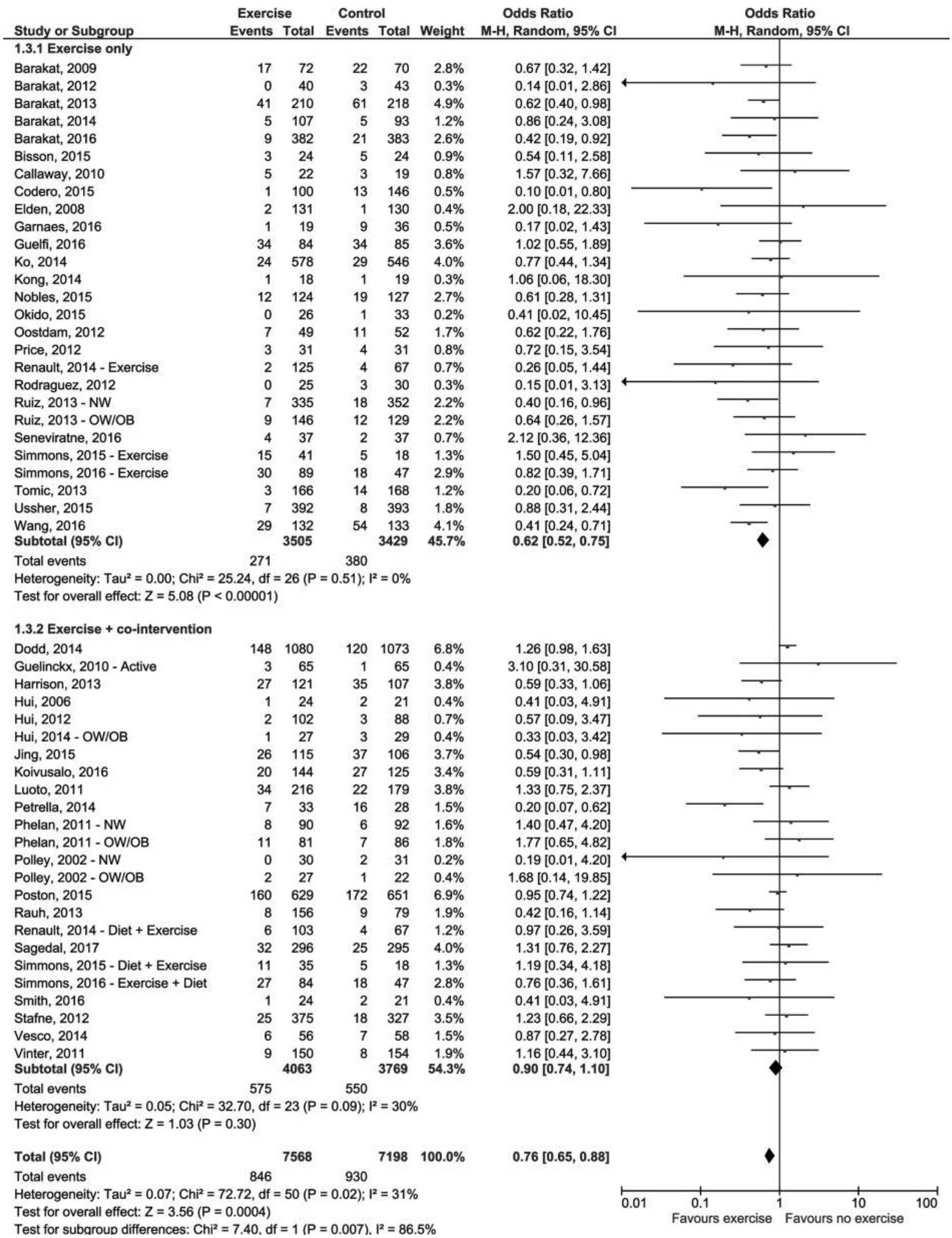

Figure 2 Effects of prenatal exercise compared with control on odds of gestational diabetes mellitus (RCTs). Sensitivity analyses were conducted with studies including exercise-only interventions and those including exercise +co- interventions. Analyses conducted with a random effects model. CI, confidence interval; df, degrees of freedom; M-H, Mantel-Haenszel method. Active: women who were previously active; Exercise: exercise arm of the intervention; Exercise + co-intervention; NW: subgroup of normal weight women; OW/OB: subgroup of women with overweight/obesity.

Subgroup analysis

The tests for subgroup differences performed for exercise-only interventions were not statistically significant (see online supplement figures 17–20).

Observational studies

Findings from cohort[83 86–88 91 92 118 128–130] and case–control studies[131–134] were consistent with findings from RCTs. The findings from non-randomised interventions[78–80 135] and

Study or Subgroup	Exercise Events	Exercise Total	Control Events	Control Total	Weight	Odds Ratio M-H, Random, 95% CI
1.2.1 Exercise alone						
Barakat, 2009	1	80	2	80	0.8%	0.49 [0.04, 5.56]
Barakat, 2011	1	40	2	40	0.8%	0.49 [0.04, 5.60]
Barakat, 2012	0	40	1	43	0.4%	0.35 [0.01, 8.84]
Barakat, 2013	5	255	4	255	2.5%	1.25 [0.33, 4.73]
Barakat, 2014	1	128	2	114	0.8%	0.44 [0.04, 4.93]
Barakat, 2016	8	382	22	383	5.9%	0.35 [0.15, 0.80]
Bisson, 2015	2	24	3	24	1.3%	0.64 [0.10, 4.20]
Codero, 2015	2	122	2	220	1.2%	1.82 [0.25, 13.06]
Garnaes, 2016	1	19	7	36	1.0%	0.23 [0.03, 2.03]
Haakstad, 2011	1	52	0	53	0.4%	3.12 [0.12, 78.27]
Hopkins, 2010	0	49	1	47	0.4%	0.31 [0.01, 7.88]
Kong, 2014	0	18	0	19		Not estimable
Murtezani, 2014	1	35	1	37	0.6%	1.06 [0.06, 17.61]
Pelaez, 2014	0	73	2	96	0.5%	0.26 [0.01, 5.44]
Perales, 2015	1	38	3	25	0.9%	0.20 [0.02, 2.02]
Price, 2012	0	31	3	31	0.5%	0.13 [0.01, 2.61]
Renault, 2014 - Exercise	4	125	2	67	1.5%	1.07 [0.19, 6.02]
Rodraguez, 2012	2	40	0	40	0.5%	5.26 [0.24, 113.11]
Ruiz, 2013 - NW	5	335	20	352	4.2%	0.25 [0.09, 0.68]
Ruiz, 2013 - OW/OB	8	146	10	129	4.5%	0.69 [0.26, 1.80]
Seneviratne, 2016	1	37	0	37	0.4%	3.08 [0.12, 78.14]
Tomic, 2013	4	166	5	168	2.5%	0.80 [0.21, 3.05]
Ussher, 2015	13	392	13	393	6.4%	1.00 [0.46, 2.19]
Subtotal (95% CI)		**2627**		**2689**	**38.0%**	**0.61 [0.43, 0.85]**
Total events	61		105			
Heterogeneity: Tau² = 0.00; Chi² = 16.76, df = 21 (P = 0.73); I² = 0%						
Test for overall effect: Z = 2.93 (P = 0.003)						
1.2.2 Exercise + co-intervention						
Avery, 1997	0	15	1	14	0.4%	0.29 [0.01, 7.74]
Dodd, 2014	101	1080	94	1073	22.4%	1.07 [0.80, 1.44]
Guelinckx, 2010 - Active	18	42	14	43	5.2%	1.55 [0.64, 3.76]
Hollingsworth, 1987 - Non Diabetic	0	12	0	8		Not estimable
Hollingsworth, 1987 - Type 1 Diabetic	2	13	2	21	1.0%	1.73 [0.21, 14.05]
Koivusalo, 2016	7	144	6	125	3.4%	1.01 [0.33, 3.10]
Petrella, 2014	1	33	7	28	1.0%	0.09 [0.01, 0.82]
Phelan, 2011 NW	3	90	11	92	2.5%	0.25 [0.07, 0.94]
Phelan, 2011OW/OB	17	81	11	86	5.8%	1.81 [0.79, 4.15]
Polley, 2002NW	2	30	4	31	1.4%	0.48 [0.08, 2.85]
Polley, 2002OW/OB	4	27	4	22	1.9%	0.78 [0.17, 3.57]
Renault, 2014 - Diet + Exercise	5	130	2	67	1.6%	1.30 [0.25, 6.89]
Stafne, 2012	11	385	11	340	5.6%	0.88 [0.38, 2.06]
Vinter, 2011 - PE/GH	23	150	28	150	9.6%	0.79 [0.43, 1.44]
Subtotal (95% CI)		**2232**		**2100**	**62.0%**	**0.95 [0.72, 1.27]**
Total events	194		195			
Heterogeneity: Tau² = 0.04; Chi² = 14.32, df = 12 (P = 0.28); I² = 16%						
Test for overall effect: Z = 0.32 (P = 0.75)						
Total (95% CI)		**4859**		**4789**	**100.0%**	**0.81 [0.65, 1.00]**
Total events	255		300			
Heterogeneity: Tau² = 0.03; Chi² = 37.10, df = 34 (P = 0.33); I² = 8%						
Test for overall effect: Z = 1.92 (P = 0.05)						
Test for subgroup differences: Chi² = 4.05, df = 1 (P = 0.04), I² = 75.3%						

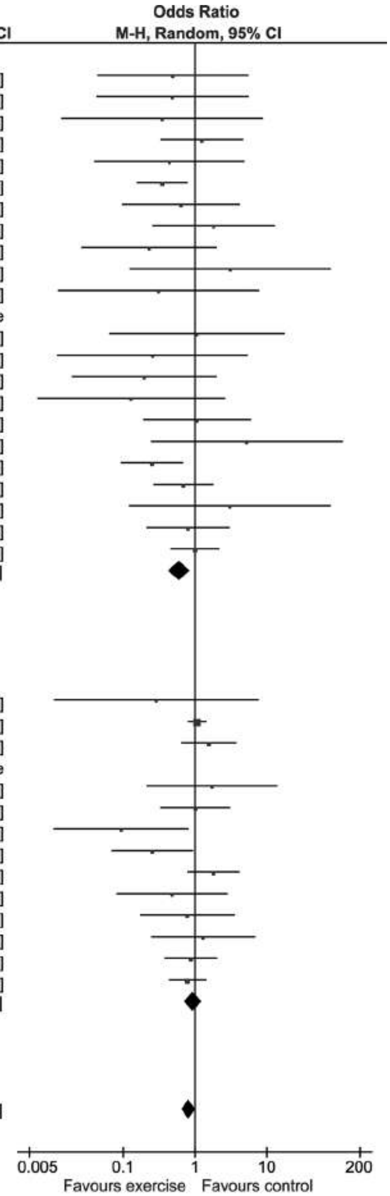

Figure 3 Effects of prenatal exercise compared with control on the odds of gestational hypertension (RCTs). Sensitivity analyses were conducted with studies including exercise-only interventions and those including exercise +co- interventions. Analyses conducted with a random effects model. CI, confidence interval; df, degrees of freedom; M-H, Mantel-Haenszel method. Active: women who were previously active; Exercise: exercise arm of the intervention; NW: subgroup of normal weight women; Non-Diabetic: subgroup of non-diabetic women; OW/OB: subgroup ofwomen with overweight/obesity. PE/GH:PE/GH combined as the outcome; Type 1 Diabetic: subgroup of type 1 diabetic women. *Note: studies with zero events in both arms are included in the forest plot but are "not estimable" and not included in the pooled analysis.*

cross-sectional studies[101 121] showed no significant relationship between prenatal exercise and PE but had a point estimate similar to that from other study types (see the online supplement for more details, and online supplement figures 21–24).

Meta-regressions

Meta-regression analysis using linear and spline regression was conducted for each outcome. Linear models were presented unless the fit of the spline was significantly better ($p<0.05$). Minimum exercise thresholds required to achieve a clinically meaningful reduction (ie, 25%) in health outcomes were identified. GDM (see online supplement figures 28–32): 2.9 METs (light intensity), 25.3 min, 2.1 days/week or 590.6 MET-min/week; GH (see online supplement figures 33–37): 3.2 METs (moderate intensity), 23.5 min, 3.1 days/week or 401.1 MET-min/week; PE (see online supplement figures 38–42): 3.2 METs (moderate intensity), 18.3 min, 2.5 days/week or 260.0 MET-min/week.

DISCUSSION

In this comprehensive systematic review of 106 studies, there was 'moderate' to 'high'-quality evidence from exercise-only RCTs indicating exercise was associated with a 38% decrease in the odds of developing GDM (26 RCTs, n=6934), 39% for developing GH (22 RCTs, n=5316) and 41% for developing PE (15 RCTs, n=3322). To achieve at least a 25% reduction in the odds of developing GDM, PE and GH, pregnant women need to accumulate at least 600 MET-min/week of moderate-intensity

Study or Subgroup	Exercise Events	Exercise Total	Control Events	Control Total	Weight	Odds Ratio M-H, Random, 95% CI
2.1.1 Exercise alone						
Barakat, 2016	2	382	9	383	1.6%	0.22 [0.05, 1.02]
Bisson, 2015	0	23	0	22		Not estimable
de Oliveria, 2012 - 13 weeks	3	54	3	29	1.4%	0.51 [0.10, 2.70]
de Oliveria, 2012 - 20 weeks	6	60	3	29	1.8%	0.96 [0.22, 4.16]
Elden, 2008	2	131	5	130	1.4%	0.39 [0.07, 2.03]
Guelfi, 2016	2	84	1	85	0.7%	2.05 [0.18, 23.03]
Haakstad, 2011	0	52	1	53	0.4%	0.33 [0.01, 8.37]
Hopkins, 2010	0	49	1	47	0.4%	0.31 [0.01, 7.88]
Kasawara, 2013	7	56	8	53	3.3%	0.80 [0.27, 2.40]
Kong, 2014	0	18	1	19	0.4%	0.33 [0.01, 8.73]
Kordi, 2013	1	35	0	35	0.4%	3.09 [0.12, 78.41]
Renault, 2014 - Exercise	5	125	2	67	1.4%	1.35 [0.26, 7.17]
Seneviratne, 2016	1	38	1	37	0.5%	0.97 [0.06, 16.15]
Taniguchi, 2016	0	54	1	53	0.4%	0.32 [0.01, 8.06]
Tomic, 2013	1	166	2	168	0.7%	0.50 [0.05, 5.60]
Ussher, 2015	4	392	11	393	2.9%	0.36 [0.11, 1.13]
Subtotal (95% CI)		**1719**		**1603**	**17.5%**	**0.59 [0.37, 0.94]**
Total events	34		49			
Heterogeneity: Tau² = 0.00; Chi² = 6.98, df = 14 (P = 0.94); I² = 0%						
Test for overall effect: Z = 2.23 (P = 0.03)						
2.1.2 Exercise + co-intervention						
Dodd, 2014	56	1080	53	1073	26.1%	1.05 [0.72, 1.55]
Guelinckx, 2010 - Active	2	42	2	22	0.9%	0.50 [0.07, 3.82]
Koivusalo, 2016	7	144	3	125	2.1%	2.08 [0.53, 8.21]
Korpi-Hyovalti, 2012	1	27	2	27	0.6%	0.48 [0.04, 5.64]
Luoto, 2011	14	216	10	179	5.5%	1.17 [0.51, 2.70]
Phelan, 2011 NW	3	90	9	92	2.2%	0.32 [0.08, 1.22]
Phelan, 2011OW/OB	17	81	11	86	5.6%	1.81 [0.79, 4.15]
Polley, 2002NW	0	30	0	31		Not estimable
Polley, 2002OW/OB	2	27	3	22	1.1%	0.51 [0.08, 3.34]
Poston, 2015	27	753	27	772	13.1%	1.03 [0.60, 1.77]
Renault, 2014 - Diet + Exercise	2	130	2	67	1.0%	0.51 [0.07, 3.69]
Sagedal, 2017	10	293	15	290	5.8%	0.65 [0.29, 1.47]
Stafne, 2012	16	426	16	426	7.8%	1.00 [0.49, 2.03]
Vinter, 2011	23	150	28	154	10.6%	0.81 [0.45, 1.49]
Subtotal (95% CI)		**3489**		**3366**	**82.5%**	**0.97 [0.78, 1.21]**
Total events	180		181			
Heterogeneity: Tau² = 0.00; Chi² = 9.28, df = 12 (P = 0.68); I² = 0%						
Test for overall effect: Z = 0.25 (P = 0.80)						
Total (95% CI)		**5208**		**4969**	**100.0%**	**0.89 [0.73, 1.08]**
Total events	214		230			
Heterogeneity: Tau² = 0.00; Chi² = 19.96, df = 27 (P = 0.83); I² = 0%						
Test for overall effect: Z = 1.16 (P = 0.25)						
Test for subgroup differences: Chi² = 3.68, df = 1 (P = 0.05), I² = 72.8%						

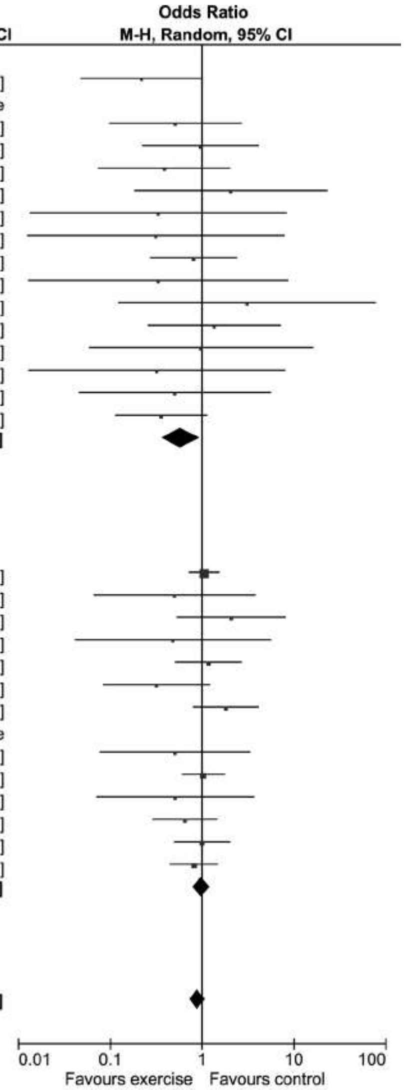

Figure 4 Effects of prenatal exercise compared with control on odds of preeclampsia (RCTs). Sensitivity analyses were conducted with studies includinge xercise-only interventions and those including exercise +co- interventions. Analyses conducted with a random effects model. CI, confidence interval; df, degrees of freedom; M-H, Mantel-Haenszel method. NW: subgroup of normal weight women; OW/OB: subgroup of women with overweight/obesity; 13 weeks: subgroup of women who initiated exercise at 13 weeks of pregnancy; 20 weeks: subgroup of women who initiated exercise at 20 weeks of pregnancy. *Note: studies with zero events in both arms are included in the forest plot but are "not estimable" and not included in the pooled analysis.*

exercise (eg, 140 min of brisk walking, water aerobics, stationary cycling or resistance training). Results from meta-regression analyses suggested that the benefits would be attained when exercise is performed at a frequency of at least 3 days/week or at least 25 min per session. Accumulated exercise volumes above 600 MET-min/week were associated with a greater reduction in the odds of developing these gestational diseases. Our systematic review and meta-analysis builds on the work of recently published meta-analyses to include 59 new RCTs and observational studies concerning GDM (41 284 additional women),[25] 12 new RCTs concerning GH (2055 additional women)[136] and 23 new RCTs and observational studies concerning PE (91 422 additional women).[136 137]

Our findings demonstrated lower odds of developing GDM, GH and PE with exercise-only interventions compared with no exercise. In contrast, interventions combining exercise+cointerventions were less effective than exercise alone for GDM (p=0.007), GH (p=0.04) and PE (p=0.05). These studies were typically counselling interventions about healthy lifestyle (including diet and physical activity) in pregnant women with overweight or obesity. In these interventions, women were unsupervised during exercise, and 67% of studies reported poor compliance (defined as <60% of participants performing 100% of the prescribed exercise sessions). Supervision has been suggested to be critical for compliance and the effect of the intervention.[138] Compliance to the exercise intervention may therefore be a critical determinant of the protective effect of exercise on GDM and hypertensive disorders of pregnancy; this might be related to actually carrying out the intervention as intended. Although many studies reported poor compliance to the prescribed intervention, our findings demonstrated a substantial reduction in the risk of developing GDM, GH and PE. This suggests that the protective effect of exercise against these diseases may be even greater in women who are compliant to exercise.

Findings from other study designs were not always in agreement with those from RCTs. This inconsistency may be due, at least in part, to the method used to assess physical activity.

Indeed, the quality of the evidence from the majority of observational studies was rated down because of risk of bias related to performance bias, specifically due to potentially flawed measurement of the physical activity. Unmeasured confounding variables might also explain different findings according to study design since subgroup analyses performed on exercise-only interventions clearly showed that the effect of prenatal exercise differs according to some characteristics of the women.

GDM and hypertensive disorders of pregnancy share several similar risk factors and pathophysiological features, such as maternal obesity, inflammation, insulin resistance, excessive gestational weight gain or impaired vascular function.[6 8 10] It is therefore possible that some of the mechanisms underlying the association between prenatal exercise and the prevention of these conditions involve the prevention of excessive gestational weight gain,[139] improvements in skeletal muscle insulin sensitivity and glucose uptake,[140 141] or a reduction in oxidative stress and associated improvement in endothelial function.[142] Abnormal placental development is also involved in the pathophysiology of PE, and it has been suggested that exercise promotes placental growth and vascular development.[142]

Women who develop GDM and hypertensive disorders of pregnancy are at long-term risk for type 2 diabetes,[3 5] hypertension[143] and cardiovascular diseases.[144] Furthermore, offspring of women who develop these conditions are at increased risk for obesity, metabolic and cardiovascular diseases later in life.[4 5] Lower odds of developing GDM and hypertensive disorders of pregnancy with prenatal exercise as we reported, therefore, have major implications for the long-term health of both women and children.

Rigorous methodological standards (GRADE) were used to guide the systematic review process, grey literature was examined, and articles in different languages were included. Twenty-seven countries from five continents were represented in the included studies. The level of quality evidence from RCTs was rated down mainly because of risk of bias and indirectness of the interventions. In future studies, more attention should be paid to monitoring compliance with exercise interventions, and to considering factors that may influence compliance and retention of study participants. More exercise-only interventions among pregnant women who are overweight or obese, diagnosed with GDM, compared supervised with unsupervised exercise, and previously inactive women are also needed to adequately power these subgroup analyses. Additional studies regarding the potential impact of specific types of exercise, timing of initiation of exercise and potential role of other mediating factors such as gestational weight gain are also strongly encouraged. Finally, no studies looked at the effect of exercising in different trimesters on the odds of developing GDM, GH or PE. Future studies addressing this question are also needed to establish the optimal time point to start an exercise intervention.

In conclusion, exercise-only interventions were effective at lowering the odds of developing GDM, GH and PE.

What is already known on this topic?

- ► Gestational diabetes mellitus (GDM), gestational hypertension (GH) and pre-eclampsia (PE) are associated with short and long-term health issues for mother and child; prevention of these complications is therefore critically important.
- ► Exercise is a cornerstone for prevention and treatment of hypertension and diabetes in general populations; however, the effectiveness of exercise in prevention during pregnancy is poorly understood.

What are the new findings?

- ► Exercise-only interventions reduced the odds of developing GDM by 38%, GH by 39% and PE by 41%.
- ► To achieve at least a 25% reduction in the odds of developing GDM, PE and GH, pregnant women need to accumulate at least 600 MET-min/week of moderate-intensity exercise (eg, 140 min of brisk walking, water aerobics, stationary cycling or resistance training).

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Effect of exercise during pregnancy to prevent gestational diabetes mellitus: a systematic review and meta-analysis

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REVIEW ARTICLE

Effect of exercise during pregnancy to prevent gestational diabetes mellitus: a systematic review and meta-analysis

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ABSTRACT

Introduction: Exercise showed some potential in preventing gestational diabetes mellitus. However, the results remained controversial. We conducted a systematic review and meta-analysis to evaluate the impact of exercise during pregnancy on gestational diabetes mellitus.
Methods: PubMed, EMbase, Web of science, EBSCO, and Cochrane library databases were systematically searched. Randomized controlled trials (RCTs) assessing the influence of exercise during pregnancy on gestational diabetes mellitus were included. Two investigators independently searched articles, extracted data, and assessed the quality of included studies. The primary outcome was the incidence of gestational diabetes mellitus. Meta-analysis was performed using random-effect model.
Results: Six RCTs involving 2164 patients were included in the meta-analysis. Compared with control intervention, exercise intervention was associated with significantly decreased incidence of gestational diabetes mellitus (Std. mean difference = 0.59; 95%CI = 0.39–.88; $p = .01$), but had no effect on gestational age at birth (Std. mean difference = −0.03; 95%CI = −0.12 to 0.07; $p = .60$), the number of preterm birth (OR = 0.85; 95%CI = 0.43–1.66; $p = .63$), glucose 2-h post-OGTT (Std. mean difference = −1.02; 95%CI = −2.75 to 0.71; $p = .25$), birth weight (Std. mean difference = −0.13; 95%CI = −0.26 to 0.01; $p = .06$), and Apgar score less than 7 (OR = .78; 95%CI = 0.21–2.91; $p = .71$).
Conclusions: Compared to control intervention, exercise intervention could significantly decrease the risk of gestational diabetes mellitus, but showed no impact on gestational age at birth, preterm birth, glucose 2-h post-OGTT, birth weight, and Apgar score less than 7.

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Exercise; gestational diabetes mellitus; incidence of gestational diabetes; meta-analysis; systematic review

Introduction

Gestational diabetes mellitus was ubiquitous in clinical work, and could increase the incidence of pre-eclampsia, macrosomia, and cesarean delivery [1]. These poor outcomes affected the long-term health of both the mothers and their offspring [2,3]. Overweight and obese pregnant women were found to have a greater than two-fold increased risk of developing gestational diabetes mellitus compared to non-obese women [4]. Overweight and obesity were determined based on the body mass index recommendations of the Group of China Obesity Task Force of the Chinese Ministry of Health on account of interracial differences: overweight, $24 \le \text{BMI} < 28\,\text{kg/m}^2$; obese, $\text{BMI} \ge 28\,\text{kg/m}^2$ [5].

Exercise intervention was known as an important part of lifestyle intervention for gestational diabetes mellitus. In non-pregnant patients, regular exercise was reported to have some ability to reduce the risk of type 2 diabetes, cardiovascular disease, and metabolic syndrome [6,7]. Life style intervention including exercise, dietary, and weight gain counseling was reported to decrease the incidence of gestational diabetes mellitus and attenuate the typical decline in glucose tolerance [8–10]. Many RCTs demonstrated that exercise intervention could significantly reduce the incidence of gestational diabetes mellitus, and glucose 2-h post-OGTT [11–15].

In contrast to this promising finding, however, accumulating relevant RCTs showed that exercise intervention showed no effect on the incidence of gestational diabetes mellitus, gestational age at birth, glucose 2-h post-OGTT, and birth weight [15–17]. Considering these inconsistent effects, we therefore conducted a systematic review and meta-analysis of RCTs to investigate the effect of exercise during pregnancy on gestational diabetes mellitus.

Materials and methods

This systematic review and meta-analysis were conducted according to the guidance of the Preferred

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Reporting Items for Systematic Reviews and Meta-analysis statement [18] and the *Cochrane Handbook for Systematic Reviews of Interventions* [19]. All analyses were based on previous published studies, thus no ethical approval and patient consent were required.

Literature search and selection criteria

PubMed, EMbase, Web of science, EBSCO, and the Cochrane library were systematically searched from inception to March 2017, with the following keywords: exercise or physical activity, and gestational diabetes. To include additional eligible studies, the reference lists of retrieved studies and relevant reviews were also hand-searched and the process above was performed repeatedly until no further article was identified. Conference abstracts meeting the inclusion criteria were also included.

The inclusion criteria were as follows: study population, pregnant woman; intervention, exercise; control, standard care; outcome measure, incidence of gestational diabetes mellitus; and study design, RCT.

Data extraction and outcome measures

The following information was extracted for the included RCTs: first author, publication year, sample size, baseline characteristics of patients, exercise intervention, control, study design, the incidence of gestational diabetes mellitus, gestational age at birth, preterm birth, glucose 2-h post-OGTT, birth weight, and Apgar score less than 7. The author would be contacted to acquire data when necessary.

The primary outcome was the incidence of gestational diabetes mellitus. Secondary outcomes included gestational age at birth, preterm birth, glucose 2-h post-OGTT, birth weight, and Apgar score less than 7.

Quality assessment in individual studies

The Jadad Scale was used to evaluate the methodological quality of each RCT included in this meta-analysis [20]. This scale consisted of three evaluation elements: randomization (0–2 points), blinding (0–2 points), dropouts, and withdrawals (0–1 points). One point would be allocated to each element if they have been mentioned in article, and another one point would be given if the methods of randomization and/or blinding had been described appropriately and in detail. If methods of randomization and/or blinding were inappropriate, or dropouts and withdrawals had not been recorded, then one point was deducted. The score of Jadad Scale varied from 0 to 5 points. An article with Jadad score ≤ 2 was considered to be of low quality. If the Jadad score ≥ 3, the study was thought to be of high quality [21].

Statistical analysis

Standard Mean differences (Std. mean difference) with 95% confidence intervals (CIs) for continuous outcomes (gestational age at birth, glucose 2-h post-OGTT and birth weight) and odds risks (ORs) with 95%CIs for dichotomous outcomes (the incidence of gestational diabetes mellitus, preterm birth, and Apgar score less than 7) were used to estimate the pooled effects. All meta-analyses were performed using random-effects models with DerSimonian and Laird weights. Heterogeneity was tested using the Cochran *Q* statistic ($p < .1$) and quantified with the I^2 statistic, which described the variation of effect size that was attributable to heterogeneity across studies. An I^2 value greater than 50% indicated significant heterogeneity. Sensitivity analysis was performed to detect the influence of a single study on the overall estimate via omitting one study in turn when necessary. Owing to the limited number (<10) of included studies, publication bias was not assessed. $p < .05$ in two-tailed tests was considered statistically significant. All statistical analyses were performed with Review Manager Version 5.3 (The Cochrane Collaboration, Software Update, Oxford, UK).

Results

Literature search, study characteristics, and quality assessment

The flow chart for the selection process and detailed identification was presented in Figure 1.

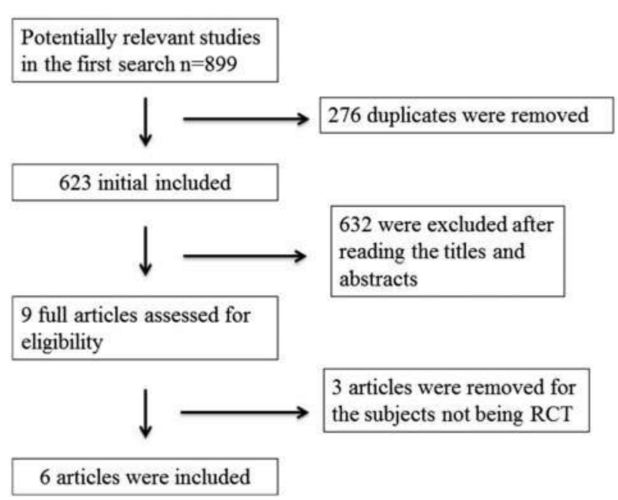

Figure 1. Flow diagram of study searching and selection process.

Table 1. Characteristics of included studies.

	Exercise group					Control group					
Author	Number	Ethnicity	Maternal age (years)	BMI, kg/m^2	Fasting glucose (mmol/L)	Number	Ethnicity	Maternal age (years)	BMI, kg/m^2	Fasting glucose (mmol/L)	Jada scores
Wang [15]	150	–	32.14 ± 4.57	26.75 ± 2.74	5.04 ± 0.37	150	–	32.50 ± 4.91	26.82 ± 2.76	5.04 ± 0.41	5
Guelfi [16]	85	76 (caucasian)	33.6 ± 4.1	N = 18 (≥30)	4.3 ± 0.4	87	68 (caucasian)	33.8 ± 3.9	N = 20 (≥30)	4.3 ± 0.3	4
Nobles [17]	124	69 (hispanic)	N = 51 (20–24 y)	N = 83 (≥30)	–	127	82 (hispanic)	N = 45(20–24 y)	N = 73 (≥30)	–	4
Cordero [12]	101	–	33.6 ± 4.1	22.5 ± 3.2	–	156	–	32.9 ± 4.5	23.6 ± 4	–	3
Barakat [11]	210	–	31 ± 3	24.1 ± 4.1	–	218	–	31 ± 4	23.7 ± 3.8	–	3
Stafne [13]	429	–	30.5 ± 4.4	24.7 ± 3.0	10.1 ± 5.42	327	–	30.4 ± 4.3	25.0 ± 3.4	10.7 ± 5.47	4

899 publications were identified through the initial search of databases. Ultimately, six RCTs were included in the meta-analysis [11–13,15–17].

The baseline characteristics of the six eligible RCTs in the meta-analysis were summarized in Table 1. The six studies were published between 2012 and 2017, and sample sizes ranged from 172 to 330 with a total of 2164. There was no significant difference of maternal age, BMI, and fasting glucose in pregnant woman at baseline. Three included studies reported that pregnant women in exercise intervention group obtained a supervised cycling program (three times/week) [12,15,16]. Three included studies reported that pregnant women in exercise intervention group obtained physical activity based on American College of Obstetricians and Gynecologists (ACOG) guidelines [11,13,17]. And, the pregnant women in control intervention group got usual daily activities in included RCTs.

Among the six RCTs, five studies reported the incidence of gestational diabetes mellitus [11,12,15–17], five studies reported gestational age at birth [11,13,15–17], three studies reported preterm birth [15–17], three studies reported glucose 2-h post-OGTT [13,15,16], five studies reported birth weight [11,13,15–17], and two studies reported Apgar score less than 7 [13,16]. Jadad scores of the six included studies varied from 3 to 5, all five studies were considered to be high-quality ones according to quality assessment.

Primary outcome: the incidence of gestational diabetes mellitus

This outcome data was analyzed with a random-effects model, the pooled estimate of the five included RCTs suggested that compared to control group, exercise intervention was associated with a significantly decreased incidence of gestational diabetes mellitus (Std. mean difference = 0.59; 95%CI = 0.39–0.88; $p = .01$), with low heterogeneity among the studies ($I^2 = 46\%$, heterogeneity $p = .11$) (Figure 2).

Sensitivity analysis

Low heterogeneity was observed among the included studies for the incidence of gestational diabetes mellitus. Thus, we did not perform sensitivity analysis by omitting one study in each turn to detect the source of heterogeneity.

Secondary outcomes

However, compared to control intervention, exercise intervention was found to have no influence on gestational age at birth (Std. mean difference = −0.03; 95%CI = −0.12 to 0.07; $p = .60$; Figure 3), the number of preterm birth (OR = 0.85; 95%CI = 0.43–1.66; $p = .63$; Figure 4), glucose 2-h post-OGTT (Std. mean difference = −1.02; 95%CI = −2.75 to 0.71; $p = .25$; Figure 5), birth weight (Std. mean difference = −0.13; 95%CI = −0.26 to 0.01; $p = .06$; Figure 6), and Apgar score less than 7 (OR = 0.78; 95%CI = 0.21–2.91; $p = .71$; Figure 7). "Barakat 2013" represented the index of corresponding figure (i.e. gestational age at birth in Figure 3 and birth weight in Figure 6) in pregnant women without gestational diabetes mellitus, while "Barakat 2013^{+}" represented the index of corresponding figure in pregnant women with gestational diabetes mellitus.

Discussion

Our meta-analysis suggested that compared to control intervention, exercise intervention could significantly decrease the incidence of gestational diabetes mellitus, but had no significant influence on gestational age at birth, preterm birth, glucose 2-h post-OGTT, birth weight and Apgar score less than 7. Exercise intervention was reported to improve maternal cardiovascular fitness, exercise automaticity, and reduce general psychological distress [16]. In addition, exercise intervention was not associated with reduced preeclampsia compared to standard care [13,16]. Safety issue of exercise intervention was confirmed because

Study or Subgroup	Exercise group Events	Exercise group Total	Control group Events	Control group Total	Weight	Odds Ratio M-H, Random, 95% CI
Barakat 2013	41	210	61	218	29.8%	0.62 [0.40, 0.98]
Cordero 2015	1	101	13	156	3.7%	0.11 [0.01, 0.85]
Guelfi 2016	34	84	34	85	22.8%	1.02 [0.55, 1.89]
Nobles 2015	12	124	19	127	17.7%	0.61 [0.28, 1.31]
Wang 2017	29	132	54	133	25.9%	0.41 [0.24, 0.71]
Total (95% CI)		**651**		**719**	**100.0%**	**0.59 [0.39, 0.88]**
Total events	117		181			

Heterogeneity: $Tau^2 = 0.10$; $Chi^2 = 7.45$, df = 4 (P = 0.11); $I^2 = 46\%$
Test for overall effect: Z = 2.55 (P = 0.01)

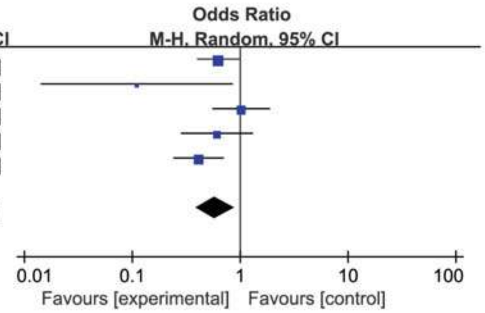

Figure 2. Forest plot for the meta-analysis of the incidence of gestational diabetes mellitus.

Study or Subgroup	Exercise group Mean	Exercise group SD	Exercise group Total	Control group Mean	Control group SD	Control group Total	Weight	Std. Mean Difference IV, Random, 95% CI
Barakat 2013	277	12	169	276	10	157	17.0%	0.09 [-0.13, 0.31]
Barakat 2013+	276	11	41	279	8	61	5.1%	-0.32 [-0.72, 0.08]
Guelfi 2016	272.3	147.7	81	269.5	9.1	76	8.2%	0.03 [-0.29, 0.34]
Nobles 2015	274.57	11.55	124	274.47	14	127	13.1%	0.01 [-0.24, 0.26]
Stafne 2012	280	13	429	281	22	426	44.7%	-0.06 [-0.19, 0.08]
Wang 2017	273.14	9.03	112	272.23	9.59	114	11.8%	0.10 [-0.16, 0.36]
Total (95% CI)			**956**			**961**	**100.0%**	**-0.01 [-0.10, 0.08]**

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 4.29$, df = 5 (P = 0.51); $I^2 = 0\%$
Test for overall effect: Z = 0.24 (P = 0.81)

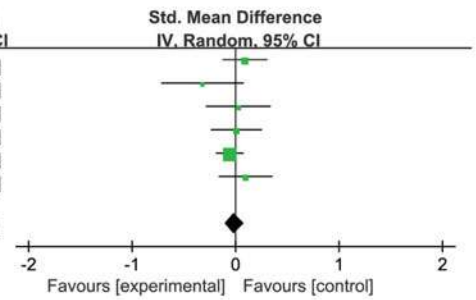

Figure 3. Forest plot for the meta-analysis of gestational age at birth (day).

Study or Subgroup	Exercise group Events	Exercise group Total	Control group Events	Control group Total	Weight	Odds Ratio M-H, Random, 95% CI
Guelfi 2016	3	81	4	76	19.4%	0.69 [0.15, 3.20]
Nobles 2015	11	124	11	127	59.2%	1.03 [0.43, 2.46]
Wang 2017	3	112	5	114	21.4%	0.60 [0.14, 2.57]
Total (95% CI)		**317**		**317**	**100.0%**	**0.85 [0.43, 1.66]**
Total events	17		20			

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.47$, df = 2 (P = 0.79); $I^2 = 0\%$
Test for overall effect: Z = 0.48 (P = 0.63)

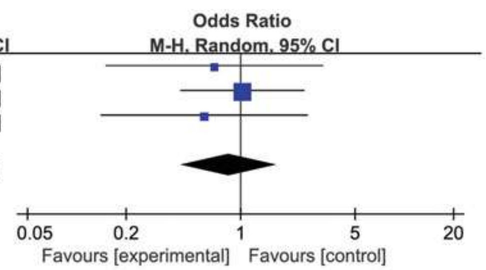

Figure 4. Forest plot for the meta-analysis of preterm birth.

Study or Subgroup	Exercise group Mean	Exercise group SD	Exercise group Total	Control group Mean	Control group SD	Control group Total	Weight	Std. Mean Difference IV, Random, 95% CI
Guelfi 2016	7.6	1.6	84	7.7	1.5	85	33.2%	-0.06 [-0.37, 0.24]
Stafne 2012	5.64	0.06	375	5.8	0.06	327	33.4%	-2.66 [-2.87, -2.46]
Wang 2017	6.57	1.18	132	7.03	1.62	133	33.4%	-0.32 [-0.57, -0.08]
Total (95% CI)			**591**			**545**	**100.0%**	**-1.02 [-2.75, 0.71]**

Heterogeneity: $Tau^2 = 2.33$; $Chi^2 = 298.42$, df = 2 (P < 0.00001); $I^2 = 99\%$
Test for overall effect: Z = 1.15 (P = 0.25)

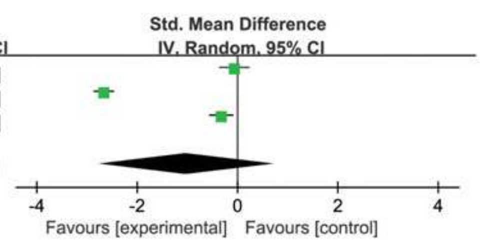

Figure 5. Forest plot for the meta-analysis of glucose 2-h post-OGTT (mmol/L).

Study or Subgroup	Exercise group Mean	Exercise group SD	Exercise group Total	Control group Mean	Control group SD	Control group Total	Weight	Std. Mean Difference IV, Random, 95% CI
Barakat 2013	3,200	442	169	3,191	470	157	19.1%	0.02 [-0.20, 0.24]
Barakat 2013+	3,204	470	41	3,429	427	61	8.6%	-0.50 [-0.90, -0.10]
Guelfi 2016	3,419	518	81	3,552	469	76	12.3%	-0.27 [-0.58, 0.05]
Nobles 2015	3,363.17	573.49	124	3,402.52	613.56	127	16.6%	-0.07 [-0.31, 0.18]
Stafne 2012	3,515	534	429	3,523	546	426	27.8%	-0.01 [-0.15, 0.12]
Wang 2017	3,345.27	397.07	112	3,457.46	446	114	15.6%	-0.26 [-0.53, -0.00]
Total (95% CI)			**956**			**961**	**100.0%**	**-0.13 [-0.26, 0.01]**

Heterogeneity: $Tau^2 = 0.01$; $Chi^2 = 9.19$, df = 5 (P = 0.10); $I^2 = 46\%$
Test for overall effect: Z = 1.88 (P = 0.06)

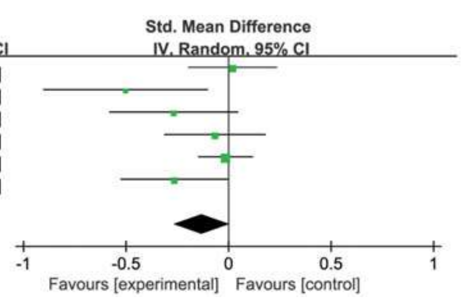

Figure 6. Forest plot for the meta-analysis of birth weight (g).

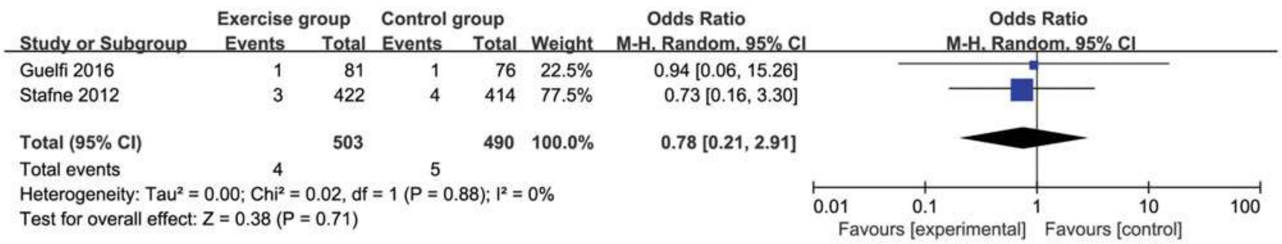

Figure 7. Forest plot for the meta-analysis of Apgar score less than 7.

of no increase in miscarriage, fetal loss, short cervical length, or preterm birth [15].

One recent meta-analysis reported that exercise intervention showed no substantial influence on lowering the incidence of gestational diabetes mellitus, but did not report the analysis of preterm birth, glucose intolerance, and birth weight etc [22]. Our meta-analysis clearly concluded that exercise intervention could significantly decrease the risk of gestational diabetes mellitus, and analyzed other outcome data including gestational age at birth, preterm birth, glucose 2-h post-OGTT, birth weight, and Apgar score less than 7. And, they showed no significant difference between exercise intervention and control intervention.

There were some conflicting results regarding the effect of exercise intervention on gestational diabetes mellitus. The incidence of gestational diabetes mellitus was not decreased after antenatal exercise (moderate-intensity aerobic, strength, and flexibility exercises by three times a week for 45–60 min) [11]. However, a program of aerobic, strength, and flexibility exercises by three times per week was reported to significantly reduce the risk of gestational diabetes mellitus [12]. Vigorous intensity activity before and after pregnancy showed some potential in preventing gestational diabetes mellitus [23]. Exercise in the second trimester might be late to reduce the incidence of gestational diabetes mellitus because endocrine and metabolic changes began in the first trimester [15,24].

Several limitations should be taken into account. Firstly, our analysis was based on only six RCTs and more clinical trials were needed to investigate this issue. The different duration time and intensity of exercise in the included studies might have an influence on the pooled results of this meta-analysis. Future studies should focus on exploring the optimal duration time and intensity of exercise in pregnant women. Next, dietary habits were not described in detail in the included RCTs. Finally, some unpublished and missing data might lead bias to the pooled effect.

Conclusions

Exercise intervention had an important ability to prevent gestational diabetes mellitus and should be recommended to be administrated in pregnant women.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Disclosure statement

No potential conflict of interest was reported by the authors.

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REVIEW

Review of general suggestions on physical activity to prevent and treat gestational and pre-existing diabetes during pregnancy and in postpartum

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Abstract The aim of this review is to provide general suggestions on physical activity (PA) in pre-gestational and gestational diabetes mellitus (GDM) and encourage women to take part in safe and effective activities throughout pregnancy, in the absence of other contraindications. PA before and during pregnancy and in postpartum has many positive effects on the mother, as it could reduce the risk of GDM, excessive weight gain and lower back pain and also prevents, in the postpartum, diabetes mellitus. It may also reduce the duration of labour and complications at childbirth, fatigue, stress, anxiety and depression, thereby leading to an improved sense of wellbeing. Clinically, it is thought to help prevent preeclampsia and premature birth even though RCTs provide conflicting evidence with regard to the prevention of GDM. The main reason for this rests on the fact that the majority of clinical trials have not been able to replicate the preventive effect of PA on the onset of GDM, such as the different adherence of the patient to PA. Herein, we survey the literature regarding exercise and PA on GDM prevention and treatment as well as on clinical outcomes in pre-GDM in pregnancy. On the basis of the current literature, we also present a series of general recommendations and suggestions on PA and exercise training in pregnancy among both diabetic patients and those at risk for GDM.

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Background

There is evidence that physical activity (PA) during pregnancy has many potential positive effects on the mother: reduced risk of excessive weight gain, gestational diabetes mellitus (GDM), preeclampsia, varicose veins, deep vein thrombosis and lower back pain [1,2]. PA also reduces the duration of labour and complications at childbirth, fatigue, stress, anxiety and depression, thereby leading to an improved sense of wellbeing [3,4]. Other potential benefits for the foetus are improvement in placental function with increased amniotic fluid, flow and volume of the placenta, foetal vascular function, placental villous tissue, speed of foetal growth, neuronal development and reduced percentage of foetal fat [5]. Physicians should advise female patients how to safely perform PA during pregnancy and in the postpartum period. Providing a woman with an adequate prescription of exercise training can encourage her to take part in safe and effective activities throughout pregnancy, in the absence of contraindications [6].

For women at high risk of GDM, initiating an exercise-training program during the preconception phase may be of importance. Risk factors include overweight, obesity, previous GDM, prior macrosomia, age above 35 years, positive family history for diabetes mellitus, polycystic ovary syndrome (PCOS) and high-risk ethnicity [7].

The prevalence of GDM is 4.7%–13.7% [8] Diagnostic criteria for GDM are according to IADPSG (International Association of Diabetes and Pregnancy Study Groups) criteria and Italian National Guidelines, and the woman should be tested between 24th and 28th gestational weeks. A single positive test result is enough for the diagnosis using a 2-h 75-g OGTT: fasting plasma glucose is $\geq$92 mg/dL ($\geq$5.1 mmol/l), 1-h glucose value $\geq$180 mg/dL ($\geq$10 mmol/l) and 2-h glucose value $\geq$153 mg/dL ($\geq$8.5 mmol/l); furthermore, in high-risk women, testing may be carried out before 24–28 gestational weeks [9].

Once GDM is diagnosed, either aerobic or resistance training can improve insulin action and glycaemic control [10]. However, to the best of our knowledge, there are no clear guidelines or clear clinical recommendations. We review the literature and make suggestions regarding areas of prevention of GDM in the general female population, treatment of GDM in gestation and prescription of exercise in pregnancy, with specific attention to type, intensity and volume.

Methods

To identify relevant studies, MEDLINE, EMBASE, Web of Science and the Cochrane Library (1982–2017) databases were searched using MeSH headings and free-text terms for "Exercise" "Pregnancy" "Diabetes", combined with the terms "prevention," "Gestational," "Pre-gestational," "symptoms," "management," "Physical Activity" and "Exercise training." The reference lists from retrieved articles were also examined for relevant papers. All randomised controlled trials (RCTs), prospective cohort studies, meta-analysis on pregnancy with and without diabetes, case–control studies, randomised trials and systematic reviews published in the English language were included in this review. We also included position statements and guidelines on PA in diabetes published by the main scientific societies such as the American Diabetes Association (ADA), the National Institute for Health and Care Excellence (NICE) and the American College of Obstetricians and Gynaecologists (AGOG) on PA during pregnancy and in the post-partum period.

We then classified the studies and formulated recommendations A–D, based on commonly accepted CONSORT standards [10,11], thus summarising the evaluation method of the current study. Each publication was assigned a level and grade according to Table 1 below:

Two reviewers (N.DB and AN) independently assessed the titles and abstracts of identified studies. Full texts of studies meeting the inclusion criteria (or in the case of uncertainty regarding inclusion) were retrieved, and consensus was achieved on inclusion status.

We excluded papers with few case reports or not justifiable retrospectives studies, studies not in English language or methodologically incorrect and included RCTs, prospective studies in English language, reviews, meta-analyses and Cochrane Collaboration publications.

Consultation among all authors revealed a 99% concordance in the evaluation of the 5 levels of the 153 publications retrieved and in the subsequent grading strengths. Of those retrieved, 93 publications were discarded for unclear procedures or with objectives other than prevention or treatment. Sixty-three publications remained and assessed the level with the grade of RCTs used.

We first discuss the assessed literature regarding prevention before and during pregnancy.

Table 1 Level and grade of evidence.

	Based upon level of evidence
Grade	
A	Further research is unlikely to change our confidence in the estimate of effect
B	Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate
C	Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate
D	Any estimate of effect is very uncertain
Level	
I	RCT with hard end-point
II	RCT with surrogate end-point
III	Non-randomised trial with a control group, or subgroup analysis of an RCT
IV	Before and after study
V	Case series > 10 patients

From Atkins D. British Medical Journal, 2004.

Prevention of gestational diabetes mellitus

Prevention before pregnancy

Epidemiological studies have shown that in the general adult population, approximately 55–60% of time awake is spent in sedentary behaviour [12,13]. Among pregnant women, the situation appears to be similar or even worse [14]. Indeed, a high proportion of pregnant women follow neither PA nor exercise guidelines, thus putting them at increased risk of obesity, other pregnancy-related diseases and complaints [15] and GDM.

Women diagnosed with GDM are at a higher risk of developing type 2 diabetes mellitus (T2DM) in later years. Kjos [16] suggests that approximately 63% of women develop T2DM within 5 years after delivery. Herein, we are not suggesting that PA could reduce this risk, but certainly, this issue is one that merits further study.

Regular PA before pregnancy has been associated with a reduced risk of developing GDM, and a more active lifestyle before pregnancy predicts a similar behaviour during pregnancy [17–19]. Even leisure time PA before pregnancy may reduce the risk of developing GDM [20,21].

During pregnancy

Being physically active also during pregnancy may prevent GDM [26] and delay the onset of T2DM [22]. Women who regularly perform PA in the year before their pregnancy have a decreased risk, reduced to 50% if the exercise is carried out during the first 20 weeks of pregnancy [23]. A more recent study reported that resistance training three times a week for 30 min throughout pregnancy is safe and leads to a reduction in GDM incidence and improves perinatal outcomes [24]. Similarly, the ETIP Trial RCT shows a GDM incidence reduction in the exercise group (27.3% vs 6.1%) as a secondary outcome observed [25].

Despite such positive evidence, not all studies concluded that PA can prevent the onset of GDM [26]. Recently, RCTs have assessed the role of prescribed exercise training on the prevention of GDM in women at high risk (obese with a history of previous GDM) [Table 2]. In Table 2, we present the major RCTs retrieved with information on outcomes and discuss these outcomes in the following paragraphs.

The 'UPBEAT' study [27], which aimed at assessing the role of lifestyle (PA + healthy eating) in obese and multiethnic English women, of whom 3–10% with previous GDM did observe a significantly weight and body fat reduction, but it did not demonstrate any difference in the prevalence of GDM (intervention group vs. standard group 26% vs. 25%) and neonatal macrosomia.

Similarly, the "LIMIT Study" [28], an Australian RCT study of 2212 overweight or obese women (1104 with standard treatment and 1108 with diet + lifestyle), did not demonstrate any differences in maternal (GDM, hypertension and preeclampsia) and neonatal outcomes (large for gestational age and macrosomia); however, there was no difference in total gestational weight gain between the two groups, while the study LIMIT2 showed a reduction in newborns whose weight was above 4.0 kg. Interestingly, the "DALI" pilot study [29], a European multicentre trial involving 150 pregnant women of BMI > 29 kg/m^2, did not show any significant difference in the three treatments, which included a change in lifestyle, healthy eating or both. Only a lower weight gain and lower fasting blood sugar in the diet-only group than the group treated with PA alone was observed. The combination of both interventions did not show any superiority in terms of outcomes.

The 'RADIEL' study [30], a Finnish RCT, assessed the efficacy of an intervention combining diet and PA during pregnancy in 293 women with high risk (BMI ≥ 30 kg/m^2 or previous GDM), recruited before the 20th week of gestation. Women in the intervention group showed a lower prevalence of GDM (13.9% vs. 21.6% in the control group), thereby reducing the risk by 39%. Improvements in increased leisure-time PA, better nutrition and a lower weight gain (−0.58 kg) were seen, but it was not clear whether which improvements were due to PA, diet or both.

A Chinese randomised clinical trial [19], recruited 300 overweight/obese women at 10 weeks' gestational age. They were randomised into an exercise group or a control group, the exercise group engaged in a supervised cycling program involving at least three sessions per week. Women randomised to the exercise group had a significantly lower incidence of GDM (22.0% *vs* 40.6%; $p < 0.001$). This represents a clinically important 45.8% reduction in the incidence of GDM. These women also had significantly less gestational weight gain by 25 gestational weeks and at the end of pregnancy and reduced insulin resistance levels at 25 gestational weeks.

A Spanish randomised clinical trial [2] included 342 women from weeks 10 and 14 to the end of the third trimester. Women who engaged in exercise program during pregnancy compared with the control group experienced a 90% reduced risk of GDM (OR = 0.103; 95% confidence interval (CI), 0.01–0.803). Significant differences were found between groups in excessive maternal weight gain according to pre-pregnancy BMI classes (IG, 22.8%, n = 23), vs CG, 34.8%, n = 54 (W21 = 4.23, p = 0.04). Women in the intervention group exercised for 50–60 min per session, three sessions per week, two on a floor mat in the gym hall and one as an aquatic water-based activity. The exercise intensity was set along the Borg's scale between 6 (without effort) and 20 (maximum effort). For the exercise sessions, Borg 12–14 was maintained. In addition, maternal HR was assessed and exercise intensity was modulated not to surpass 60% of the calculated HR reserve. These publications point to the conclusion that to reduce the incidence of GDM, a mixture of aerobic and muscle conditioning exercise at intensity and frequency utilised is necessary.

The Norwegian FIT for Delivery (NFFD) [31] RCT included 606 and examined the effect of the NFFD intervention on glucose metabolism, including an assessment of the subgroups of normal-weight and overweight/obese participants. The intervention group showed reduced

Table 2 RCTs on the prevention of GDM.

Clinical trials	Country	Patient no.	Patients' characteristics	GDM diagnosis criteria	Exercise type, intensity and duration	Nutritional counselling	GDM incidence reduction	Level and grade
UPBEAT [26]	UK	1555	Weeks' gestation 15–18 week. BMI $\geq$ 30 kg/m^2	IADPSG criteria	Intervention group • Handbook • DVD • Exercise regime • Pedometer • Logbook for recording weekly activities	• Social cognitive theory: 8 sessions $\times$ 1 h/week. • Suggested dietary changes. • Fewer carbohydrate-rich foods for foods with lower glycaemic index. • Restricting dietary intake of saturated fat.	NONE	I A
LIMIT [27]	Australia	2212	Weeks' gestation 10 + 0 to 20 + 0. week BMI $\geq$ 25 kg/m^2	WHO criteria	• Generic recommendations to increase the amount of walking and incidental activity	• Current dietary Australian standards • Reduce intake of refined carbohydrates and saturated fats, and increase intake of fibre, two servings of fruits and five servings of vegetables, each day	NONE	II A
RADIEL [29]	Finland	269	Weeks' gestation 13 week BMI $\geq$ 32 kg/m^2 Previous history of GDM	WHO criteria	Physical activity • 30 min $\times$ 5/week or • 50 min $\times$ 3/week • Moderate Intensity (11–15 on Borg's visual scale)	• Finnish nutritional guidelines • encourage increased intake of vegetables, legumes, fruits and berries; whole grain and fibre; low-fat dairy and vegetable fats.	13.9% in IG vs 21.6% in CG [95% CI 0.40–0.98%] $P = 0.044$	IA
DALI [28]	9 European Countries	150	Weeks' gestation Before 19 + 6 week BMI $\geq$ 29 kg/m^2	IADPSG criteria	Three random intervention groups • Healthy Eating (HE) • Physical Activity (PA) • At least 30 min per day, for at least 5 days in a week • HE + PA	• Lifestyle coach • Patient empowerment and cognitive behavioural techniques. • Motivational Interviewing	NONE	IA
CHINE [18]	China	300	Weeks' gestation <12 week 24 < BMI < 28 kg/m^2	IADPSG criteria	Supervised cycling • $\geq$3 sessions $\times$ week • At least 30 min/session • Moderate Intensity (12–14 on Borg's visual scale)	• No special dietary recommendations	22.0% vs 40.6%; $P < 0.001$	I A
Norwegian FIT Study [30]	Norway	606	Weeks' gestation $\leq$20 week Normal weight Overweight Obese	WHO criteria	Exercise training • 2 sessions/week at a GYM Physical Activity • 30 min $\times$ 3 day/week	• Dietary counselling 2$\times$ by phone • Recommendations (food choices; portion sizes; limiting snacks; increasing intake of water, fruits and vegetables)	NONE	I A

Gestational Diabetes: the Role of Exercise in the Prevention [2]	Spain	342	Weeks' gestation 10–12 week BMI 22–23 kg/m^2	The national diabetes data group criteria	Intervention Group (IG) • 3 sessions/week • 2 sessions × 60 min on land • 1 session × 50 min for aquatic activities Intensity • Between 6 and 20 Borg's scale at <60% Heart Rate Reserve Control Group (CG) • Generic recommendations to increase the physical activity	• NONE	90% P = 0.009	IA

insulin (adj. mean difference − 0.91 mU/l, p = 0.045) and leptin levels (adj. mean difference − 207 pmol/l, p = 0.021) compared to routine care, while glucose concentrations were unchanged. However, the effect of intervention on both fasting and 2-h glucose was influenced by pre-pregnancy BMI (interaction p = 0.030 and p = 0.039, respectively). For overweight/obese women (n = 158), the intervention was associated with increased risk of at least one glucose measurement exceeding International Association of Pregnancy and Diabetes Study Group thresholds (33.7% vs. 13.9%, adj. OR 3.89, p = 0.004).

Finally, a recent review and meta-analysis [32] that included five RCTs involving 1872 patients in the exercise intervention was found to significantly reduce the risk of GDM (std. mean difference 0.62; 95% CI 0.43–0.89; p < 0.01) compared with control intervention.

The inability to draw definitive conclusions about the risk of developing GDM in women who received a combination of diet and exercise intervention is likely dependant on the individual characteristics of the interventions, such as objectives, intensity, frequency, timing and type of PA as well as on the differences of the studied populations, without considering the pathogenesis of GDM and different P.A. patients' adherence [26].

In our opinion, further studies are required to assess the relationship between lifestyle change in gestation and GDM incidence, including data on women with varying degrees of insulin resistance and on women with reduced insulin-secreting capacity.

Post-partum

Physical exercise is highly recommended to the broad population before and after pregnancy, especially for women suffering from GDM and populations at risk [33]. It is advised to continue physical exercise in the postpartum period. PA increases cardio-respiratory fitness and improves mood without any negative effects on maternal milk volume and composition [34]. Continuing PA after the pregnancy helps women in achieving and maintaining ideal weight, when combined with caloric restriction, and can prevent and/or delay diabetes onset in women who previously suffered from GDM for up to 10 years after delivery [35,36].

In the following section, we discuss what treatment outcomes are desirable and the characteristics of the exercise intervention required to achieve the outcome in pregnancy.

Treatment outcomes

The primary goal of GDM treatment is to keep blood glucose concentrations within the normal range throughout pregnancy to ensure appropriate foetal growth in women receiving personalised diet prescriptions.

Exercise interventions may be useful in helping with glycaemic control and may improve maternal and foetal outcomes. In Table 3, we present the following studies on treatment outcomes. The majority of exercise intervention

Table 3 Studies on treatment outcomes of GDM.

Clinical trials	Country	Study Patient no.	Patients' Characteristics	GDM diagnosis criteria	Exercise type, intensity and duration	Nutritional counselling	Outcomes	Level and grade
RADIEL [30]	Finland	RCT 269	Weeks' gestation 13 week BMI ≥ 32 kg/m^2 Previous history of GDM	WHO criteria	Physical activity • 30 min × 5/week or • 50 min × 3/week • Moderate Intensity (11−15 on Borg's visual scale)	• Finnish nutritional guidelines • Encourage increased intake of vegetables, legumes, fruits and berries; whole grain and fibre; low-fat dairy and vegetable fats.	Reduction in fasting plasma glucose (P = 0.011); the increase in 2-h glucose value from baseline to the second trimester was significantly lower in the intervention group (P = 0.42)	IA
COCHRANE DATABASE SYST.REW [37]	Canada Thailand Italy USA Canada Thailand Italy	4 RCTs, 363 3 RCTs, 344 women	Weeks' gestation From 13 to 24 week Weeks' gestation From 13 to 24 week	–	Physical activity • From low to moderate Intensity • Aerobic and resistance exercise	–	Reduction in fasting blood glucose concentrations (average standardised mean difference (SMD) −0.59, 95% CI −1.07 to −0.11; four RCTs, 363 women; I^2 = 73%; T^2 = 0.19) Reduction postprandial blood glucose concentration (average SMD −0.85, 95% CI −1.15 to −0.55; I^2 = 34%; T^2 = 0.03).	IA
Barakat R [41]	Spain	RCT 510	Weeks' gestation 10−12 week BMI 24 kg/m^2	WHO and IADPSG criteria	Physical activity • 50−55 min × 3/week • Moderate Intensity (10−12 on Borg's visual scale)	Patients received advice on a 2000 kcal diet	Reduction by 58% of macrosomia (OR 1.76, 95% CI 0.04−78.90 vs 4.22, 95% CI 1.35−13.19) and by 34% of acute and elective caesarean delivery (OR 1.30, 95% CI 0.44−3.84 vs 1.99, 95% CI 0.98−4.06)	IA
Ehrlich SF [40]	USA	Prospective cohort study 1055	Weeks' gestation 24 week BMI > 25 kg/m^2	Carpenter and Coustan criteria	Physical activity • Moderate intensity 3−6 MET/h • Vigorous intensity >6 MET/h	Patients received advice on a 1600 kcal diet	Vigorous exercise was associated with 57% decreased odds of GWG above the recommended ranges [0.43, (0.23, 0.92)] p = 0.03	

studies including RCTs [37] show that exercise decreases both fasting (average standardised mean difference (SMD) −0.59) and postprandial blood glucose concentrations compared with control interventions (average SMD −0.85). In the Radiel [30] study, the intervention group had a significant reduction in fasting plasma glucose ($p = 0.011$) and gestational weight gain ($p = 0.037$); Davenport [38] showed that exercise decreases glucose concentrations in the fasting state and 1 h after meals and achieved a lower insulin requirement (0.50 ± 0.37 U kg^{-1} vs 0.16 ± 0.13 U kg^{-1}; $p < 0.05$).

In support of these findings, both aerobic and strength, exercise improves insulin sensitivity and increases glucose uptake. In late pregnancy, biopsies of the vastus lateralis muscle show that GLUT 4 expression is higher in exercise-trained women (30% VO_2 peak) who started exercising from 16 to 20 weeks' gestation until delivery [39].

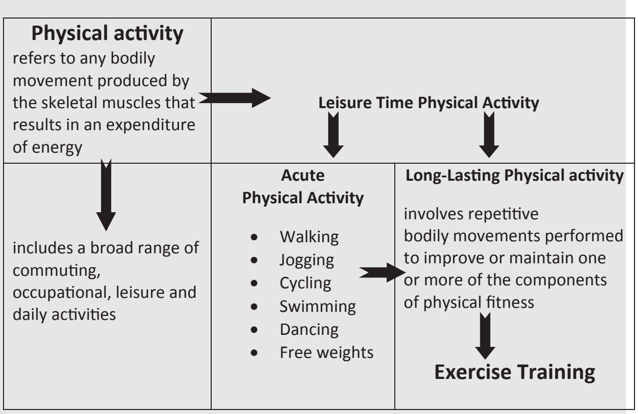
Vigorous intensity exercise is associated with a decreased number of women with a weight gain exceeding IOM recommendations (OR = 0.63 (0.40, 0.99)) as compared to no participation [40]. One interventional study has shown that regular PA during pregnancy in women with GDM can improve other outcomes such as having an infant with macrosomia (58% risk reduction) or a preterm delivery (34% risk reduction) [41].

Exercise training prescription: characteristics of exercise training and PA

PA practiced during pregnancy is frequently insufficient to insure the benefits of an active lifestyle even in normal-weight women. Among the overweight/obese, both volume and type of PA are strikingly low [42].

An initial approach to helping women become more physically active can simply be to encourage them to incorporate more unstructured PA into daily living, both before and during pregnancy, as outlined in Table 4, in the absence of contraindications. This would be considered as a starting point from which to progress towards the prescription of exercise training, if there are no other contraindications. The prescription should consider not only type and intensity but also frequency, duration and progression [10], which we discuss below.

Table 4 Definition of physical activity.



Type of exercise

Most pregnant women with and without GDM can safely perform aerobic (strengthens heart, vascular and respiratory systems) and strength exercises (increases the amount of muscle fibres used within a muscle to increase strength). These exercises include walking; running; dancing; strength machines and weightless body activities such as cycling, different aquatic activities and exercises on the chair or hand-crank ergometer [40] (level IIIB).

Resistance exercises are safe and effective when adapting insulin dose (where necessary) and checking for hyperglycaemia; weightlifting exercises are done using progressive resistance elastic bands for arms, legs, abdomen and back [43].

The exercise should be tailored to each woman's physical condition, with mild to moderate intensity. One systematic review identified eight RCTs involving 588 participants: aerobic or resistance exercise, performed at a moderate intensity at least three times per week, safely helps to control postprandial blood glucose concentrations and other measures of glycaemic control in women diagnosed with GDM [44]. Activities with high risk of falling (horse riding, downhill skiing, etc.) or abdominal trauma should be discouraged. Sports with high potential for physical contact (such as ice hockey, football and basketball) can cause severe trauma to both mother and foetus and should therefore be discouraged. Diving should be avoided during pregnancy because the foetus is at risk of decompression sickness. Caution should be observed in practising physical exercise at a high altitude (>2500 m).

Intensity

We propose three simple methods to evaluate the intensity of aerobic exercise: the target heart rate zones, the Borg's scale and the Talk test. Heart rate is a relatively simple way to prescribe aerobic exercise in a manner that corresponds with perceived exertion and thus intensity. However, during pregnancy, heart rate is elevated by 10–15 beats and is blunted at maximal exercise levels; the Royal College of Obstetricians and Gynaecologists (RCOG), the Society of Obstetricians and Gynaecologists of Canada (SOCG) and Canadian Society for Exercise Physiology (CSEP) have all recommended the use of a modified heart rate target zone developed by the CSEP, when prescribing moderate intensity aerobic exercise.

In Table 5, we report the Modified Heart Rate Target Zone for aerobic exercise in pregnancy proposed by Padayachee [33], which refers to Joint SOGC/CSEP clinical practice guideline of Davies 2003 [45] and the validated works of Mottola [46] and Davenport [47] for sedentary overweight and obese pregnant women. This model aims to provide exercise to previously sedentary pregnant women at 20%–39% VO_2 reserve as recommended by

Table 5 Modified heart rate target zone for aerobic exercise in pregnancy.

Maternal age (years)	Heart rate target zone (beats/min)	Heart rate target zone (beats/10 s)	Heart rate target zone (SOwt/Sob)
<20	140–155	23–26	–
20–29	135–150	22–25	102–124
30–39	130–145	21–24	101–120
≥40	125–140	23–26	–

SOwt: Sedentary Overweight; Sob: Sedentary obese.
From Padayachee C, Coombes JS. World J Diabetes 2015 [33].

American College of Sports Medicine (ACSM). When the heart rate is not usable, the ACOG recommends using Borg's Modified Rate of Perceived Exertion Scale instead.

The Borg scale [48], as shown in Table 6, is used to assess the intensity of different training sessions, and it represents the subjective assessment index and perception of fatigue and is recommended in pregnancy. For most healthy women who are not already highly active or doing vigorous-intensity activity, moderate intensity aerobic activity is recommended during pregnancy and in the postpartum period, corresponding to 4–5 BORG-modified RPE scale level or 14–15 BORG RPE scale level. A poorly conditioned woman may start as low, as 3 BORG-modified RPE scale level or 12–13 BORG RPE scale level, and then progress to moderate levels. Women who are already highly active or doing regular vigorous activity can continue these activities during pregnancy [46].

A further measure of the intensity of exercise is the 'Talk test' [49]. This is a simple system, alternative or complementary to the previous tests used to evaluate the adequacy of exercise intensity, as follows: If a woman can maintain a conversation while exercising, the intensity of PA is adequate. Intensity should be reduced whenever the conversation is not possible.

Frequency

Existing guidelines encourage PA throughout gestation, involving both aerobic and strength work during most, if not all, days. This also applies to women with GDM [10]. A daily physical exercise improves glucose metabolism. The muscular contractions associated with PA can increase glucose uptake through increased glucose transporter type four (GLUT 4) production and increased insulin signalling within the skeletal muscle, thus increasing insulin sensitivity. The increased muscular sensitivity, due to insulin, lasts for at least 24 h after exercising [50]. It is therefore suggested that the recommended frequency for any kind of PA in women suffering from GDM is from 3 to 7 days a week [51].

Table 6 The Borg scale is used to assess the intensity of the various training sessions, and it is the index subjective of fatigue evaluation and perception.

BORG RPE	Modified RPE	Breathing
6	0	No exertion
7		Very light
8	1	
9		
10	2	Deeper but comfortable breathing.
11		Able to hold a conversation
12	3	
13		Aware that breathing is harder;
14	4	able to talk but difficult to hold conversation
15	5	Starting to breath hard and getting
16	6	uncomfortable
17	7	Deep and forceful breathing.
18	8	Uncomfortable and not wanting to talk
19	9	Extremely hard
20	10	Maximum exertion

Duration

Pregnant women without medical and/or obstetrical complications should be allocated at least 150 min per week to PA.

For inactive women, increase duration of moderate exercise slowly; if they are already more active, then maintain or lower the intensity during pregnancy and increase the frequency or duration.

Prolonged duration of PA (*i.e.* lasting for 60–90 min when performed continuously) usually is not recommended for pregnant women due to heightened concern over possible hypoglycaemia or hyperthermia.

To reach and maintain a metabolic effect, aerobic exercise should last for a minimum of 15 min per session, three times a week, and it should be gradually increased during the second trimester up to approximately 30–40 min per session, four times or more a week [10]. Aerobic activity should be preceded by a short warm-up (10–15 min) and followed by a short cool down phase (10–15 min), including stretching and relaxation exercises [45].

Progression

Sedentary women with GDM should begin with low intensity (3 BORG modified RPE scale level or 12–13 BORG RPE scale level) and gradually progress to moderate intensity (4–5 BORG modified RPE scale level or 14–15 BORG RPE scale level), if there are no obstetrical contraindications. At the beginning of pregnancy, it is recommended to increase activity frequency and duration rather than its intensity [10]. Women, who were active before and during pregnancy, should continue to engage in moderate to vigorous intensity even after being diagnosed with GDM, if there are no obstetrical contraindications [10,33].

Patients with diabetes

In the following section, we turn our attention to diabetic patients with diabetes and summarise current recommendations for prescribing PA for both type 1 diabetes mellitus (T1DM) and T2DM patients in pregnancy.

Type 1 diabetes patients in pregnancy

During pregnancy, a structured PA program may assist T1DM women without complications in achieving optimal metabolic control [52].

Table 7 shows general contraindications to PA, even though safety and dose adjustments must be considered according to the severity of complications [53].

The impact of exercise on glucose homeostasis is influenced by the type, intensity and duration of the activity; hence, any exercise program for pregnant diabetic women must consider type, duration, frequency, intensity and timing, similar to those for GDM as outlined in Section 2 above.

Participation in aerobic PA, sprint and resistance training can result in widely varying blood glucose responses [54,55]. Differences in exercise intensity also influence outcomes, with high-intensity activities causing a greater release of counter-regulatory hormones like epinephrine and glucagon that can cause immediate and lasting elevations in blood glucose concentrations [56]. The exercise intensity modulates effects on blood glucose, namely, marked activation of the sympathetic nervous system, which causes hyperglycaemia after strenuous exercise. It should be remembered that sub-maximal (70–85% VO_{2max}) or moderate (50–70% VO_{2max}) PA in the presence of adequate insulinisation lowers blood glucose, with an effect dependent on duration and intensity.

Duration also has an impact, with longer periods of exercise generally resulting in greater blood glucose use and the risk of hypoglycaemia, although large individual variations in hormonal responses to prolonged exercise of varying types have been demonstrated in athletes with T1DM [57]. Exercising more than once in a day or on sequential days can also affect blood glucose outcomes during the exercise itself and afterwards [55].

Long-term effects on the metabolism of glucose, lipids and proteins in individuals with T1DM are difficult to assess, as such patients are frequently unable to adequately alter endogenous insulin levels and experience normal hormonal glucose counter regulation during and following exercise. Consequently, they are at risk for early and late hypoglycaemia and also hyperglycaemia [58].

In addition, exercise induces the activation of antiregulatory hormones that might trigger an acute metabolic disorder in individuals with severe insulin deficiency. In the setting of T1DM, in which exogenous insulin is required to maintain glucose control, the combined effects of exercise and insulin-mediated glucose disposal increase the risk of hypoglycaemia during exercise and in the late post-exercise period. Insulin therapy during exercise during pregnancy of T1DM women should ensure, first, a close-as-possible simulation of the normal physiological response to exercise and, second, a reduction in basal insulin during aerobic exercise of moderate or submaximal intensity.

Continuous glucose monitoring during PA in pregnant female patients with insulin-dependent diabetes mellitus could be useful in performing PA safely. Monitoring should aim at maintaining blood glucose approximately 6.7 mmol/l [53]. Additionally, continuous glucose monitoring may play an important role in detecting delayed, including nocturnal, hypoglycaemia that may otherwise go unnoticed when exercise is performed during evening hours.

Blood glucose response to PA among TID patients is highly variable based on activity type and timing and require different adjustments. Before carrying out a PA session, it is necessary to assess blood glucose and ketone levels [53]. The optimal time to begin an exercise session is 2 h after a fast-acting administration or 8–10 h after a long-acting insulin administration [53].

With regard to aerobic exercise, muscles use up glucose, which causes an immediate need to release glucose from the liver. If the insulin dose has not been reduced before physical exercise, the insulin concentration will be relatively high and glucose hepatic production inhibited [53]. Therefore, blood glucose concentrations should always be checked before exercise. The ADA Position statement suggests carbohydrate intake or other actions based on blood glucose concentrations at the start of exercise in nonpregnant T1DM patients [53]. As there is no literature supporting these actions in pregnancy, hyperglycaemia and ketone presence should be managed differently. Information about the early and late glycaemic response to exercise can be collected by checking blood glucose at the end of the session and in the following hours until the next morning [53,55,57–59]. In this way, it is possible to adjust subsequent exercise sessions in both duration and intensity and to reduce insulin therapy in response to PA. With this information, the patient can tailor adjustments of insulin therapy and carbohydrate intake in relation to these variables.

For these reasons, in T1DM, PA requires two caveats: first, clear knowledge about the effects of PA on glycaemic levels and, second, a thorough understanding of what kinds of adjustment should be made to both food and insulin therapy. Any adjustment should be linked to recorded blood glucose before exercise, with consideration of the type and timing of prior insulin therapy, as well as

Table 7 Contraindications to physical activity in type 1 diabetes outside of pregnancy.

Diabetic complications	Contraindicated sports
Proliferative retinopathy	Sports with heavy work and power: weightlifting, throwing
Severe nephropathy	Intense physical activity, need strict blood pressure
Peripheral neuropathy	Running, jogging
Autonomic neuropathy	exercise restrictions for hypotension risk and high cardiovascular risk

type, duration, intensity and progression of exercise. As can be seen, the complexity of these factors explains the difficulty in defining guidelines applicable to all diabetics, particularly to pregnant women with T1DM [60].

Type 2 diabetes patients in pregnancy

Obesity has been increasing worldwide, contributing to a growing number of women of childbearing age with T2DM and a further deterioration in outcome among diabetic women. Generally speaking, exercise improves blood glucose control in T2DM, reduces cardiovascular risk factors, contributes to weight loss and improves wellbeing [58–61].

All pregnant women with T2DM should ideally perform both aerobic and resistance exercise training for optimal glycaemic and health outcomes in the absence of contraindications. Any exercise prescription should consider the type, intensity, frequency, duration and progression, just as those outlined above for GDM in section 2.2 to 2.6.

Insulin therapy may increase the risks of exercise-related hypoglycaemia and doses may need to be adjusted based on exercise training; therefore, it is appropriate to apply the same recommendations as that for T1DM women who are pregnant.

Summary of recommendations and conclusions

Exercise aimed at preventing and/or treating gestational diabetes mellitus

Pre-pregnancy: Physical exercise improves insulin sensitivity and reduces plasma levels of glucose through several insulin-mediated and non-insulin-mediated mechanisms (level IA).

With regard to the positive effects

- The combined intervention of exercise and diet in gestational diabetes mellitus limits the maternal weight gain and foetal overgrowth (level IB).
- Physical activity prevents gestational diabetes mellitus in obese women belonging to certain ethnicities or genetic characteristics (level IA).

The quality of exercise

- Aerobic and strength exercise can determine delayed start of insulin therapy, reduced insulin need and better cardio-respiratory fitness (level IIIB).
- Encouraging women to do physical activity throughout the day, before and during pregnancy, is a precondition for a personalised exercise prescription in the absence of contraindications (level IA).

Physical exercise for pregnant women with pre-existing diabetes

Type 1

- Physical exercise during pregnancy is useful in diabetic women (level IIIB).
- Continuous monitoring of blood glucose in type 1 diabetes mellitus patients during exercise is a useful method (level IIA).
- Physical exercise is contraindicated in diabetic women with severe disease complications (level IA).
- Any exercise prescription should consider the type, intensity, frequency, duration and progression.

Type 2

- Physical exercise during pregnancy is useful n diabetic women as well as in non-diabetic women (level IIIB).
- Physical exercise and diet in patients with type 2 diabetes mellitus may help improve glycaemic control during pregnancy (level IIB).

Post-partum physical exercise

- Physical activity increases cardio-respiratory fitness and improves mood without having any negative effects on maternal milk volume and composition (level IA).
- Physical activity helps women achieve and maintain ideal weight after childbirth, and it promotes weight loss when combined with an adequate caloric restriction (level IA).
- Physical activity combined with a proper nutrition can prevent and/or delay diabetes onset in women who previously suffered from gestational diabetes mellitus (level IB).

List of abbreviations

RCOG	Royal College of Obstetricians & Gynaecologists
SCOG	Society of Obstetricians and Gynaecologists of Canada
CSEP	Canadian Society for Exercise Physiology
ACSM	*American College of Sports Medicine*

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REVIEW

Influence of exercise intervention on gestational diabetes mellitus: a systematic review and meta-analysis

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Abstract

Aims Exercise intervention might be a promising approach to prevent gestational diabetes mellitus. However, the results remained controversial. We conducted a systematic review and meta-analysis to explore the effect of exercise intervention on gestational diabetes mellitus.

Methods PubMed, EMbase, Web of science, EBSCO, and Cochrane library databases were systematically searched. Randomized controlled trials (RCTs) assessing the effect of exercise intervention on gestational diabetes mellitus were included. Two investigators independently searched articles, extracted data, and assessed the quality of included studies. The primary outcome was the incidence of gestational diabetes mellitus, preterm birth, and gestational age at birth. Meta-analysis was performed using random-effect model.

Results Five RCTs involving 1872 patients were included in the meta-analysis. Overall, compared with control intervention, exercise intervention was found to significantly reduce the risk of gestational diabetes mellitus (std. mean difference 0.62; 95% CI 0.43–0.89; $P = 0.01$), but demonstrated no influence on preterm birth (OR 0.93; 95% CI 0.44–1.99; $P = 0.86$), gestational age at birth (std. mean difference −0.03; 95% CI −0.12 to 0.07; $P = 0.60$), glucose 2-h post-OGTT (std. mean difference −1.02; 95% CI −2.75 to 0.71; $P = 0.25$), birth weight (std. mean difference −0.10; 95% CI −0.25 to 0.04; $P = 0.16$), Apgar score less than 7 (OR 0.78; 95% CI 0.21–2.91; $P = 0.71$), and preeclampsia (OR 1.05; 95% CI 0.53–2.07; $P = 0.88$).

Conclusions Compared to control intervention, exercise intervention was found to significantly reduce the incidence of gestational diabetes mellitus, but had no significant influence on preterm birth, gestational age at birth, glucose 2-h post-OGTT, birth weight, Apgar score less than 7, and preeclampsia.

Keywords Exercise intervention · Gestational diabetes mellitus · Randomized controlled trials (RCTs) · Meta-analysis · Systematic review

Introduction

Gestational diabetes mellitus was regarded as one of the most common complications of pregnancy (ranging from 1 to 20% depending on the population and diagnostic criteria) [1–3]. Women with gestational diabetes mellitus showed increased risk of suffering from pregnancy complications, type 2 diabetes, elevated cardiovascular disease, and metabolic syndrome [4–7]. Improved maternal glucose concentrations could stimulate excessive growth and the increase in birth weight that might result in macrosomia and birth injury [4, 8, 9]. These offspring showed an increased risk of obesity, type 2 diabetes, and metabolic syndrome [5, 10].

Many studies revealed that exercise could serve as an effective approach to delaying the progression of glucose intolerance in type 2 diabetes [11]. But, few randomized controlled trials (RCTs) focusing on this issue showed

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some conflicting results. Physical exercise before and during pregnancy was reported to reduce the risk of gestational diabetes mellitus and attenuate the typical decline in glucose tolerance [12, 13]. Some RCTs reported that exercise intervention could significantly reduce the incidence of gestational diabetes mellitus and glucose 2-h post-OGTT compared to standard care [11, 14].

In contrast to this promising finding, however, accumulating relevant RCTs showed that exercise intervention had no influence on the incidence of gestational diabetes mellitus, gestational age at birth, glucose 2-h post-OGTT, and birth weight [2, 15, 16]. Considering these inconsistent effects, we therefore conducted a systematic review and meta-analysis of RCTs to investigate the influence of exercise intervention on gestational diabetes mellitus.

Materials and methods

This systematic review and meta-analysis were conducted according to the guidance of the Preferred Reporting Items for Systematic Reviews and Meta-analysis statement [17] and the *Cochrane Handbook for Systematic Reviews of Interventions* [18]. All analyses were based on previous published studies; thus, no ethical approval and patient consent were required.

Literature search and selection criteria

PubMed, EMbase, Web of science, EBSCO, and the Cochrane library were systematically searched from inception to December 2016, with the following keywords: exercise or physical activity, and gestational diabetes. No limitation was enhanced. To include additional eligible studies, the reference lists of retrieved studies and relevant reviews were also hand-searched and the process above was performed repeatedly until no further article was identified. Conference abstracts meeting the inclusion criteria were also included.

The inclusion criteria were as follows: study population, pregnant woman; intervention, exercise at 10–22 weeks of pregnancy; control, standard care; outcome measure, incidence of gestational diabetes mellitus, preterm birth, and gestational age at birth; and study design, RCT.

Data extraction and outcome measures

The following information was extracted for the included RCTs: first author, publication year, sample size, baseline characteristics of patients, exercise intervention, control, study design, the incidence of gestational diabetes mellitus, preterm birth, gestational age at birth, glucose 2-h post-OGTT, birth weight, Apgar score less than 7, and preeclampsia. The author would be contacted to acquire the data when necessary.

The primary outcome was the incidence of gestational diabetes mellitus, preterm birth, and gestational age at birth. Secondary outcomes included glucose 2-h post-OGTT, birth weight, Apgar score less than 7, and preeclampsia.

Quality assessment in individual studies

The Jadad Scale was used to evaluate the methodological quality of each RCT included in this meta-analysis [19]. This scale consisted of three evaluation elements: randomization (0–2 points), blinding (0–2 points), and dropouts and withdrawals (0–1 points). One point would be allocated to each element if they have been mentioned in article, and another one point would be given if the methods of randomization and/or blinding had been detailedly and appropriately described. If methods of randomization and/or blinding were inappropriate, or dropouts and withdrawals had not been recorded, then one point was deducted. The score of Jadad Scale varies from 0 to 5 points. An article with Jadad score ≤ 2 was considered to be of low quality. If the Jadad score ≥ 3, the study was thought to be of high quality [20].

Statistical analysis

Standard mean differences (std. MDs) with 95% confidence intervals (CIs) for continuous outcomes (gestational age at birth, glucose 2-h post-OGTT, and birth weight) and odds risks (ORs) with 95% CIs for dichotomous outcomes (the incidence of gestational diabetes mellitus, preterm birth, Apgar score less than 7, and preeclampsia) were used to estimate the pooled effects. All meta-analyses were performed using random-effects models with DerSimonian and Laird weights. Heterogeneity was tested using the Cochran Q statistic ($P < 0.1$) and quantified with the I^2 statistic, which described the variation of effect size that was attributable to heterogeneity across studies. An I^2 value greater than 50% indicated significant heterogeneity. Sensitivity analysis was performed to detect the influence of a single study on the overall estimate via omitting one study in turn when necessary. Owing to the limited number (<10) of included studies, publication bias was not assessed. $P < 0.05$ in two-tailed tests was considered statistically significant. All statistical analyses were performed with Review Manager Version 5.3 (The Cochrane Collaboration, Software Update, Oxford, UK).

Results

Literature search, study characteristics, and quality assessment

The flowchart for the selection process and detailed identification is presented in Fig. 1. 814 publications were identified through the initial search of databases. Ultimately, five RCTs were included in the meta-analysis [2, 11, 14–16].

The baseline characteristics of the five eligible RCTs in the meta-analysis are summarized in Table 1. The four studies were published between 2012 and 2016, and sample sizes ranged from 172 to 330 with a total of 1872. There was no significant difference of maternal age, BMI, and fasting glucose in pregnant woman at baseline. Three included studies reported the BMI [11, 15, 16], but the other two included trials reported the number of women with BMI ≥30 [2, 14]. Thus, it was not possible to adjust for BMI because BMI reported in the five included RCTs was not presented in a similar manner. Two included studies reported that pregnant women in exercise intervention group obtained a supervised cycling program (3 times/week), while those in control intervention group got usual daily activities [11, 14]. Three included studies reported that pregnant women in exercise intervention group obtained physical activity based on American College of Obstetricians and Gynecologists (ACOG) guidelines, while those in control intervention group got usual daily activities [2, 15, 16].

Among the five RCTs, four studies reported the incidence of gestational diabetes mellitus [2, 11, 14, 15], two studies reported preterm birth [2, 14], four studies reported gestational age at birth [2, 14–16], three studies reported glucose 2-h post-OGTT [11, 14, 16], four studies reported birth weight [2, 14–16], and two studies reported Apgar score less than 7 and preeclampsia [14, 16]. Jadad scores of the five included studies varied from 3 to 4, and all five studies were considered to be high-quality ones according to quality assessment.

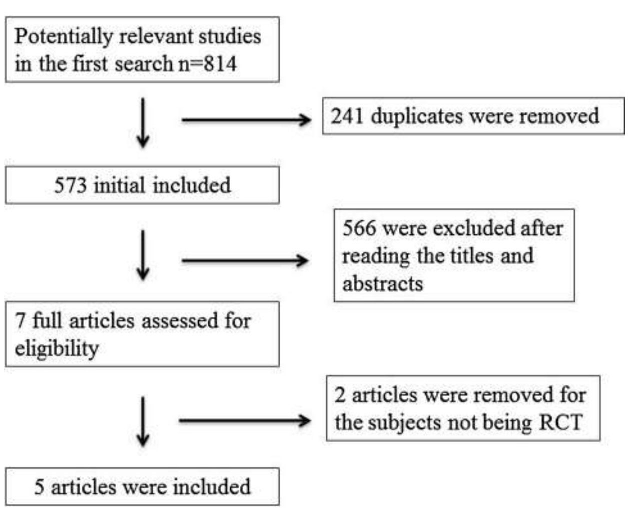

Fig. 1 Flow diagram of study searching and selection process

Primary outcome: the incidence of gestational diabetes mellitus, preterm birth, gestational age at birth

These three outcome data were analyzed with a random-effects model, and the pooled estimate of the four included RCTs suggested that compared to control group, exercise intervention was associated with a significantly decreased incidence of gestational diabetes mellitus (std. mean difference 0.62; 95% CI 0.43–0.89; $P = 0.01$), with low heterogeneity among the studies ($I^2 = 37\%$, heterogeneity $P = 0.19$) (Fig. 2).

However, exercise intervention was found to not significantly reduce preterm birth (OR 0.93; 95% CI 0.44–1.99; $P = 0.86$) than control intervention, with no heterogeneity among the studies ($I^2 = 0\%$, heterogeneity $P = 0.66$) (Fig. 3). Consistently, gestational age at birth in exercise intervention group showed no significant difference when compared to those in control intervention group (std. mean difference −0.03; 95% CI −0.12 to 0.07; $P = 0.60$), with no heterogeneity among the studies ($I^2 = 0\%$, heterogeneity $P = 0.47$) (Fig. 4). In Fig. 4, "Barakat 2013" represented the index of corresponding figure (such as gestational age at birth in Fig. 4) in pregnant women without gestational diabetes mellitus, while "Barakat 2013^{+}" represented the index of corresponding figure (such as gestational age at birth in Fig. 4) in pregnant women with gestational diabetes mellitus, and these were the same in Fig. 6.

Sensitivity analysis

Low heterogeneity or no heterogeneity was observed among the included studies for the incidence of gestational diabetes mellitus, preterm birth, gestational age at birth. Thus, we did not perform sensitivity analysis by omitting one study in each turn to detect the source of heterogeneity.

Secondary outcomes

Compared with control intervention, exercise intervention showed no significant influence on glucose 2-h post-OGTT (std. mean difference −1.02; 95% CI −2.75 to 0.71; $P = 0.25$; Fig. 5), birth weight (std. mean difference −0.10; 95% CI −0.25 to 0.04; $P = 0.16$; Fig. 6), Apgar score less than 7 (OR 0.78; 95% CI 0.21–2.91; $P = 0.71$; Fig. 7), and preeclampsia (OR 1.05; 95% CI 0.53–2.07; $P = 0.88$; Fig. 8).

Table 1 Characteristics of included studies

No.	Author	Exercise group					Control group					Jada scores
		Number	Ethnicity	Maternal age (years)	BMI (kg/m^2)	Fasting glucose (mmol/L)	Number	Ethnicity	Maternal age (years)	BMI (kg/m^2)	Fasting glucose (mmol/L)	
1	Wang (2016)	132	–	–	26.78 ± 2.75	–	133	–	–	26.78 ± 2.75	–	3
2	Guelfi (2016)	85	76 (caucasian)	33.6 ± 4.1	*N* = 18 (≥30)	4.3 ± 0.4	87	68 (caucasian)	33.8 ± 3.9	*N* = 20 (≥30)	4.3 ± 0.3	4
3	Nobles (2015)	124	69 (hispanic)	*N* = 51 (20–24 y)	*N* = 83 (≥30)	–	127	82 (hispanic)	*N* = 45 (20–24 y)	*N* = 73 (≥30)	–	4
4	Barakat (2013)	210	–	31 ± 3	24.1 ± 4.1	–	218	–	31 ± 4	23.7 ± 3.8	–	3
5	Stafne (2012)	429	–	30.5 ± 4.4	24.7 ± 3.0	10.1 ± 5.42	327	–	30.4 ± 4.3	25.0 ± 3.4	10.7 ± 5.47	4

Discussion

Our meta-analysis clearly suggested that compared to control intervention, exercise intervention was associated with a significantly reduced incidence of gestational diabetes mellitus, but showed no significant effect on preterm birth, gestational age at birth, glucose 2-h post-OGTT, birth weight, Apgar score less than 7, and preeclampsia. In addition, exercise intervention was also found to improve maternal cardiovascular fitness, exercise automaticity, and reduce general psychological distress indicated by the 21-item Depression Anxiety Stress Scale [14].

It was well known that nutrition intake was critical for the incidence of gestational diabetes mellitus. In order to avoid the influence of nutrition intake, participants in intervention group and control group obtained similar nutrition intake. One included study reported that each eligible woman received mean daily nutritional intake (total energy, carbohydrate, fat, protein, sugar, and fiber) after completed a 7-day food diary preintervention and postintervention [14]. Two trials reported that each woman got appropriate nutrition based on the Institute of Medicine Guidelines [2, 15]. In addition, exercise was found to improve health and reduce the incidence of obesity as well as diabetes mellitus in non-pregnant individuals. But there was no effective evidence for the efficacy of exercise in pregnant women [21]. One study reported that exercise and weight control may reduce the incidence of gestational diabetes mellitus if BMI > 25.95 kg/m^2 and homeostasis model assessment-insulin resistance score >2.08 [22].

One recent meta-analysis concluded that there was insufficient evidence to confirm the efficacy of physical activity during pregnancy on lowering the risk of gestational diabetes mellitus, but did not analyze the data of preterm birth, glucose intolerance, and birth weight. [23]. Our meta-analysis clearly indicated that exercise intervention could significantly prevent gestational diabetes mellitus and focused on other measures including preterm birth, gestational age at birth, glucose 2-h post-OGTT, birth weight, Apgar score less than 7, and preeclampsia, but without significant difference between exercise intervention and control intervention.

Several clinical trials investigating the effect of exercise intervention on the incidence of gestational diabetes mellitus reported conflicting results. Two included trials showed that exercise intervention had no effect of antenatal exercise (moderate-intensity aerobic, strength, and flexibility exercises by three times a week for 45–60 min) on the incidence of gestational diabetes mellitus [15, 16]. In contrast, another study resulted

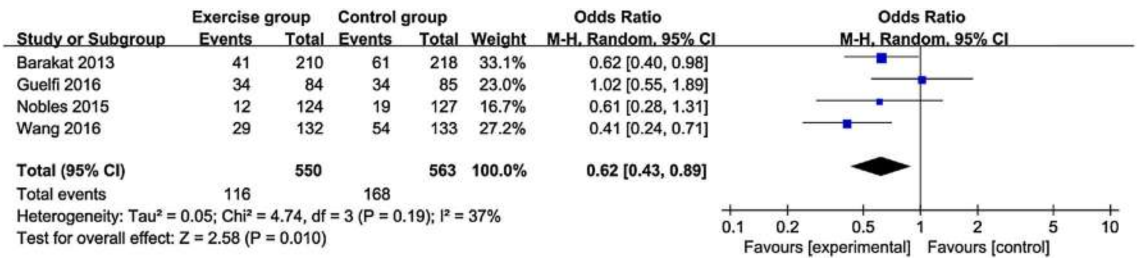

Fig. 2 Forest plot for the meta-analysis of the incidence of gestational diabetes mellitus

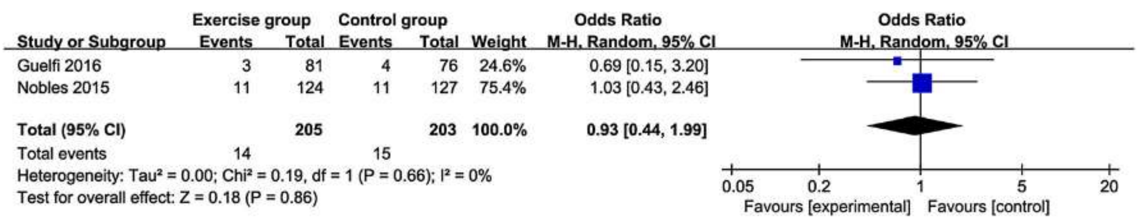

Fig. 3 Forest plot for the meta-analysis of preterm birth

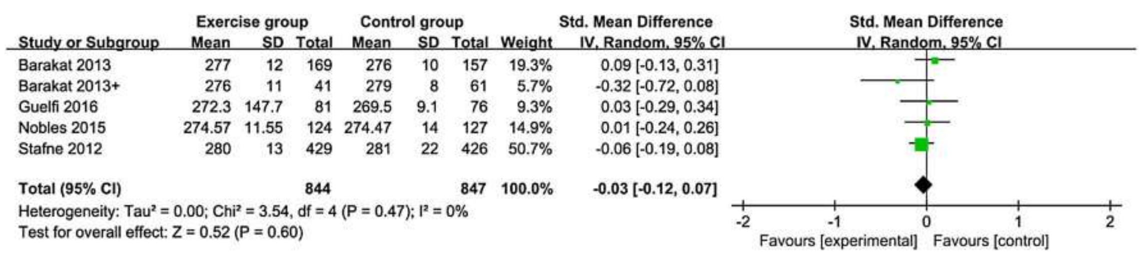

Fig. 4 Forest plot for the meta-analysis of gestational age at birth (day)

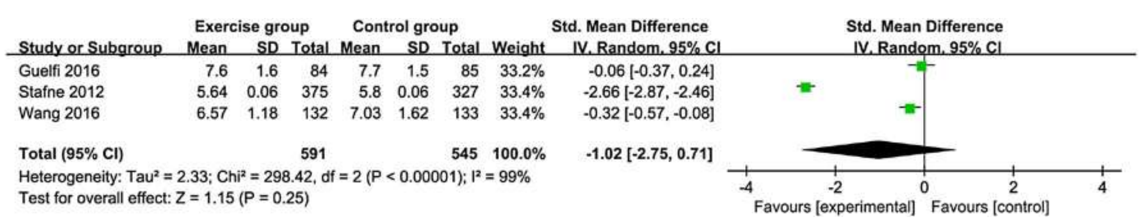

Fig. 5 Forest plot for the meta-analysis of glucose 2-h post-OGTT (mmol/L)

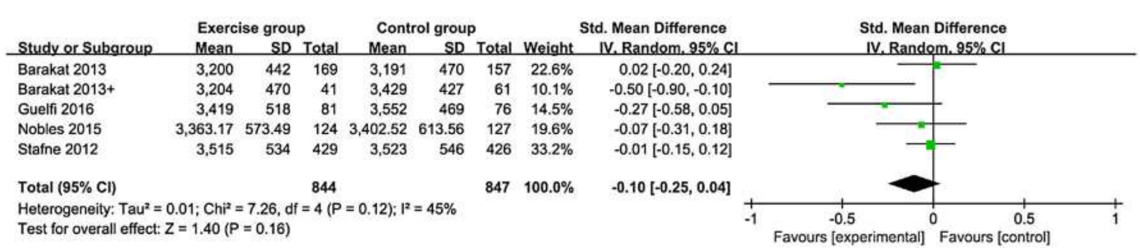

Fig. 6 Forest plot for the meta-analysis of birth weight (g)

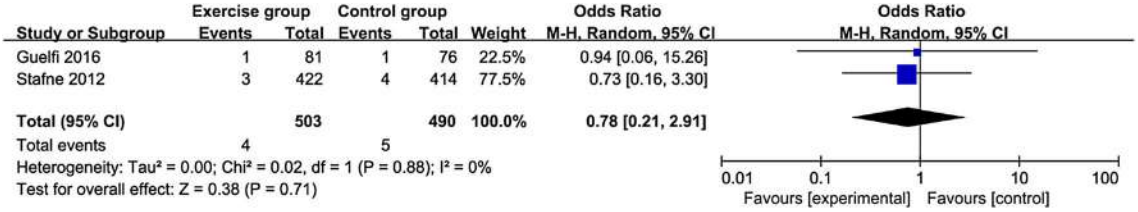

Fig. 7 Forest plot for the meta-analysis of Apgar score less than 7

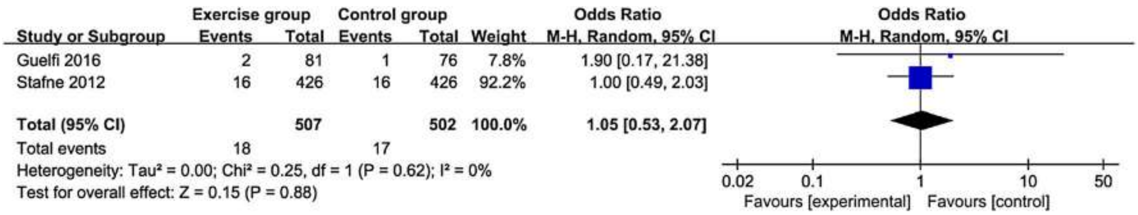

Fig. 8 Forest plot for the meta-analysis of preeclampsia

in reduced incidence of gestational diabetes mellitus following a program of aerobic, strength, and flexibility exercises by three times per week started from 10 to 14 weeks of gestation [24]. A beneficial effect of exercise on the prevention of gestational diabetes mellitus may occur in women who participated in vigorous intensity activity prior to pregnancy and continued some activity into early pregnancy [25]. In addition, energy expenditure up to a minimum of 16 MET-h/week (that was equivalent to approximately 1 h of moderate activity on 5 days of the week) was reported to have some potential in reducing the risk of gestational diabetes, but this levels of exercise was generally challenging for pregnant women [26]. Different frequency, duration time, and intensity of exercise may have the possibility to alter the results, but the optimal selection for pregnant women was elusive. In addition, daily nutritional intake and physical activity levels outside of the intervention may also have some influence on the results.

Several limitations should be taken into account. Firstly, our analysis was based on only five RCTs and more clinical trials with large sample were needed to explore this issue. The duration time and intensity of exercise in the included studies were different, and it may have an influence on the pooling results. Next, exercise intervention based on ACOG guidelines may not meet the requirement of preventing gestational diabetes, and future studies should focus on increased intensity of exercise for pregnant women. Finally, some unpublished and missing data might lead bias to the pooled effect.

Exercise intervention showed an important ability to reduce the risk of gestational diabetes mellitus. Exercise intervention was recommended to be administrated in pregnant women, but more studies should investigate the optimal duration time and intensity of exercise.

Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent No informed consent.

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Diabetology & Metabolic Syndrome

REVIEW

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The effect of exercise on the prevention of gestational diabetes in obese and overweight pregnant women: a systematic review and meta-analysis

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Abstract

Background: Gestational diabetes mellitus (GDM) is one of the most common complications of pregnancy and its prevalence worldwide is increasing along with enhancing type two of diabetes. Contrary results have been found in some review articles that examine the effect of exercise activities on preventing GDM, regardless of obesity. Therefore, the aim of this study was to systematically review the articles on the effect of exercise activities on the prevention of GDM in obese and overweight pregnant women.

Main text: Literature was retrieved by formally searching PubMed, Embase, Cochrane library, Web of Science, Scopus, Proquest and by hand searching of reference lists of related articles. Finally, a total of eight literatures included, and Review manager 5.3 and STATA 14.0 statistical software were utilized for processing. In order to investigate the effect of sports activities on the incidence of GDM, the risk ratio (RR), and for quantitative indices, the standardized mean difference (SMD) with 95% confidence interval (CI) for each study was calculated. Out of 5107 papers identified, eight papers with 1441 participants included in meta-analysis (intervention group 727, control group 714). In the intervention group, 143 (19.66%, 95% CI 76.83 to 22.74) and in the control group, 196 (27.45%, 95% CI 20.24 to 30.88%), pregnant women had diabetes. The RR of gestational diabetes was 0.76 (95% CI 0.56 to 1.03, $I^2 = 50\%$, $P = 0.05$). In studies that the time for the intervention was three times a week or less, effect of intervention was significant in reducing the incidence of diabetes (RR: 0.59, 95% CI 0.46 to 0.76, $I^2 = 0\%$, $P = 0.47$). However, in studies with repeat of intervention was more than three times a week, the effect of intervention between two intervention and control groups was not different (RR: 1.03, 95% CI 0.78 to 1.35, $I^2 = 0\%$, $P = 0.46$).

Conclusions: The exercise activities, alone, in obese or overweight pregnant women did not have a significant effect on the overall incidence of GDM, but considering the effect measure, the incidence of GDM was 24% lower in the intervention group than control group. This difference is considerable in the two groups. As the systematic review literatures both represent the information gap on the research subject and pave the way for further studies so it seems that there is a need for more randomized controlled trials so that we can make a complete conclusion on the type, intensity and duration of exercise in preventing GDM.

Keywords: Gestational diabetes mellitus, Exercise, Obese and overweight, Pregnancy, Prevention

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Background

Gestational diabetes mellitus is a disorder of carbohydrate and glucose metabolism, which is first occurring or diagnosed during pregnancy [1, 2]. Due to the physiological, endocrine and metabolic changes during pregnancy in order to meet the nutrient and oxygen requirements of the fetus continuously, the diabetogenic condition similar to that occurring in type 2 diabetes (T2D) is created, increasing the insulin resistance, decreasing the insulin sensitivity and consequently enhancing the need for insulin [3]. In most pregnancies, this need is met and the balance between insulin resistance and secretion is provided. However, if there is no such balance in a person, the symptoms of gestational diabetes are manifested [4]. This disorder is one of the most common complications of pregnancy and its prevalence worldwide is increasing along with enhancing T2D [5].

Gestational diabetes mellitus not only is associated with adverse maternal and perinatal outcomes such as macrosomia, birth weight >90th percentile for gestational age, increased cesarean section, hypertension, fetal hyperinsulinemia, serum C-peptide level of more than 90th percentile (fetal hyperinsulinemia), preterm labor, shoulder dystocia, birth defects, need for care in the neonatal intensive care unit, hyperbilirubinemia and preeclampsia [5–7], but also increases the risk of long-term problems in mother and infant [8]. Therefore, screening, diagnosis and treatment of GDM are important and necessary to prevent undesirable outcomes.

A number of risk factors affect the incidence and development of GDM. The most common risk factors include obesity and overweight, high maternal age, family history of T2D, previous history of GDM, polycystic ovary syndrome, persistent glucosuria, recurrent abortions, previous history of a large baby (birth weight ≥ 4000 g), history of stillbirth, history of chronic hypertension or blood pressure associated with pregnancy and maternal smoking as well as other risk factors [6, 8]. Among these risk factors, women with overweight, obesity and morbid obesity are related to an increased risk of developing GDM at a rate of two, four and eight times, respectively [9]. With the rise of obesity in the worldwide and the consequent increase in GDM, preventive strategies are needed to avoid the unwanted consequences of obesity and hyperglycemia during pregnancy [10]. Today, the interventions such as lifestyle changes, the use of metformin [11], glyburide [12], myo-inositol [13], insulin [14], diet and exercise activities [15] are applied to prevent and treat the GDM. Contrary results have been found in some review articles that examine the effect of exercise activities on preventing GDM, regardless of obesity [16–18]. A use inexpensive, easy and safe prevention method is preferred in pregnancy. Some studies showed physical activity in pregnancy has these features [19, 20], and also it is effective on insulin resistance [21]. So in the present study, we assessed physical activity from different strategies for preventing diabetes.

Therefore, the researchers of the current study reviewed the articles in which exercise activities were used to prevent GDM in obese or overweight pregnant women. According to the searches, few systematic review articles have been performed related to the effect of exercise activities on GDM in obese and overweight pregnant women, up to now [22].

The studies that have so far been conducted on obese and overweight pregnant women are a combination of lifestyle, diet and exercise on the prevention of GDM, and the independent effect of exercise has not been reported [23–25]. On the other hand, we could find any review about the effect of physical activity on GDM in obese and overweight mothers. Furthermore, since different methods of exercise activities have been used in studies, summarizing the results of these studies can be useful to determine the effective exercise program. Therefore, the aim of this study was to systematically review the articles on the effect of exercise activities on the prevention of GDM in obese and overweight pregnant women in order to achieve a regular summation in this regard.

Methods

This study was fulfilled through databases and search engines including Medline, Cochrane Library, PubMed, Scopus, Web of Science (WoS), Embase and Cumulative Index to Nursing and Allied Health Literature (CINAHL) databases with interest in studies that reported on the effect of exercise activities on the risk of GDM in obese and overweight pregnant women in the period 1/1/2008 to 5/30/2018 using the relevant keywords. For a complete list of search terms, please refer to Additional file 1. The manual search was also carried out to review the list of references of related articles. In addition, gray literatures were searched in the ProQuest and Prospero, and dissertations and articles presented in conferences were searched in Scopus and WoS. These keywords were selected based on the medical subject headings (MeSH). The advanced search strategy was examined using the operators and tags appropriate to each of the scientific bases.

Inclusion criteria consistent of randomized controlled clinical trials conducted on obese and overweight pregnant women; pregnant women in the control group received routine prenatal care, and the intervention group performed exercise in addition to routine prenatal care. All singleton pregnant women who had no contraindication to exercise. Review and descriptive articles, studies on non-obese and overweight individuals, studies whose interventions were both exercise and other lifestyles such as nutritional modification, studies that did not compare the control and intervention groups and did not answer the research question were excluded from the study.

Different stages of study selection and data extraction are shown in Fig. 1. At first, a list of articles was prepared from the databases based on the mentioned keywords. Then, after reviewing the titles of the found articles and removing duplicate titles, two researchers independently reviewed the abstract of articles based on the inclusion and exclusion criteria of the current study. If an article was excluded, the reasons were mentioned. If necessary, the full text of the articles was reviewed. Any disagreement was discussed and if no agreement was found between two researchers, a third researcher independently assessed the article in question. In the next step, the related information of the articles entered into this systematic study including authors' name, title, year of publication, inclusion and exclusion criteria, sample size, type of intervention, comparison group, outcome and intervention results was recorded. The methodological quality of studies was evaluated according to the recommendation by the Cochrane Handbook, including assessments of the generation of the allocation sequence (selection bias); concealment of the allocation sequence (selection bias); blinding (detection and performance bias); blinding of participants and personnel to outcome assessment; incomplete outcome data (attrition bias); selective outcome reporting (reporting bias); and other

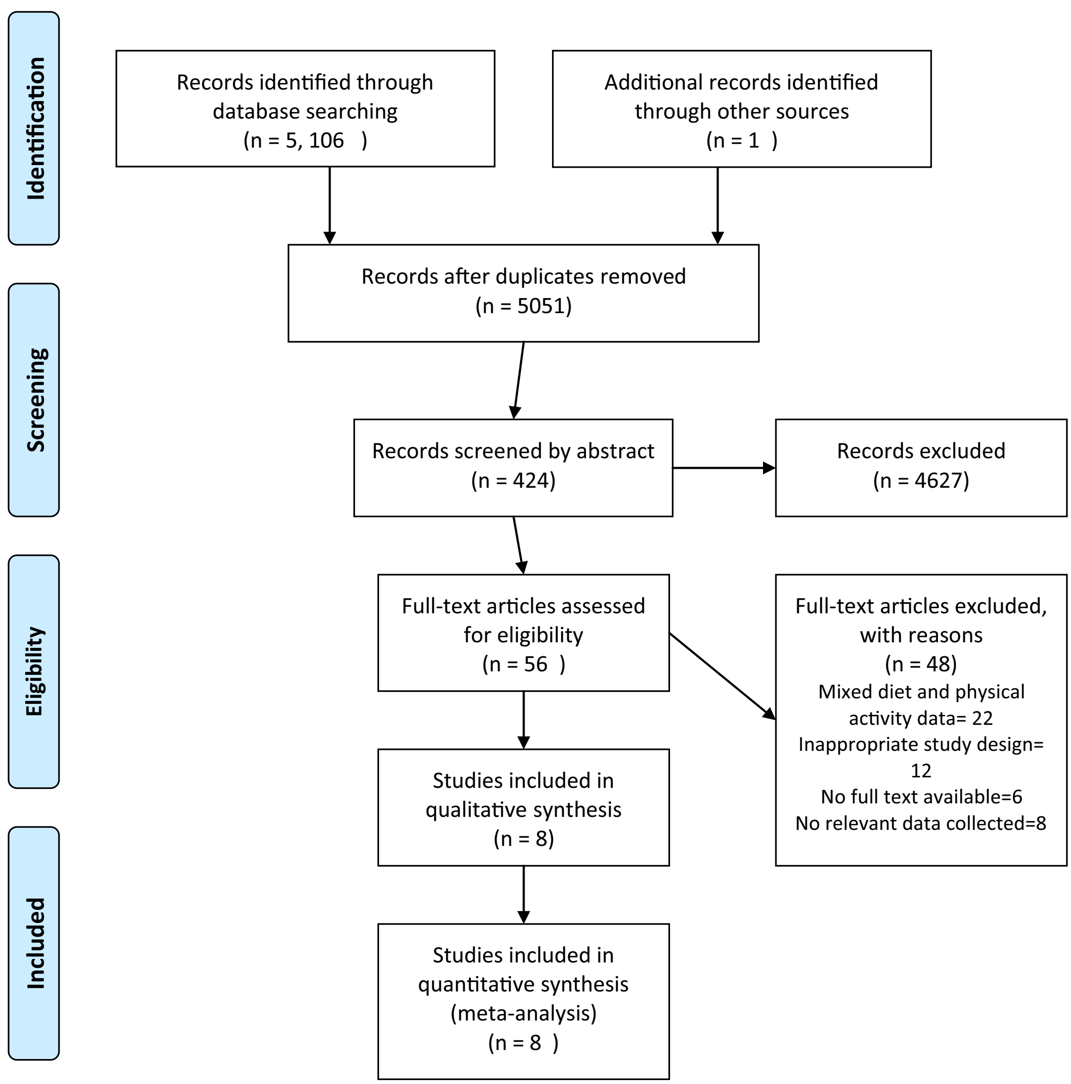

Fig. 1 PRISMA flow diagram of screening, selection process and inclusion study

bias (https://www.bmj.com/content/343/bmj.d5928.extract).

For each article, the RR was calculated in order to investigate the effect of exercise activities on the incidence of GDM, and standardized mean difference with 95% confidence intervals was calculated for quantitative indices. Data were combined using the random-effects model.

Heterogeneity of the studies was assessed graphically with forest plots and statistically by Chi-square-based Q statistic and I^2 value. Heterogeneity was considered significant at a P-value of <0.10 in Q-test or $I^2>40\%$. Subgroup analysis was carried out based on the frequency and time of intervention. Statistical analyses were performed using Review Manager 5.0.1 [26].

Results

In the initial search, 5107 papers were found in different databases. Totally, 56 articles were selected after screening the titles and abstracts and removing duplicate and unrelated titles. Then, the authors read the full text of the articles and choose eight articles were analyzed (Fig. 1).

The characteristics of the articles studied on the effect of exercise activities on the incidence of GDM in comparison with the control group in overweight and obese women are summarized in Table 1. Different studies were not the same in terms of the type, manner and intensity of exercise. The total number of participants in these studies was 1441 pregnant women. Of these women, 727 and 714 were in the intervention group and control group, respectively. All women were obese or overweight, in the first or second trimester of pregnancy as well as singleton pregnancies without maternal chronic disease and without abnormalities in the fetus. These women may have been nulliparous and multiparous.

None of the studies has been conducted on women of particular ethnicity or race. A study in Norway [27], a study in Spain [28] a study in Ireland [29] a study in the Netherlands [30], a study in Australia [31], a study in China [32] a study in New Zealand [33] and a multicentre study conducted in nine countries (New Zealand, the United Kingdom, Austria, Poland, Italy, Denmark and Belgium, the Netherlands and Australia) [34] were performed. The methodological quality of the studies entered into the final meta-analysis is illustrated in Table 2. The randomization process was correctly performed in all studies. The randomization and concealment process were not carried out in three studies [29, 33, 34] and explicitly described in two studies [27, 32]. Due to the type of intervention, it was impossible to blind participants in any study. Blinding the outcome measurement was correctly observed in all studies. In five studies, the analytical process was not intention to treat (ITT) [28–30, 33, 34]. The reporting process was in accordance with the protocol. There was only one protocol violation, which was mentioned in the article by the authors [30].

Exercise programs

There were different types of exercise program, severity, duration and frequency in studies that included aerobic [29, 30, 32–34], resistance [27, 34], strength [30] exercises and resistance exercises with pelvic floor exercises [29]. In a study, an exercise program with 900 kg calorie per week was conducted through a pregnancy physical activity questionnaire (PPAQ) [31]. In a number of studies, exercise programs began in the first trimester and continued until delivery [31, 32]. In three studies, exercise activities began in the second trimester and lasted until 34–37 weeks of gestation [27, 30, 33]. In two studies, exercise activities started less than 17 weeks (in the first and second trimesters) and continued up to 6 weeks after delivery [29, 34]. In a study, exercise program was repeated twice a week [30]. In four studies, it was repeated three times a week [27, 29, 32, 34]. In a study, the exercise program was daily repeated during a week [31] and repeated three to five times a week in another study [33]. In all studies, the duration of exercise was between 15 and 60 min [27, 29–34].

The intensity level of exercise activities was low to moderate [32, 34] in two studies, moderate to high in three studies [29, 30, 33] and moderate in a study [27], respectively, and it was not determined in one study [31]. In four studies, the intensity scale of exercise activities was based on Borge-Scale [27, 29, 32, 33]. In a study, the intensity level of exercise was according to the American College of Obstetricians and Gynecologists (ACOG) and American College of Sports Medicine (ACSM) guidelines [30]. The ACOG guideline was used to assess the intensity level of exercise in a study [34]. In a study, the intensity level of exercise was at the start of the study based on mother's maximum heart rate [32]. Another study applied a specific questionnaire for assessing the metabolic equivalent of task to determine the intensity level of exercise [34]. In all studies, the exercise activities were evaluated by an observer [27, 29–32, 34]. In one study, exercise activities were performed only once at home in addition to conducting at the hospital's clinic [27]. In one study, the exercises were conducted only at home [33].

All included studies of the current research assessed the effect of exercise during pregnancy on a number of pregnancy outcomes. The primary outcome of the recent study was to compare the incidence of gestational diabetes in the intervention group (exercise training during pregnancy) and control group. In the case of diabetes incidence, eight clinical trials with a sample size of 1441 were entered into the final

Table 1 Characteristics of the articles on gestational diabetes in obese and overweight women

Participants							Study characteristic			Out comes			
Author, year, Country	Group No.	Mean age	BMI	Participant	Ges.Age	History	Typ	*D.M-GDM	Setting	Intervention	Neonate	GDM N (%)	OR (CI 95%) P-value
Kirsti Krohn Garnæs (2016) Norway [27]	Int: 46 Con: 45	31.3 ± 3.8 31.4 ± 4.7	33.9 ± 3.8 35.1 ± 4.6	NP* and MP*	Baseline 12–18 weeks Late pregnancy 34–37	–	Clinical trial (RCT)	Based on the IADPSG	Trondheim University Hospital	The exercise group was offered thrice weekly supervised sessions of 35 min of moderate intensity endurance exercise and 25 min of strength training Women received Standard Care Controls	–	2 (6.1) 9 (27.3)	0.1 (0.02–0.95) 0.04
Ruben Barakat (2013) Spain [28]	Int: 255 Cont:255	31 ± 3 31 ± 4	24.1 ± 4.1 23.7 ± 3.8	NP and MP	10–12 weeks	–	RCT	WHO criteria and IADPSG	Centro de Los Pedroches and Centro de Salud Leganés Norte, Leganés, Madrid	Moderate-intensity resistance and aerobic exercises (three times/week, 50–55 min/session) Women in control group received the routine care	Apgar score 1 min Apgar score 5 min Birth weight (g) Gestational age (days) Cesarean delivery (n, %)	41 (19.5) 61 (28) 29 (13.8) 32 (14.7)	0.98 (0.40–0.62) 0.040 Based on WHO criteria 0.797 IADPSG criteria

Table 1 (continued)

Participants							Study characteristic			Out comes			
Author, year, Country	Group No.	Mean age	BMI	Participant	Ges.Age	History	Typ	*D.M-GDM	Setting	Intervention	Neonate	GDM N (%)	OR (CI 95%) P-value
Niamh Daly (2017) Ireland [29]	Int:44 Cont:44	30.0 ± 5.1 29.4 ± 8.4	34.7 ± 4.6 34.7 ± 5.1	NP	less Than 17 weeks	–	RCT	Based on the IADPSG	Coombe Women and Infants University Hospital, Dublin	50–60 min of exercise: warm-up, resistance or weights, aerobic exercises, and cool-down. All women received routine pre-natal care	Birth weight (g) Gestation at birth (week) Gestation at birth (week) Apgar scores	25 (58.8) 21 (48.8)	P = 0.51
Oostdam (2012) Neth-erlands [30]	Int: 59 Cont: 62	30.8 ± 5.2 30.1 ± 5.4	33 ± 3.7 33.9 ± 5.6	NP and MP	After 20 weeks	History of macroso-mia OR history of GDM; OR first-grade relative with T2D	RCT	Based on the IADPSG	VU Univer-sity Medi-cal Center, Amster-dam	The interven-tion group twice weekly exercises for 60 min Training consisted of aerobic and strength exercises	Gestational age Birth-weight, g Caesarean section, % (n) GDM, % (n)	7 (14.6) 11 (21.6)	0.27 (1.55–0.65) 0.37

Table 1 (continued)

Participants							Study characteristic			Out comes			
Author, year, Country	Group No.	Mean age	BMI	Participant	Ges.Age	History	Typ	*D.M-GDM	Setting	Intervention	Neonate	GDM N (%)	OR (CI 95%) P-value
Chen Wang (2016) China [32]	Int: 133 Cont: 132	32.14 ± 4.57 32.50 ± 4.91	26.82 ± 2.76 26.75 ± 2.75	NP and MP	< 12 + 6 weeks	–	RCT	Based on the IADPSG	Peking University first hospital	The women in the intervention group performed exercises for 50 min three times a week and in a hospital under the supervision of one of the researchers until the end of the week of 37 weeks of pregnancy	Gestational age, Apgar score, birth-weight, Apgar score	29 (22) 54 (40.6)	0.412 (0.240–0.705) 0.001
David Simmons (2016) New Zealand, UK, Austria, Poland, Italy, Denmark, Belgium, Netherlands Australia [34]	439 Healthy eating N: 113 Physical activity N: 110 HE&PA: 108 Usual care: 105	Age total: 32.0 ± 5.4	33.7 ± 4.0	NP and MP	< 20 weeks	History of GDM	The DALI Lifestyle Study RCT	Based on the IADPSG	Antenatal clinics a cross 11 centers in 9 European counteries	Interventions start from 20 weeks and up and continue until the 35th week. Both aerobic and resistance physical activity (frequency, intensity, time, type) based on ACOG	Birth weight, gestational age	99 (21.9) 100 (19)	1.21 (0.55–2.67) 0.05 > P

Table 1 (continued)

Participants							Study characteristic			Out comes			
Author, year, Country	Group No.	Mean age	BMI	Participant	Ges.Age	History	Typ	*D.M-GDM	Setting	Intervention	Neonate	GDM N (%)	OR (CI 95%) P-value
Seneviratn (2016) New Zealand [33]	Int: 37 Cont: 38	–	32.4 ± 4.6 34.5 ± 6.2	NP and MP	From 20 weeks	–	RCT	–	Home-based intervention in Auckland	In this study, individuals in the intervention group performed moderate-intensity home-based exercise programs from week 20 to 35 in moderate intensity three to five times a week, and each time for 15 to 15 min using a steady-state magnetic bicycle	Gestational age (days) Birth weight (g) Occipito-frontal circumference (cm) Ponderal index (g/cm^3) BMI at birth (kg/m^2) Placental weight (g) Apgar score Hypoglycaemia Respiratory distress	4 (11) 2 (5)	*2.1 (0.3–12.8)* P = 0.432
Leonie, Callawa, Fracp Australia [31]	Int: 25 Cont: 25	–	–	NP and MP	12 weeks' gestation and followed to delivery	–	Pilot randomized controlled trial	Australasian Diabetes in Pregnancy Society criteria were used for the diagnosis and management of GDM	Royal Brisbane and Women's Hospital	Exercise for the intervention group with the goal of energy consumption up to 900 kcal/week	–	3 (12) 5 (23) 0 (0) 3 (16)	0.07 12 weeks 0.57 28 weeks 0.07 12 weeks 0.57 28 weeks

D.M-GDM*: diagnostic method for GDM; NP*: Nulipara; MP*: multipara

Table 2 The methodological quality of the included studies

Author, year	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Callway et al. 2010	−	+	+	−	−	−	−
Oostdam et al. 2012	−	+	+	−	+	−	−
Barakat et al. 2013	−	+	+	−	+	−	−
Seneviratne et al. 2015	−	−	+	−	−	−	−
Simmons et al. 2018	−	−	+	−	−	−	−
Wang et al. 2017	−	?	+	−	+	−	−
Krohn Garnæs1 et al. 2018	−	?	+	−	+	−	−
Daly et al. 2018	−	−	+	−	+	−	−

meta-analysis. Accordingly, 143 (19.66%, with 95% CI 16.83 to 22.74) and 196 (27.45%, with a 95% CI 24.20 to 30.88) pregnant women suffered from diabetes in the intervention group and control group, respectively. The RR of GDM was 0.76 (with 95% CI 0.56 to 1.03, P = 0.07). There was moderate heterogeneity between studies ($I^2 = 50\%$, P = 0.05) (Fig. 2).

Moreover, there was no statistically significant relationship between the studies with intervention in the first trimester of pregnancy (0.85, with 95% CI 0.55 to 1.29, $I^2 = 66\%$, P = 0.03) and those with intervention in the second trimester of pregnancy (0.64, with 95% CI 0.40 to 1.04, $I^2 = 23\%$, P = 0.27) (Fig. 3).

In studies which had an intervention time in three times a week or less, the effect of intervention was observed on reducing the incidence of diabetes (0.59, with 95% CI 0.46 to 0.76, $I^2 = 0\%$, P = 0.47). However, the effect of intervention on reducing the incidence of diabetes was not seen in studies with an intervention time of more than three times a week (1.03, with 95% CI 0.78 to 1.35, $I^2 = 0\%$, P = 0.46) (Fig. 4).

Fasting plasma glucose (FPG) was evaluated in six clinical trials with a sample size of 819 participants (423 and 396 in the intervention group and control group, respectively), entered into the final meta-analysis [27, 29–31, 34]. The mean FPG had no significant difference between intervention and control groups (SMD: 0.01, 95% CI −0.34 to 0.36, $I^2 = 82\%$, P < 0.001). In addition, no significant difference was found between the studies with intervention in the first trimester of pregnancy [29, 31, 32, 34]. (SMD: −0.20, 95% CI −52.0 to 0.12, $I^2 = 71\%$, P = 0.02) and those with intervention in the second trimester of pregnancy [27, 30] (SMD: 0.45, 95% CI −0.20 to −10.1, $I^2 = 79\%$, P = 0.03) (Fig. 5). There was no significant difference between the intervention and control groups in the studies whose intervention time was three times a week or less (SMD: 0.13, 95% CI −0.60 to −0.86, $I^2 = 92\%$, P < 0.001) like studies with intervention

Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Risk Ratio M-H, Random, 95% CI
Barakat 2013	41	255	61	255	21.2%	0.67 [0.47, 0.96]
Callaway 2010	5	22	3	19	4.6%	1.44 [0.40, 5.24]
Daly 2017	25	44	21	44	19.6%	1.19 [0.80, 1.78]
Krohn 2016	2	46	9	45	3.6%	0.22 [0.05, 0.95]
Oostdam 2012	7	62	11	59	8.4%	0.61 [0.25, 1.46]
Seneviratne 2015	4	38	2	37	3.0%	1.95 [0.38, 10.00]
Simmons 2016	30	110	35	105	19.4%	0.82 [0.54, 1.23]
Wang 2016	29	150	54	150	20.0%	0.54 [0.36, 0.79]
Total (95% CI)		**727**		**714**	**100.0%**	**0.76 [0.56, 1.03]**
Total events	143		196			

Heterogeneity: Tau² = 0.08; Chi² = 13.92, df = 7 (P = 0.05); I² = 50%
Test for overall effect: Z = 1.79 (P = 0.07)

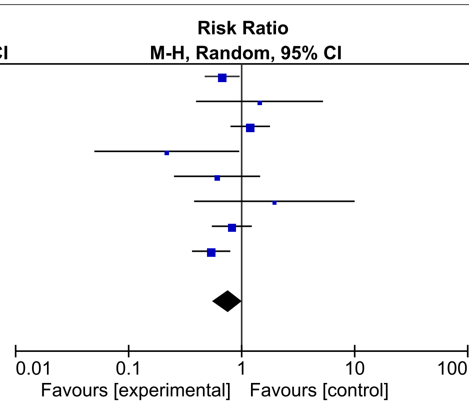

Fig. 2 Forest plot of risk ratio of GDM among the intervention and control groups

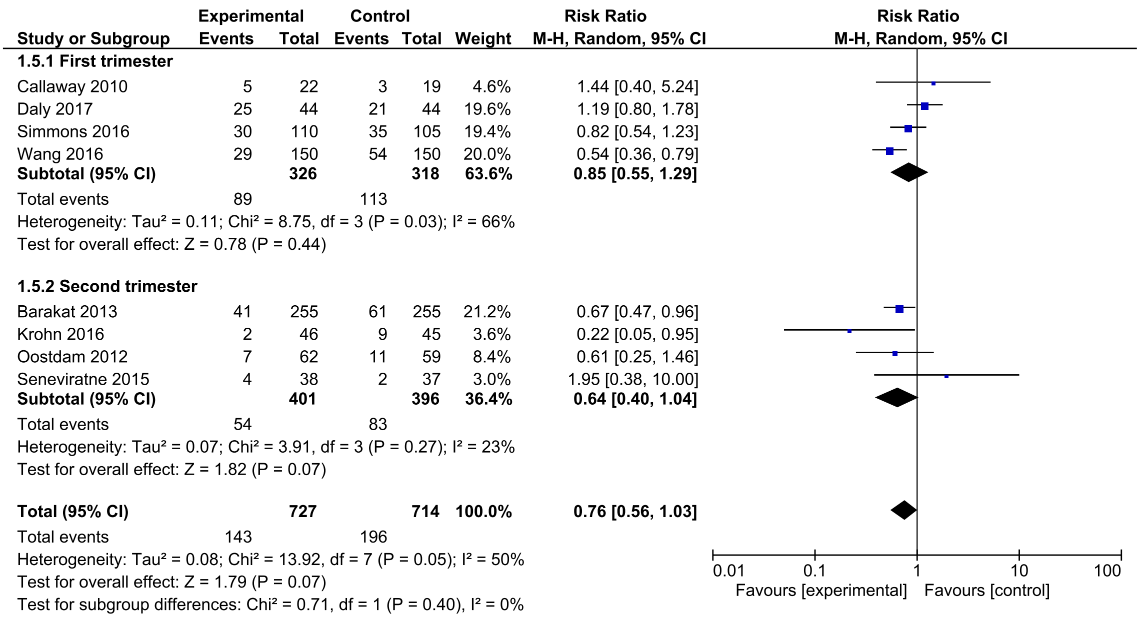

Fig. 3 Forest plot of risk ratio of GDM among the intervention and control groups in the first and second trimester of pregnancy

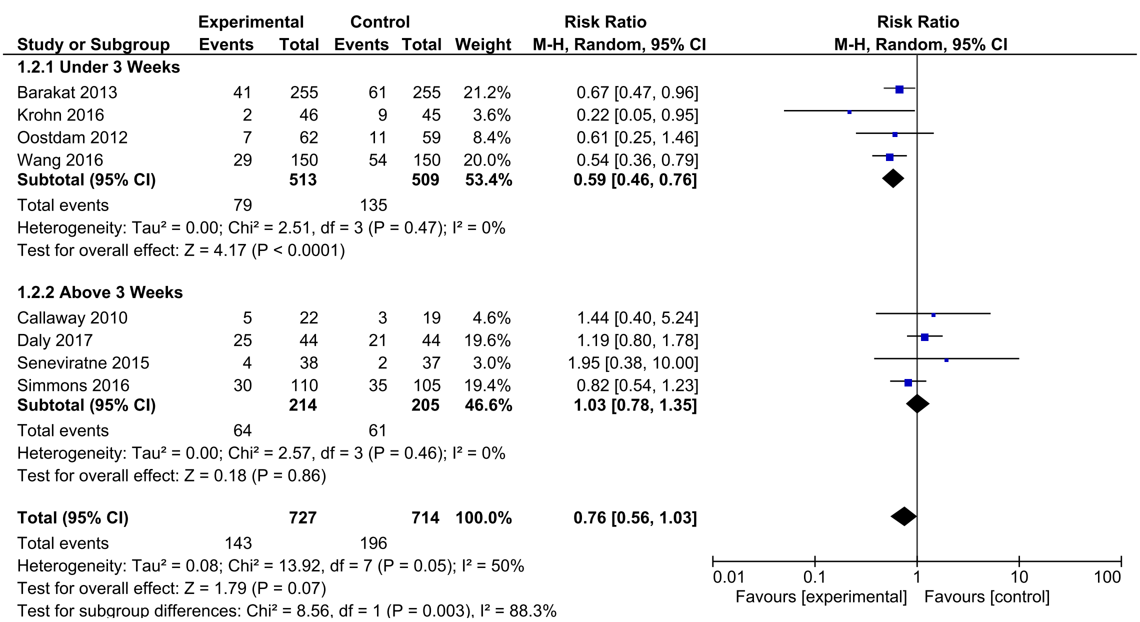

Fig. 4 Forest plot of risk ratio of GDM among the intervention and control groups with an intervention time in three times a week or less and an intervention time of more than three times a week

time more than three times a week (SMD: − 0.04, 95% CI − 0.28 to 0.21, $I^2 = 19\%$, P = 0.29) (Fig. 6).

Fasting plasma insulin (FPI) was investigated in three clinical trials with a sample size of 235 participants (119 and 116 in the intervention and control groups, respectively), entered into the final meta-analysis [30, 31, 33]. The mean FPI had no significant difference between two intervention and control groups (SMD: − 0.28, 95% CI − 0.65 to 0.08, $I^2 = 49\%$, P = 0.14) (Fig. 7).

Discussion

The objective of this review and meta-analysis study was to determine the effectiveness of exercise activities alone in preventing GDM in obese or overweight pregnant

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
1.6.1 First trimester								
Callaway 2010	-0.29	0.44	25	-0.17	0.59	25	13.8%	-0.23 [-0.78, 0.33]
Daly 2017	0.1	0.44	43	0.2	0.44	43	16.1%	-0.23 [-0.65, 0.20]
Simmons 2016	-0.04	0.4	110	-0.09	0.44	110	18.8%	0.12 [-0.15, 0.38]
Wang 2016	-0.28	0.39	150	-0.08	0.47	132	19.2%	-0.46 [-0.70, -0.23]
Subtotal (95% CI)			**328**			**310**	**67.8%**	**-0.20 [-0.52, 0.12]**
Heterogeneity: Tau² = 0.07; Chi² = 10.37, df = 3 (P = 0.02); I² = 71%								
Test for overall effect: Z = 1.22 (P = 0.22)								
1.6.2 Second trimester								
Krohn 2016	0	0.54	46	-0.5	0.72	38	15.7%	0.79 [0.34, 1.24]
Oostdam 2012	0.17	0.46	49	0.11	0.48	48	16.5%	0.13 [-0.27, 0.53]
Subtotal (95% CI)			**95**			**86**	**32.2%**	**0.45 [-0.20, 1.10]**
Heterogeneity: Tau² = 0.17; Chi² = 4.71, df = 1 (P = 0.03); I² = 79%								
Test for overall effect: Z = 1.36 (P = 0.17)								
Total (95% CI)			**423**			**396**	**100.0%**	**0.01 [-0.34, 0.36]**
Heterogeneity: Tau² = 0.15; Chi² = 28.57, df = 5 (P < 0.0001); I² = 82%								
Test for overall effect: Z = 0.06 (P = 0.95)								
Test for subgroup differences: Chi² = 3.08, df = 1 (P = 0.08), I² = 67.6%								

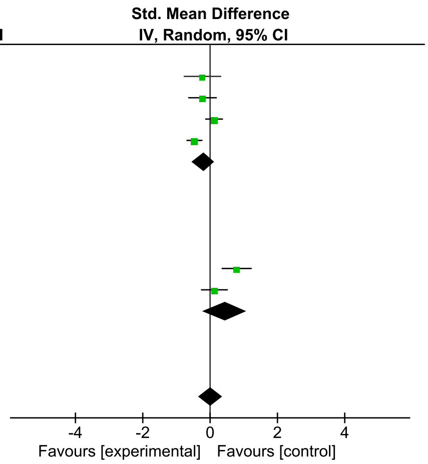

Fig. 5 Forest plot of the standardized mean differences FPG the intervention and control groups in the first and second trimester of pregnancy

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Callaway 2010	0.83	8.73	25	7.86	9.36	25	25.6%	-0.76 [-1.34, -0.19]
Krohn 2016	50.7	79.32	46	58	85.23	46	37.1%	-0.09 [-0.50, 0.32]
Oostdam 2012	31	51.29	48	38.4	45.71	45	37.3%	-0.15 [-0.56, 0.26]
Total (95% CI)			**119**			**116**	**100.0%**	**-0.28 [-0.65, 0.08]**
Heterogeneity: Tau² = 0.05; Chi² = 3.90, df = 2 (P = 0.14); I² = 49%								
Test for overall effect: Z = 1.52 (P = 0.13)								

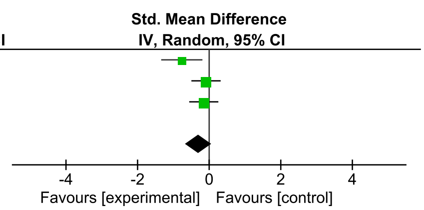

Fig. 6 Forest plot of the standardized mean differences FPG among the intervention and control groups with an intervention time in three times a week or less and an intervention time of more than three times a week

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Callaway 2010	0.83	8.73	25	7.86	9.36	25	25.6%	-0.76 [-1.34, -0.19]
Krohn 2016	50.7	79.32	46	58	85.23	46	37.1%	-0.09 [-0.50, 0.32]
Oostdam 2012	31	51.29	48	38.4	45.71	45	37.3%	-0.15 [-0.56, 0.26]
Total (95% CI)			**119**			**116**	**100.0%**	**-0.28 [-0.65, 0.08]**
Heterogeneity: Tau² = 0.05; Chi² = 3.90, df = 2 (P = 0.14); I² = 49%								
Test for overall effect: Z = 1.52 (P = 0.13)								

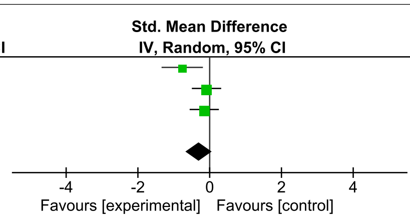

Fig. 7 Forest plot of the standardized mean differences FPI among the intervention and control groups

women. The results of the present study showed that the exercise activities, alone, in obese or overweight pregnant women did not have a significant effect on the overall incidence of GDM, but considering the RR, the incidence of GDM was 24% lower in the intervention group than control group. This difference is considerable in the two groups. Furthermore; the effect of intervention on reducing the incidence of GDM was significant in studies whose intervention time was three times a week or less. So that the RR of GDM was up to 41% lower in the intervention group than routine care group. According to the RR, the number needed to treat (NNT) value was 4.2 (confidence ranges from 3.0 to 4.4). The inverse of the absolute risk reduction or increase and the number of patients that need to be treated for one to benefit compared with a control. The ideal NNT is 1, where everyone has improved with treatment and no-one has with control. The higher the NNT, the less effective is the treatment. But the value of an NNT is not just numeric. For instance, NNTs of 2–5 are indicative of effective therapies [35].

Start taking an exercise intervention in the first or second trimesters of pregnancy had no significant difference to decrease the incidence of GDM, but the RR of GDM was up to 36% lower in the intervention group of studies that began the exercise intervention in the second trimester of pregnancy. The review and meta-analysis study of Sanabria-Martínez et al. assessed the effect of physical activity on preventing of GDM and maternal weight gain in 13 studies with 2873 pregnant women. The results of their study also indicated that the risk of developing GDM can be prevented by 31% through physical activities before pregnancy. This prevention of GDM was more evident when exercise was a combination of resistance and aerobic exercises. They have stated that since the resistance exercises lead to blood glucose uptake without varying the muscle capacity to respond to insulin, and aerobic exercises cause glucose uptake via insulin; thus, when these two types of exercise combine with together, the probability of preventing GDM is increased [17].

Du et al. [22] in their review study evaluated the effect of exercise on 1439 pregnant women of 13 studies, and observed that the exercise decreased the risk of GDM in obese and overweight pregnant women. They believed that the heterogeneity in the diagnosis criteria of GDM in various studies may be effective on a result of the study.

However, Han et al. [36] reviewed clinical trials (a total of five articles with 1115 participants) about the impact of exercise on preventing GDM and suggested that there was no significant difference in GDM incidence in women receiving moderate-intensity exercise intervention compared to those receiving routine prenatal care. Moreover, Rogozińska et al. [18] in a review study evaluated the effect of exercise and diet on maternal and fetal outcomes in 24 studies with 8852 participants and found that the exercise, alone, had no significant effect on GDM. In a review study by Yin [16], the effect of physical activity on the risk of developing GDM was assessed in six clinical trials with 1089 pregnant women, and no statistically significant difference was observed in the risk of developing GDM between the intervention and control groups. Besides, Larijani et al. [37] in a review study on GDM women have explained that the upper-body exercises which begin gradually and last 35 to 40 min per day (with two 5-min rest periods during exercise) are as one of the treatments for controlling GDM. This study was conducted not only on obese and overweight pregnant women, but also on all GDM pregnant women. Another study by Khan et al. examined the effects of exercise and diet on maternal outcomes through reviewing 36 articles (with 12,526 pregnant women). After analyzing the results of the studies, the researchers found that observing diet and doing exercise reduce the risk of developing GDM [18]. In the current study, the intervention was a combination of exercise and diet; therefore, the difference between the results of that intervention and those of the present intervention can be due to the differences in intervention type.

An interesting result of this systematic review study was that doing exercise three times a week or less had better outcomes than doing it more time in preventing GDM, and this difference was statistically significant. This phenomenon may occur through two mechanisms. The stress exerted on the muscles increases the cortisol secretion and cortisol also enhances the blood glucose levels by increasing liver gluconeogenesis and stimulating protein degradation [38]; on the other hand, the body's metabolism moves into a fat intake and the energy needed to do exercise is obtained by burning fat in people who do daily exercises. As a result, the blood glucose levels of these individuals may remain unchanged or even higher, while when the exercise period is 3 days a week, the body's metabolism moves to available sources such as blood glucose which reduces the blood glucose [39].

Nasiri and colleagues examined a relationship between the amount of physical activity in the first 20 weeks of pregnancy and the risk of developing GDM in a case–control study. They determined that women with low physical activity in the first 20 weeks of pregnancy, according to the PPAQ questionnaire, were at high risk for development of GDM compared with those who had more physical activity. In addition, after adjusting for age, BMI, gravidity and a family history of diabetes, females with lower physical activity (PPAQ) in the domain of transportation activity during the first 20 weeks of pregnancy were at a significantly higher risk of developing GDM [40].

In this review study, the mean of FBG and FBI changes had no significant difference between intervention and control groups. Motahari et al. studied the effect of eight-week aerobic exercises on insulin resistance in women with T2D. In their study, the participants (who were housewives with T2D) did moderate-intensity aerobic exercise three times a week (daily: 50 min) during 8 weeks. Their results illustrated that the exercise had a significant effect on reducing plasma glucose concentration, insulin resistance and insulin levels, which is inconsistent with the results of the current study [21]. Because their study was conducted on non-pregnant and diabetic women, the exercise had significant effect on the reduction of glucose concentration and, generally, on the control of T2D.

Shakil-ur-Rehman [41] in relation to the effect of exercise on FBG and plasma insulin levels in T2D patients suggested that a 25-day structured aerobic exercise could be a good management of FBG and plasma insulin levels, which are inconsistent with the present study. The study of Shakil-ur-Rehman was also performed on non-pregnant women, which might have resulted in more success of exercise in controlling T2D. In general, these contradictory results represent that more and more precise trials are needed to make a good conclusion.

The researchers of the present study could not investigate the effect of exercise type on the incidence of GDM because of differences in the type of exercise and use of a combination of various exercises in some studies. Besides, the intensity of exercise in all articles of this study was moderate; therefore, it was impossible for the researchers of the current study to assess the effect of different intensities of exercise on the risk of developing GDM. Moreover, the duration of exercise in various studies was between 15 and 50 min, and the lack of access to a sufficient number of studies made it impossible for researchers to compare the exercise duration.

Among the limitations of the current study, the search was only performed in Persian and English, which limited the opportunity to access the trials published in other languages. Unfortunately, due to the lack of studies, there was no possibility to analyze the subgroup for the type and duration of exercise.

The positive aspects of this study were that the HOMA index was used in all studied articles to assess the effects of exercise on insulin level. Furthermore, the intensity of exercise was the same in all early studies (moderate intensity).

Although the effect of exercise on incidence of GDM was not significant, this incidence was considerably lower in the intervention groups. So it seems practitioners may recommend physical activity along with other interventions such as change in life style to prevention of GDM in obese and overweight pregnant women.

Conclusion

The exercise activities, alone, in obese or overweight pregnant women did not have a significant effect on the overall incidence of GDM, but considering the effect measure, the incidence of GDM was 24% lower in the intervention group than control group. This difference is considerable in the two groups.

Given the above, since the response to exercise in most studies was based on limited evidence and the current research was basically limited to the responses of a hormone to a variety of type, intensity or duration of exercises, and no study was found to consider the various aspects of exercise on other factors affecting gestational diabetes; hence, more trials are needed to actually find the effect of exercise on GDM in obese and overweight pregnant women. As the systematic review literatures both represent the information gap on the research subject and pave the way for further studies so it seems that there is a need for more randomized controlled trials so that we can make a complete conclusion on the type, intensity and duration of exercise in preventing GDM.

Supplementary information

Supplementary information accompanies this paper at https://doi.org/10.1186/s13098-019-0470-6.

Additional file 1. Searching keywords based on the medical subject headings (MeSH).

Abbreviations

GDM: gestational diabetes mellitus; SMD: standardized mean difference; CI: confidence interval; RR: risk ratio; T2D: type 2 diabetes; WoS: Web of Science; CINAHL: Cumulative Index to Nursing and Allied Health Literature; MeSH: medical subject headings; IADPSG: International Association of Diabetes in Pregnancy Study Group; WHO: World Health Organization; GCT: glucose challenge test; OGTT: oral glucose tolerance test.

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Authors' contributions

FNA was involved in study design, search in databases, quality assessment, study selection, data extraction, data analysis, manuscript drafting, and critical discussion. SMT conceptualized the study and was involved in study design, quality assessment, data analysis, revising manuscript, and critical discussion. MAS contribute in quality assessment, data extraction, critical discussion, and manuscript drafting. MS and PH performed statistical analysis, interpreting data and manuscript drafting. All authors read and approved the final manuscript.

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Availability of data and materials

All data generated or analyzed during this study are included in this article.

Ethics approval and consent to participate

All analyses were based on previous published studies, thus no ethical approval and patient consent are required.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Accepted Article

Effects of weekly-supervised exercise or physical activity counseling on fasting blood glucose in women diagnosed with gestational diabetes mellitus: a systematic review and meta-analysis of randomized trials

Exercise and gestational diabetes: a meta-analysis

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ABSTRACT

Background: Exercise is an important part of gestational diabetes mellitus (GDM) lifestyle management. However, there is no meta-analysis analyzing the effects of exercise programs on fasting blood glucose (FBG) in women with GDM. A systematic review with meta-analysis was performed to evaluate the effect of weekly-supervised exercise (EXE group) or physical activity counseling (PA group) in women with GDM compared to usual prenatal (UPN group) on glycemic control.

Methods: Eligible trials were identified from MEDLINE, EMBASE, Web of Science, Scopus and SportDiscus up to 11 December 2016. Data were retrieved from randomized controlled trials comparing UPN with UPN plus weekly-supervised (at least once a week) prenatal exercise or PA counseling for which FBG values pre and post intervention were available. Random-effects meta-analysis was performed for mean difference in FBG post exercise intervention.

Results: Our search yielded 781 publications of which 82 were assessed for eligibility, and eight were included in the meta-analysis. The overall effect on absolute FBG concentrations was not significant (*P*=0.11) compared to UPN. However, PA vs. UPN showed a significant reduction in the absolute FBG concentrations (WMD -3.88 mg/dL, 95% CI-7.33 to -0.42; I^2, 48%; *P* for heterogeneity<0.15).

Conclusions: PA counseling in women with GDM showed a significant effect compared to UPN on FBG concentrations, possibly due to longer follow-up time compared to the EXE groups. This result highlights the importance of an early intervention that lasts to delivery for best practice of GDM management.

Key points

Significant findings of the study: There was no overall effect of exercise when all interventions were tested. The sensitivity analysis showed physical activity counseling, interventions with longer follow ups, had significant effect on fasted blood glucose in GDM.

What this study adds: Physical activity counseling added to standard care may help to motivate women with GDM to be active for longer periods and acquire benefits. More interventional trials comparing different kinds of interventions are need, regarding duration and supervision modes, to address this lack in the literature.

Keywords: Pregnancy, exercise, glycemic control, insulin resistance, hyperglycemia.

Introduction

Gestational diabetes mellitus (GDM) has been defined as hyperglycemia detected during routine testing in pregnancy (generally between 24 and 28 weeks) that does not meet the criteria of diabetes mellitus in pregnancy.[1] The diagnosis of GDM is made using a single-step 75-g oral glucose tolerance test (OGTT) when one or more of the following results are recorded during routine testing, between 24-28 weeks of pregnancy: 1) fasting plasma glucose: ≥92mg/dL; 2) 1-hour post: ≥180mg/dL; 3) 2-hour post: ≥153mg/dL.[2] Worldwide, approximately 7% of all pregnancies are affected by GDM (ranging from one to 14%, depending on the population studied and the diagnostic tests employed), with more than 200,000 cases diagnosed annually.[1] Elevated glucose concentrations are associated with adverse pregnancy outcomes such as fetal macrosomia, shoulder dystocia, neonatal hypoglycemia and future diabetes type 2.[1]

Exercise is an important part of GDM lifestyle management, since physical activity enhances maternal insulin sensitivity, helps maintain daily fasting and postprandial normoglycemia and decreases the need for insulin.[3-6] Exercise and an active lifestyle may also decrease the risk of developing type 2 diabetes for women with GDM in the future.[7,8] However, structured exercise programs are not available for all women with GDM, and most women will receive only counseling to increase physical activity from their primary care providers or health care team.

A Cochrane Review examined the effect of exercise programs compared to no specific program or to other therapies in women with GDM, and concluded that no significant difference was found between exercise and the other regimens in several outcomes evaluated, such as gestational age at delivery, preterm delivery (< 37 weeks), birthweight at delivery, caesarean section and macrosomia (> 4000 g). However, fasting blood glucose was not evaluated.[9] Furthermore, the authors did not analyze the effect of different supervised exercise modalities or physical activity counseling in maternal and perinatal outcomes. To our knowledge, there is no systematic review that summarized the effects of exercise programs on fasting blood glucose, specifically in women with GDM.

The aim of the present study was to conduct a systematic review with a meta-analysis of randomized controlled trials (RCTs) to evaluate the effect of weekly-supervised exercise (EXE) or physical activity counseling (PA) in women diagnosed with GDM compared to usual prenatal care (UPN) on glycemic control.

Methods

The present systematic review and meta-analysis were performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement.[10]

Search strategy and study selection

Eligible trials were identified by a structured electronic search in the following databases: MEDLINE, EMBASE, Web of Science, Scopus and SportDiscus up to 11 December 2016. Electronic databases were searched using similar search strategies focusing on four main groups of terms: “exercise”, “pregnancy”, “gestational diabetes mellitus” and “randomized controlled trial”. These terms were adjusted to fit the requirements specified in each database. The complete search strategy used for the

PubMed database is shown in the Supplementary Material Table S1. The lists of references from each study were also searched to identify additional studies. Relevant review articles were evaluated for information on additional trials.

Eligibility criteria

Studies including pregnant women diagnosed with GDM in which treatment allocation was randomized, with a control group receiving standard prenatal care for GDM were considered for further eligibility assessment. The RCTs were required to have at least one intervention arm of either EXE, defined as exercise sessions performed with study personnel at least once a week throughout the program, or PA counseling in which women with GDM received counseling for physical activity or performed exercise without any direct supervision. For inclusion, studies were required to provide before- and after-intervention absolute values of fasting blood glucose or differences between means and dispersion values. Excluded studies had criteria summarized as follows: 1) interventions consisting solely of pelvic floor exercises, stretching or relaxation; 2) studies regarding pregnant women diagnosed with diabetes type 1 or type 2 before pregnancy; 3) studies that analyzed exercise interventions in risk factors or prevention of GDM; 4) interventions that lasted less than four weeks; 5) studies that did not provide data on blood glucose; 6) studies not published in English, Spanish, Italian or Portuguese. No restrictions regarding the year of publication were applied.

Study selection and data extraction

Two independent authors (R.B. and P.A.B.R.) reviewed the titles and/or abstracts to exclude any clearly irrelevant studies. Reviewers were not blinded to journal of publication, author names or their institutions. All abstracts that provided insufficient information on the inclusion and exclusion criteria were selected to evaluate the full text. Corresponding authors of potentially eligible studies were contacted if the required data could not be located in the published report. The full texts of the remaining studies were then retrieved and read in fulltext by the same authors to determine whether the studies met inclusion criteria. Disagreement was solved by a third author (J.G.L.R.) who independently examined the studies.

Using a standardized data extraction sheet, the following information (if available) was extracted in duplicate and recorded from studies: authors, year of publication, country of origin, total sample size, age, criteria for GDM diagnosis, fasting blood glucose concentrations, trial duration (in weeks), insulin requirements, pre-pregnancy body mass index, weight gain during pregnancy, gestational age at birth, birth weight and length and APGAR scores in 1 and 5 minutes. Information on adherence/ compliance to protocols and dropout rates were also extracted.

Assessment of risk of bias and quality of studies

Methodological quality was explored using an approach similar to that recommended by The Cochrane Collaboration in assessing risk.[11] The criteria for methodological quality of studies included the following dimensions: adequate sequence generation, allocation concealment, blinding of participants or personnel, blinding of outcome, description of losses and exclusions, intention-to-treat analysis, incomplete outcome data and selective reporting. Studies without a clear description of these features were considered as unclear. The complete assessment of risk of bias is shown in the Supplementary Material Table S2.

Data synthesis and analysis

Meta-analysis was carried out using software Review Manager 5.3.[11] The baseline values of fasting blood glucose were not different between groups for the RCTs included. Based on this information, the post-intervention values of fasting blood glucose were considered the primary outcome of the present study. For continuous outcomes, mean differences between exercise and control groups were examined. Gestational age, birthweight at delivery, pre-pregnancy body mass index, weight gain during pregnancy, macrosomia, preterm delivery and cesarean section were considered secondary outcomes. Random-effects models were applied because clinical heterogeneity between trials was expected (because of different intervention regimens). Results of the meta-analysis were expressed as weighted mean differences (WMD) for continuous outcomes and odds ratio for dichotomous outcomes, both with 95% confidence intervals (CI), and with I^2 values as markers of intertrial heterogeneity. The assumption of homogeneity of true effect sizes was assessed by the Cochran's Q test and the degree of inconsistency across studies was calculated I^2.[12] In the case of I^2 greater than 40%, heterogeneity was explored with subgroup and sensitivity analysis and the overall result was presented using the random-effect model. Meta-analysis comprised the comparisons of overall effect (EXE + PA vs. UPN). Sensitivity analysis considering the type of prescription (EXE vs. PA) and additional nutritional counseling (combined or not with the intervention) were performed. The presence of publishing bias for the hypothesis of an association between supervised exercise training during pregnancy and blood glucose control was assessed informally by visual inspections of funnel plots (Supplementary Material Figure S2). The α value ≤ 0.05 was considered statistically significant.

Results

A flow diagram of the search results is shown in Figure 1. The initial literature search resulted in 781 potentially relevant citations. After exclusion of duplicates, titles and abstracts review and full text review, eight studies were included in the meta-analysis (Table 1), five studies were RCTs of EXE groups and three were RCTs of PA counseling.

The study characteristics for EXE groups and PA counseling are shown in Tables 1 and 2, respectively. The eight RCTs included in our analysis totaled 469 pregnant women, of which 91 women with GDM engaged in EXE and 143 women with GDM were given PA counseling. Four trials had an exclusively aerobic supervised intervention[3,6,13,14] and one study examined the effects of a supervised circuit-type resistance exercise alone.[5] For the PA counseling analysis, only one trial had an exclusively aerobic exercise counseling intervention.[15] The control groups received UPN for women with GDM, and all groups received nutritional counseling added to the interventions.

For the EXE trials the frequency ranged from 2 to 3 times per week and the time of each supervised session ranged from 20 to 45 minutes. The duration of the interventions ranged from 4 to 7 weeks, ending in the late third trimester or delivery. Mode of supervised exercise included walking, stationary cycling, arm cycling, and circuit-type resistance training. Exercise intensity was assessed by heart rate monitors[3,6,13,14] and the Borg Scale of Perceived Exertion.[5,6,13]

For the PA counseling trials the frequency ranged from 2 to 7 times per week and the time of each exercise session ranged from 15 to 20 minutes. The duration of the interventions ranged from 8 to 14 weeks, ending in the late third trimester or delivery. Mode of PA included walking, yoga and circuit-type resistance training and the exercise intensity was assessed by perceived exertion.

Quality Assessment (Risk of Bias)

Among the EXE studies, 80% presented adequate sequence generation (4 of 5), 40% reported allocation concealment (2 of 5), 20% had blinding of participants or personnel (1 of 5), none had blinded assessment of outcomes, 100% described losses to follow-up and exclusions, 20% used the intention-to-treat principle for statistical analyses (1 of 5), 100% described incomplete outcome data, and 80% were free of selective reporting (4 of 5). Among the PA counseling studies, 100% presented adequate sequence generation (3 of 3), 100% reported allocation concealment (3 of 3), 33.3% had blinding of participants or personnel (1 of 3), 33.3% had blinded assessment of outcomes, 100% described losses to follow-up and exclusions, 33.3% used the intention-to-treat principle for statistical analyses (1 of 3), 100% described incomplete outcome data, and 66.6% were free of selective reporting (2 of 3). The nature of the interventions did not allow blinding of the subjects and personnel to the type of intervention.

Effect of interventions on fasting blood glucose

The overall effect of exercise, supervised or counseling, was not significantly different (P = 0.11) compared to UPN interventions on fasting blood glucose concentrations (WMD= -2.76 mg/dL, 95% CI -6.13 to 0.61; I^2, 87%; P for heterogeneity < 0.00001; Figure 2). However, when the different exercise interventions were tested, PA counseling showed a significant decrease in fasting blood glucose concentrations of -3.88 mg/dL versus control (WMD= -3.88, 95% CI -7.33 to -0.42; I^2, 48%; P for heterogeneity < 0.15; Figure 2). The effect of EXE interventions vs. UPN was not significantly different (WMD= -1.92 mg/dL, 95% CI -7.50 to 3.65; I^2, 91%; P for heterogeneity < 0.00001; Figure 2).

Sensitivity analyses and exploration of heterogeneity

Sensitivity analyses for nutritional counseling, type of intervention and training volume were performed to explore the heterogeneity in the studies. Studies that had nutritional advice integrated with the exercise intervention were analyzed (7 interventions, 444 patients). The overall effect of exercise, supervised or counseling, was not significantly different (P = 0.08) compared to controls on fasting blood glucose concentrations (Supplementary Material Figure S1A). However, when the different exercise interventions were tested, PA counseling showed a significant decrease in fasting blood glucose concentrations of 3.88 mg/dL versus control (Supplementary Material Figure S1A). The effect of a EXE intervention versus UPN on fasting blood glucose concentrations was not significantly different (Supplementary Material Figure S1A).

The type of intervention (exercise modality) in absolute changes of fasting blood glucose was examined. Aerobic exercise only was chosen for the majority of the studies, and the overall effect, was not significantly different (5 interventions, 219 patients; $P = 0.30$; Supplementary Material Figure S1B) compared to control on fasting blood glucose concentrations.

Sensitivity analyses of data according to the weekly amount of exercise (sessions duration x frequency= training volume) were performed according to ACOG guidelines that recommends moderate-intensity exercise for at least 20–30 min/day on most of days of the week for pregnant women.[17] This recommendation leads to a range of 100 to 150 min/week of exercise (20-30 min/day x 5 days/week). However, the participants reached the 150min/week of exercise in only one study.[6] We then stratified by the lower limit of 100min/week of exercise, our results showed that the overall effect of the weekly amount of exercise (5 interventions, 182 patients), supervised or counseling, was not significantly different ($P = 0.46$) compared to usual care (details on supplementary Material Figure S1C).

Effect of interventions on secondary outcomes

The secondary outcomes were analyzed only for the weekly-supervised exercise trials, since the physical activity counseling trials did not report these data. Overall, EXE had no effect on gestational age of delivery (WMD= 0.01 weeks, 95% CI -0.33 to 0.36; I^2, 0.0%; P for heterogeneity = 0.75) and birthweight at delivery (WMD= -69.41 g, 95% CI -202.05 to 63.22; I^2, 0.0%; P for heterogeneity = 0.52). The odds of having a macrosomic newborn (birthweight at birth greater than 4000 g) was also not significant (OR 0.79, 95% CI 0.24 to 2.62; I^2, 20.0%; P for heterogeneity = 0.57), as well as a preterm delivery (< 37 weeks of gestation) (OR 1.16, 95% CI 0.39 to 3.41; I^2, 20.0%; P for heterogeneity = 0.93) or a cesarean delivery (OR 0.75, 95% CI 0.37 to 1.55; I^2, 20.0%; *P* for heterogeneity = 0.95). Only two weekly-supervised exercise trials[6,14] reported data on pre-pregnancy body mass index and weight gain during pregnancy; analysis of these secondary outcomes were not performed.

Discussion

The present systematic review provides the summarized effect from eight RCTs, involving 469 pregnant participants. The overall effect of EXE and PA counseling, was not significantly different compared to UPN on fasting blood glucose concentrations. Since UPN for women with GDM includes some type of physical activity recommendation, these results are not surprising. However, when the different exercise interventions were tested, PA counseling showed a significant decrease in absolute fasting blood glucose concentrations of 3.88 mg/dL compared to control. Although reduction in fasting blood glucose concentrations may be an important indicator of the efficacy of the intervention program for women with GDM, especially if these values are brought below the suggested target for FBG concentrations, the exact target remains a global controversial issue. We were not expecting PA counseling to be more successful in reducing FBG compared to control over a program of direct PA intervention, which was contrary to our hypothesis. We expected that direct interventions would show better improvements than counseling, as previously demonstrated[18] for Hb_{A1c} in type 2 diabetic subjects. Our results are probably due to the timing of the PA counseling interventions that were longer than direct exercise interventions (PA counseling interventions: 8 to 14 weeks vs. exercise interventions: 4 to 7 weeks). Furthermore, PA counseling started in early pregnancy and was not delayed until GDM diagnoses, so the metabolic unbalance was already established. Moreover, to our knowledge, our study represents the first systematic review and meta-analysis of RCTs that stratified the studies by type of physical activity interventions, which can help health practitioners improve adherence in this population.

It is important to point out methodological differences between our study and the Cochrane review.[9] Fasting blood glucose was not considered as an outcome in the latter, however FBG was analyzed as a primary outcome in the present study. We analyzed the effect of different exercise interventions on maternal and perinatal outcomes that consisted of eight trials. Most of the meta-analyses comparisons in the previous review[9] were performed by including one study only, decreasing the power of their results.

Persistent hyperglycemia during pregnancy is associated with increased risk of fetal malformations, macrosomia, and neonatal hypoglycemia at delivery.[2,19] The literature reports that exercise affects body composition, carbohydrate and lipid metabolism and stimulates glucose uptake, lowering blood glucose concentrations.[20,21] Exercise increases the rate of glucose uptake into the skeletal muscle, a process that is regulated by the translocation of the glucose transport protein GLUT-4.[22-24] Thus, it would be logical to introduce exercise to neutralize the negative effects of GDM, thereby improving health during pregnancy.

In order to understand the possible factors underlying the lack of an overall effect of the exercise on fasting blood glucose we used sensitivity analysis stratified by nutritional advice integrated with exercise, type and volume of the exercise intervention.

Concerning nutritional advice as a co-intervention, a significant fasting blood glucose reduction of 3.55 mg/dL was observed when nutritional counseling was integrated with PA counseling. A partial explanation for these results is the number of participants and time of follow-up was greater for the PA counseling trials. In addition, the heterogeneity of the PA counseling trials was smaller than the EXE trials (48% vs 93%, respectively).

In almost all studies patients were under diet advice as part of the prenatal care routine. The aim of dietary advice for women with GDM is to optimize glycemic control, thus preventing maternal hyperglycemia and reducing post-prandial glucose concentrations. The diet is based on low-glycemic index food ingestion that induces a gradual increase in blood glucose due to slow digestion and absorption. The studies included are considerably homogeneous regarding to caloric intake, with the range of 24 to 35 kcal/kg per day, as recommended for successful pregnancy outcomes.[1]

We did not observe a clear trend for the weekly volume of exercise or the type of exercise that affected fasting blood glucose. ACOG guidelines recommends moderate-intensity exercise for at least 20–30 min/day on most of days of the week for pregnant women.[17] Only few pregnant women meet the upper range of 150 min/week of exercise.[25] Borodulin et al.[26] reported that the prevalence of sufficient activity varied between 3% and 38%, depending on the type of activity and measurement of intensity included. The present review showed that only one study[6] met the current recommendation of 150 min/week of exercise. It is clear that further research is needed to tailor exercise programs that reach the target amount of exercise recommended, and then verify the effect of the exercise program on GDM and perinatal outcomes. There is evidence that to achieve at least 150 min/week or more is advantageous for blood glucose control, as shown in previous studies with type 2 diabetes in non-pregnant individuals.[18]

The analyses of the secondary outcomes were performed with EXE trials only because data were not available for the PA counseling studies. EXE interventions did not affect gestational age, and the odds of having a preterm delivery or a cesarean delivery compared to controls. To date no studies have shown an increased risk of preterm labour or an increased incidence of premature rupture of membranes among exercising pregnant women that were not at risk for these conditions. The PA counseling trials evaluated did not report data of gestational age and birthweight at delivery, incidence of macrosomia, pre-pregnancy body mass index and gestational weight gain. It is strongly encouraged that future RCTs report these important outcomes to understand the extension of the effect of non-supervised interventions, in terms of public health.

Our review suggests that additional studies are required before reaching specific conclusions regarding the effect of supervised exercise or physical activity counseling on blood glucose control in women with GDM. Considering the small number of total participants (less than 100 for exercise intervention trials and 143 in counseling) and that half of the studies did not show significant effects, we do believe that larger RCTs with longer intervention times would reduce the heterogeneity of the studies and help to establish consensus for exercise intervention in women with GDM. We understand that direct supervision will not be available to all women with GDM, and, in this situation, physical activity counseling should be encouraged, or when possible both interventions should be combined throughout pregnancy.

The present study has strong methodological points, as the careful selection of the studies, data extraction and analysis of the methodological quality of the articles. Thus, trials were only reviewed if the participants were diagnosed with GDM, the analyses were stratified by type of intervention (EXE vs, PA), and the included articles exhibited geographical diversity leading to high generalizability with trials in North America, South America, Europe, Asia, and Oceania.

The limitations of the present study are mainly from the quality of the included studies (Supplementary Material Table S2) and the substantial evidence of heterogeneity and potential publication bias. The random-effects model was chosen to account for heterogeneity of the studies that was considered high for most of the analyses. Overall, general quality of the studies was low, reflecting an increased risk of bias in many of the included studies. The oldest study included was performed 26 years ago, and the criteria to diagnose GDM have changed substantially over the past several years. Despite these limitations, our systematic review with meta-analysis provides a general overview of the research literature addressing the role of exercise, with or without supervision, to blood glucose control in women with GDM.

In conclusion, the overall effect of exercise in women diagnosed with GDM, supervised or through counseling, was not significantly different compared to control interventions on fasting blood glucose concentrations. When the different exercise interventions were tested, physical activity counseling showed a significant decrease in absolute fasting blood glucose concentrations. There is insufficient evidence to recommend, or advice against, women with GDM to enroll in exercise programs. Physical activity counseling sessions in addition to standard care may help to motivate women with GDM to be more active, while structured exercise may be more difficult to achieve. For future studies, we suggest that larger RCTs be designed to compare early intervention of supervised exercise to physical activity counseling (or at least be of similar length), with longer follow-up time to delivery for best practice of GDM management in order to directly evaluate the different effects of these types of interventions on glycemic control in women with GDM.

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Disclosure

All authors have no conflicts of interest to declare.

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Figure legends

Figure 1. Flow diagram of included studies.

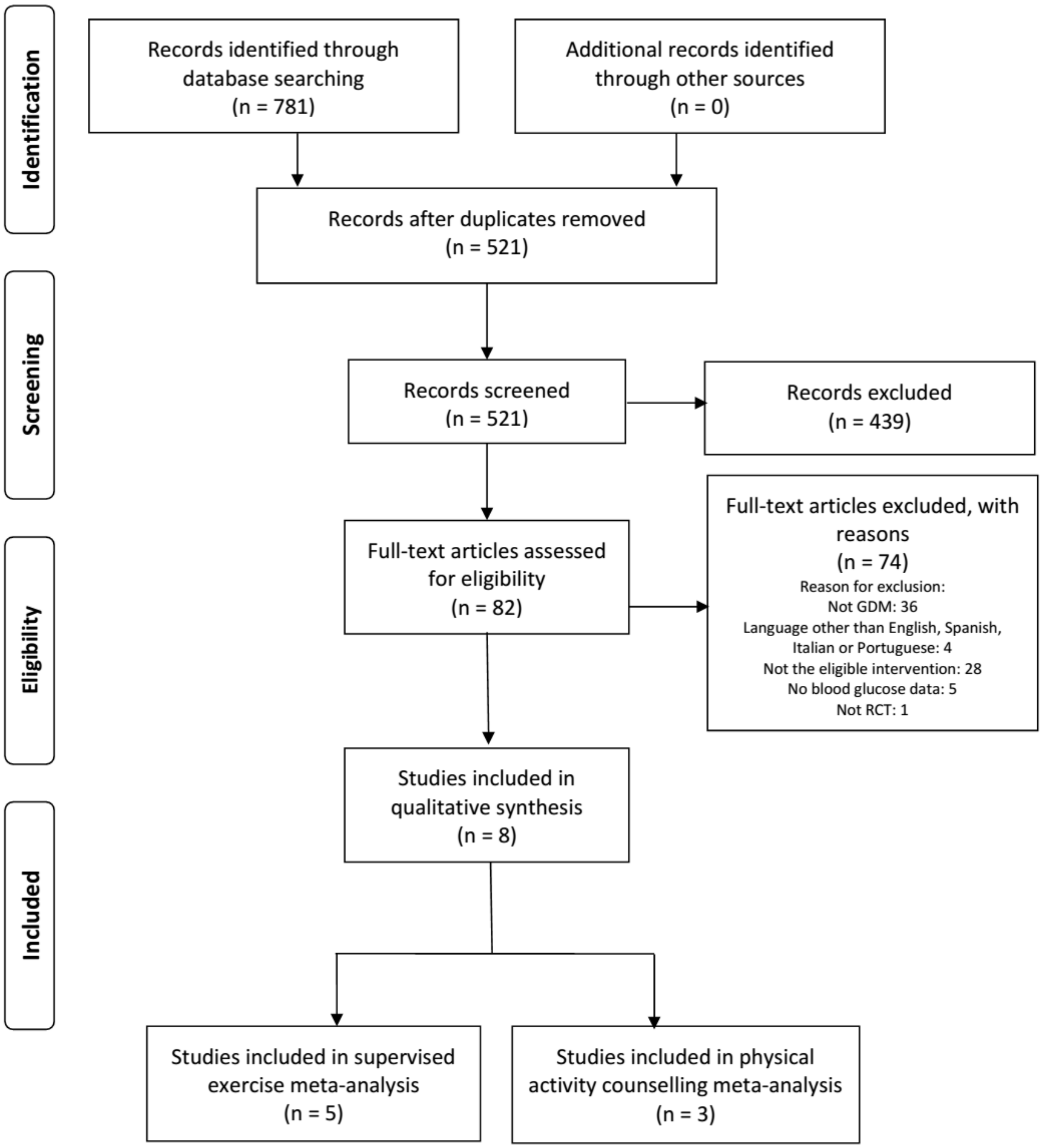
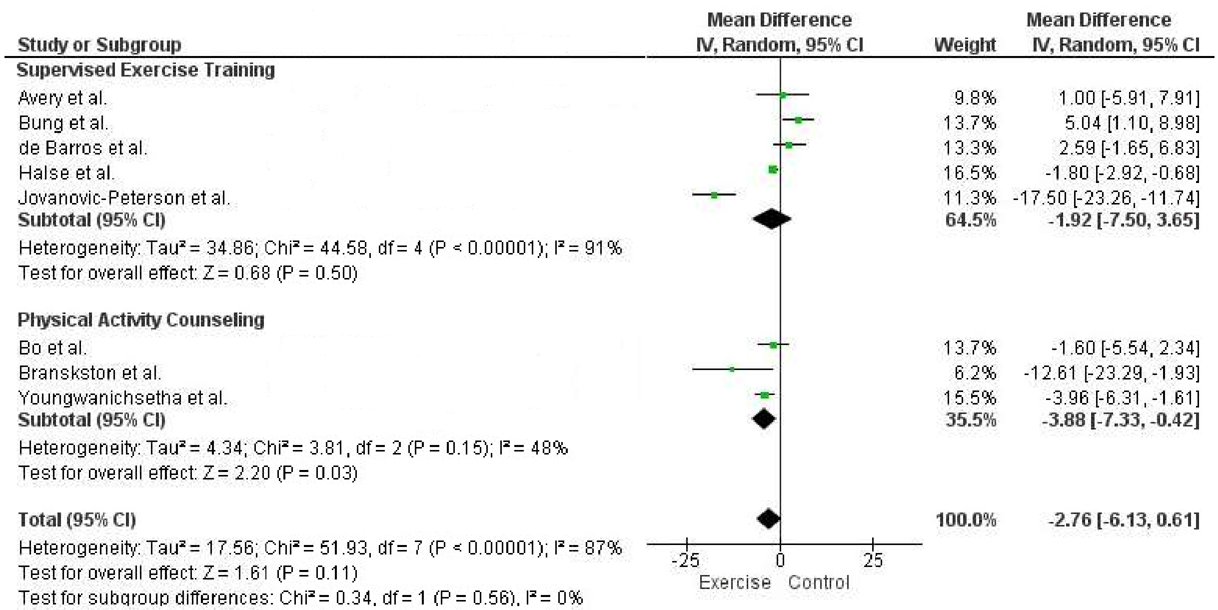


Figure 2. Mean weighted difference and 95% confidence interval (CI) on fasting blood glucose (in mg/dL) for weekly-supervised exercise versus prenatal standard care, and physical activity counseling versus prenatal standard care in women diagnosed with gestational diabetes mellitus. Squares represent study-specific estimates; diamonds represent pooled estimates of random-effects meta-analyses.



Supplementary Material Figure S1. Weighted mean difference and 95% confidence interval (CI) for A) studies with a diet counseling integrated with the exercise intervention, B) aerobic exercise only performed during pregnancy, and C) weekly amount of exercise in fasting blood glucose. Squares represent study-specific estimates; diamonds represent pooled estimates of random-effects meta-analyses.

Supplementary Material Figure S2. Funnel plot of each trial observations for supervised exercise training and physical activity counseling in fasting blood glucose change.

Table 1. Characteristics of the weekly-supervised exercise and physical activity counseling studies included in the meta-analysis (mean ± standard deviation).

Author/ Country (Year)	Sample size (n)	Age (years)	GA at entry (weeks)	Exercise intervention: Frequency (times per week)	Intensity	Time (min)	Type	Time of follow up (weeks)	Adherence	Drop-out rate(n)	Control group	Diet advice/ caloric intake
WEEKLY-SUPERVISED EXERCISE												
Avery et al./ USA (1997)[13]	I: 14 C: 14	I: 32.2 ±4.9 C: 30.4 ±5.1	I: 28.7 ±3.0 C: 26.3 ±8.1	2 with supervision 1-2 without supervision	70% HR_{max} and RPE	30	Cycle ergometer or walking	NR	NR	I: 1 C: 3	Dietary therapy and usual physical activity	Yes/ I: 2301 ± 550 kcal/day C: 2190 ± 472 kcal/day
Bung et al./ USA (1991)[14]	I:21 C:20	I:31.0±4.5 C:32.0±5.7	I: 30.3 ±1.9 C: 30.3 ±2.0	3	50% of the last $VO_{2max.}$	45	Recumbent bicycle	Minimum of 4	> 90%	I: 4 C: 3	Insulin therapy and diet protocol	NR/ 30-kcal.kg^{-1} diet.
de Barros et al./ BRA (2010)[5]	I:32 C: 32	I: 32.4 ±5.4 C:31.8±4.8	I:31.0±2.3 C: 31.5 ±2.2	2 with supervision 1 without	RPE 5-6 (“somewhat hard”)	30-40	Circuit type resistance training	7	NR	I: 1 C: 1	Prenatal routine care	Yes/ 35 kcal/kg ideal weight^{-1}/day^{-1}, and 300 kcal/day were added in the 2nd and 3rd

				supervision								trimesters.
Halse et al./ AUS (2014)[6]	I: 20 C: 20	I: 34±5 C: 32±3	I: 28.8 ±0.8 C: 28.8 ±1.0	3 with supervision 2 without supervision	Interval: 55%-85% age-predicted HR_{max}. and RPE 9-16	25 to 45	Cycle ergometer	6±1	96%	0	Usual physical activity regimen	Yes/ I: Week 1: 7252 ± 2060 kJ, final week: 6897 ± 1932 kJ C: Week 1: 7414 ± 2412 kJ, final week: 7005 ± 2067 kJ
Jovanovic-Peterson et al./ USA (1989)[3]	I: 10 C: 9	I:29.5±2.5 C:31.1±2.8	I: 28 C: 28	3	70% reserve HR	20	Arm ergometer	6	NR	0	Diet	Yes/ 24 to 30-kcal/kg/24 hours diet.
PHYSICAL ACTIVITY COUNSELING												
Bo et al./ ITA (2014)[15]	I: 51 C: 50	I: 35.9 ±4.8 C: 33.9 ±5.3	Range 24-26	7	RPE 12-14	At least 20	Walking	12-14	68.8 %	I: 0 C: 0	Diet	Yes/ I: 2116.2 ± 267.7 kcal/day C: 2115.9 ± 383.0 kcal/day
Branskston et al./ CAN (2004)[4]	I: 16 C: 16	I: 30.5 ±4.4 C: 31.3 ±5.0	I: 29.0 ±2.0 C: 29.6 ±2.1	2.0± 0.9	‘‘Somewhat hard”	NR	Circuit type resistance training	26-32 weeks’ pregnancy to delivery	NR	6	Standard diabetic diet	Yes/ 24 to 30 kcal/kg per day diet.

Youngwani-chsetha et al./ THA (2014)[16]	I: 85 C: 85	I: 32.5 ±5.0 C: 31.2 ±4.5	Range 24-30	5	NR	15-20	Yoga	8	> 80%	I: 5 C: 5	Standard diabetes care	Yes/ NR

I: intervention group; C: control group; GA: gestational age; BMI: body mass index; RPE: ratings of perceived exertion; NR: not reported; HR: heart rate; Max: maximum; VO_2: oxygen consumption;

Table 2. Newborn characteristics of the weekly-supervised exercise and physical activity counseling studies included in the meta-analysis.

Author/ Country	Gestational age at birth (weeks)	Birth weight (g)	Birth length (cm)	APGAR score in 1 minute	APGAR score in 5 minutes
WEEKLY-SUPERVISED EXERCISE					
Avery et al. / USA (13)	I: 39.4±1.2 C: 39.7±0.9	I: 3419±528 C: 3609±428	NR	I: 8 C: 9	I: 9 C:9
Bung et al. / USA (14)	I: 38.9±1.7 C: 38.3±2.0	I: 3369±534 C: 3482±502	I: 49.3±2.0 C: 51.0±3.0	I: >8 C: >8	I: >8 C: >8
de Barros et al. / BRA (5)	I: 38.5±1.2 C: 38.6±1.1	I: 3230±450 C: 3330±490	NR	NR	NR
Halse et al. / AUS (6)	I: 38.6±1.7 C: 38.7±1.2	I: 3176±526 C: 3319±478	I: 49.8±2.5 C: 49.9±2.9	I: 9±1 C: 9±1	I: 9±0 C: 9±0
Jovanovic-Peterson et al. / USA (3)	I: range 39.5 – 40.5 C: range 39.4 – 40.0	I: 3634±317 C: 3465±343	NR	NR	NR
PHYSICAL ACTIVITY COUNSELING					
Bo et al. / ITA (15)	NR	NR	NR	NR	NR
Branskston et al. / CAN (4)	NR	NR	NR	NR	NR
Youngwanichsetha et al. / THA (16)	NR	NR	NR	NR	NR

I: intervention group; C: control group; NR: not reported

Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. Literature search strategy used for the PubMed database.

Table S2. Risk of bias of studies included in the meta-analysis: weekly-supervised exercise and physical activity counseling groups.

Figure S1. Weighted mean difference and 95% confidence interval (CI) for A) studies with a diet counseling integrated with the exercise intervention, B) aerobic exercise only performed during pregnancy, and C) weekly amount of exercise in fasting blood glucose.

Figure S2. Funnel plot of each trial observations for supervised exercise training and physical activity counseling in fasting blood glucose change.

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Review

Physical Activity Programs during Pregnancy Are Effective for the Control of Gestational Diabetes Mellitus

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Abstract: Gestational diabetes mellitus has an incidence of 14% worldwide and nursing is responsible for its monitoring during pregnancy. Excessive weight gain during pregnancy is directly related to gestational diabetes mellitus development. Gestational diabetes mellitus (GDM) has negative repercussions on the evolution of the pregnancy and the fetus. The objective of this systematic review is to establish how physical activity influences pregnant women with gestational diabetes mellitus and to analyze what benefits physical activity has in the control of gestational diabetes mellitus. A systematic search was carried out in different databases (Cochrane, Superior Council of Scientific Investigations (CSIC), EBSCOhost, Pubmed, Scopus, Web os Science, and Proquest) for papers published within the last 12 years, taking into account different inclusion and exclusion criteria. Six randomized controlled studies and one observational case-control study of a high quality were selected. Fasting, postprandial glucose and HbcA1 were assessed, as well as the requirement and amount of insulin used. Thus, there is a positive relationship between the performance of physical activity and the control of gestational diabetes mellitus. Resistance, aerobic exercise, or a combination of both are effective for the control of glucose, HbcA1, and insulin. Due to the variability of the exercises of the analyzed studies and the variability of the shape of the different pregnant women, it does not permit the recommendation of a particular type of exercise. However, any type of physical activity of sufficient intensity and duration can have benefits for pregnant women with GDM. Pregnant women with gestational diabetes mellitus should exercise for at least 20–50 min a minimum of 2 times a week with at a least moderate intensity.

Keywords: active pregnancy; exercise; gestational diabetes mellitus; nursing; physical activity; pregnant

1. Introduction

Life expectancy has increased and people live longer, although this increase in life has increased the number of chronic diseases, each time at an earlier stage [1]. It has been observed that one of the most frequent chronic diseases, diabetes, has increased in adolescents and is estimated for a more than 4-fold increase in the next few decades [2]. Diabetes is a chronic disease suffered by 283 million people, a number that is expected to reach 592 million in 2035 [3]. This chronic disease appears when the pancreas is incapable of producing enough insulin, or when it is not used effectively by the body. Spain, together with the United States, is one of the countries with the highest fasting diabetes and glucose index [4].

The American Diabetes Association (ADA) defines gestational diabetes mellitus (GDM) as diabetes diagnosed in the second or third trimester of pregnancy that was not clearly overt diabetes prior to gestation [5]. GDM can reach up to 14% of the population worldwide [6]. Insulin may or may not be necessary in this case, regardless of the degree of metabolic disorder. In addition, this pathology can persist once the pregnancy has ended [7].

Pregnancy causes major biochemical changes that cause a decrease in insulin sensitivity, offset by an increase in insulin production. Good control of a woman with GDM through diet and exercise can avoid the use of insulin, requiring only 20–30% insulin [8]. According to this statement, the consensus of the Spanish Group on Diabetes and Pregnancy defines that GDM should be treated with dietary measures and physical exercise first. However, this does not mean that pharmacological treatment, such as insulin, is not necessary when adequate metabolic control is not achieved with the above indications [9,10]. Nurses and midwives, among other professionals, are in charge of monitoring a pregnancy and carrying out the diagnostic tests for GDM—indications for physical activity—and are in the closest contact with pregnant women [11].

It is important to treat this complication of pregnancy because patients with GDM are at an increased risk of developing type II diabetes after pregnancy [7]. There is also the possibility that the child will suffer complications as macrosomia, impaired intrauterine growth, obstetric trauma, hyperbilirubinemia, hypoglycemia, intection, and a length of stay in the intensive care unit [12]. A combination of diet and exercise reduces excessive weight gain during pregnancy and GDM because weight gain is directly related to GDM development [13,14]. In addition, obese women tend to have an unbalanced glucose tolerance and higher insulin resistance during pregnancy than those with a healthy weight [7]. Thus, pregnant women who are overweight or obese have between 2.14 and 3.56 times more risk of GDM than those with a healthy weight. If we focus on percentages, the prevalence of GDM would be 0.7% in women with a healthy weight, 2.3% for those overweight, 4.8% for those who are obese, and 5.5% for those with a body mass index higher than 35 [15].

There has always been a controversy about exercising during pregnancy [16]. For this reason, around 80% of pregnant women are physically inactive, increasing this inactivity during the last trimester of pregnancy [17]. However, today it is known that there are many benefits that exercise offers to both the fetus and the mother. Among the maternal benefits are a general decrease in cramps, lower back pain, oedema, depression, urinary incontinence, the duration of labour, and constipation as well as the number of caesarean sections of the mother [18]. Physical activity has benefits for the fetus: decreased fat mass, improved stress tolerance, and advanced neurobehavioral maturation, among others [19]. In addition, physical activity reduces the rate of GDM to those who perform it between three to twelve months regularly before or during the gestation period [20].

Physical exercise can be carried out safely by pregnant women preventing excessive weight gain, macrosomia, high blood pressure, GDM, respiratory distress syndrome, neonatal hypoglycemia, and hypocalcemia [21–24]. The benefits of physical activity requires physical activity for 30 min at a moderate intensity for five days, or 150 min of aerobic activity every week on average, depending on the women's physical activity level or fitness status before pregnancy [25]. It should not be noted that both the intensity and the type of activity depend on each person and should always be recommended individually [26].

On the other hand, it should not be forgotten that sometimes there are severe restrictions to exercise. These circumstances include heart or lung problems, cervical incompetence, threatened labour, or premature rupture of the membrane, pre-eclampsia or severe anaemia. For this reason, it is necessary to follow the instructions of professionals, such as midwives and gynaecologists, who offer tailored safe recommendations on the sports or activities each pregnant woman can carry out [26].

This review investigates the influence of physical activity in women with GDM so in the future its importance and adherence to it are recognized. It also discusses the controversy of physical activity in pregnancy in a recent meta-analysis which indicates that exercise can only perform a preventive approach in GDM [16]. The close relationship between the nursing community and midwives has great potential to influence pregnant women and to profoundly improve their health to face the battle against excess weight in pregnancy and GDM [11]. In addition, professionals can reach an agreement on the safest and most effective recommendations, since currently there is still controversy about the screening protocols or diagnostic criteria of GDM and the best or most successful treatment for this pathology [27].

Objectives: Peak Question

Due to the controversy over whether it is beneficial for pregnant women with GDM to carry out physical activity or not, this review aims to find out how physical activity influences pregnant women with this pathology and to analyze what benefits exercise, or physical activity, brings to the GDM control.

2. Materials and Methods

2.1. Information Sources

The following review was carried out through a bibliographic search that started in September 2019 and ended in December 2019 in the following health-related databases: Pubmed, WOS (Web Of Science), Scopus, Cochrane Library, Proquest, CSIC, EBSCOhost.

2.2. Search Strategy

The search strategy was based on the search string with keywords in the MeSH/DeCS descriptors of the databases mentioned earlier. The string was completed with the Boolean operators AND and OR.

Table 1 shows the used PICO criteria, where it shows how each part of the search chain belongs to each of the peak criteria, following the proper structure with its corresponding keywords.

Table 1. PICO criterion.

Criterion (PICO)	Keywords
Population (P)	(pregnant) and ("gestational diabetes" or "type one diabetes" or "type i diabetes" or "type 1 diabetes" or "type two diabetes" or "type ii diabetes" or "type 2 diabetes")
Intervention (I)	("physical activity" or exercise or "exercise training" or "aerobic training" or "cardiorespiratory fitness" or "resistance training" or "resistance exercise" or "training intervention" or sport)
Outcome (O)	("woman benefits" or "women benefits" or "woman effects" or "women effects")

2.3. Inclusion Criteria

The inclusion criteria include publication within the last 12 years (from 1 January 2008, to 31 December 2019), the population of pregnant women without age range with diagnosed GDM in pregnancy and not a priori or after gestation, a specific type of activity or physical exercise carried out as the intervention, and the studies in English or Spanish.

The exclusion criteria are animal tests and an unspecific amount or type of physical activity by women. The articles that did not differentiate the physical activity from the diet of the pregnant women were also discarded. All GDM prevention studies and systematic reviews were excluded due to inadequate scientific quality.

2.4. Selection of Studies and Collection of Data

After an exhaustive search, a total of 590 results were obtained, of which 554 were eliminated by title and summary, leaving a total of 36 (Figure 1). Nineteen duplicates were removed. The review was conducted independently by two investigators using the inclusion and exclusion criteria of this review.

Thus, a total of 17 articles were chosen for the systematic review. However, 10 of them were discarded for not meeting the established inclusion criteria.

The results were structured under a standardized registry using author, year, type of study, objective, randomization, blind, country, duration of the study, women with GDM, weeks of gestation at study start and at end, activity or exercise, intervention, and glucose levels.

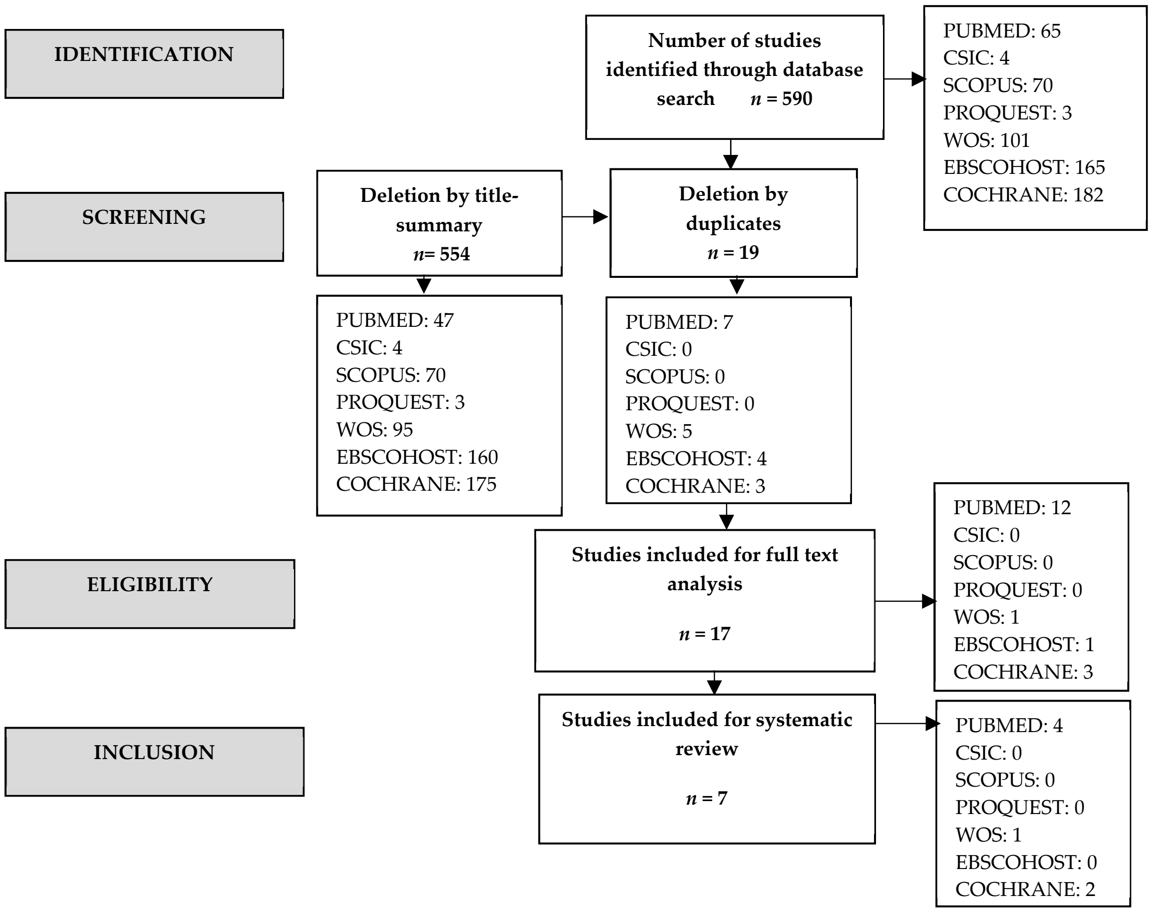

Figure 1. Prisma flow chart.

2.5. Assessment of the Quality of Studies: Detection of Possible Bias

Rating scales have been made to assess the quality of the studies. The PEDRO scale (11 items) was used out for randomized controlled trials (RCTs) [28]. The selection criteria were taken into account if the study population was randomized and the study was blinded for the intervention. The groups were similar at the start of the study and all subjects, therapists or those who collected the data, and evaluators were blinded as to whether there was a high proportion of population lost during the study.

In addition to the PEDRO scale, another type of scale known as the Newcastle–Ottawa scale for case-control [29] was used since 1 study of the 7 is an observational case-control study.

These scales have been carried out by one reviewer and analyzed by a second reviewer to detect possible biases.

Low risk of bias characterizes all the included articles according to the used scales.

2.6. Analysis of Data and Levels of Evidence

The degree of evidence depends on factors, e.g., the type of study and the methodological quality. To assess the level of evidence, a qualitative assessment was made using the SIGN scale (Scottish Intercollegiate Guidelines Network) [30]. According to this scale, all the selected RCTs are of high evidence since, as mentioned in the previous section, all of them have a low risk of bias, as does the observational case-control study.

3. Results

After an exhaustive search in the different databases, a total of 590 results were obtained, of which seven were finally selected to carry out this systematic review. These articles were selected using the inclusion criteria. The studied population comes from Italy, Croatia, Brazil, Thailand, Australia, Nigeria, and the United Kingdom.

Participants of the seven articles are pregnant women with GDM diagnosed during pregnancy whose ages range from 18 to 50 years. The total sample of participants is 782 women. The gestational age of women at the time of the intervention is between week 24 and the end of pregnancy (approximately week 40).

The final choice was made using the description of the exercise, and the variables of the GDM analyzed at each intervention. For this reason, the articles where the only intervention measure for GDM was a physical activity were prioritised, although fourof them combined exercise with diet [31–34]. These four articles mentioned a suitable diet: approximately 50% of carbohydrates, 20% of proteins, and 30% of fats. The article by Bo et al. [32], unlike that of Sklempe et al. [31], includes the recommended amount of fibre per day (20–25 g/day) and indicates the prohibition of alcohol during pregnancy. Furthermore, Barros et al. [33], Davenport et al. [34], and Sklempe et al. [31] specify that the total amount of food per day is around 1800–2000 Kcal.

Table 2 shows the characteristics of the selected studies.

Table 2. Description of the type of study, intervention, sample, results, conclusions, and year of the selected studies.

Author—Year	Type of Study	Type of Intervention	Sample Size	Results	Conclusions	Quality
Sklempe et al., 2017 [31]	ECA Randomization method: it is based on the web in two groups (experimental and control) Place: 2 university hospitals in Zagreb (Croatia). Participants were not blinded. Laboratory personnel and doctors were blinded.	EG: exercises twice a week → 50–55′ session + 30′ walking/day. 20′ aerobic activity (static tape with individualized intensity) + 20–25 resistance exercises (6 exercises in 3 sets of 10 to 15 repetitions with weight and elastic band) + pelvic exercises and stretching + 10′ relaxation. CG: standard care + unsupervised exercise. Program duration: 6 w minimum. Nutrition therapy for women with GDM at the beginning: 1800 kcal per day: 20% protein (90 g), 30% fat (60 g) and 50% carbohydrates (225 g), distributed in three main meals and three snacks. Postprandial and fasting glucose levels were measured 1 or 2 times a month during pregnancy.	N = 38 (18 EG, 20 CG) Inclusion criteria: pregnant women with GDM between 20 and 40 years. Characteristics: age (EG: 32.78 ± 3.83; CG: 31.95 ± 4.91); upper limit gestational age (30 w); diabetic family history (EG: 7; CG: 8); gestational age of diagnosis (EG: 22.44 ± 6.55; CG: 20.80 ± 6.05); sedentary lifestyle (EG: 25.16 ± 13.2; CG: 24.36 ± 17.09)	365 exercise sessions. Intensity exercise between 3 and 14 in the Borg rating. 4.42% of maximum heart rate. Walking compliance > 70%. Moderate physical activity and transport levels during the 30th to 36th week of pregnancy > EG. No pharmacological treatment. Average fasting glucose < EG (p = 0.367). Postprandial glucose < EG (p < 0.001) No differences in weight gain or fat mass between both groups. No significant correlation was found between glycemic parameters and the duration of the intervention, adherence to the protocol or the number of assisted exercise sessions.	Aerobic exercises + resistance exercises → benefits for women with GDM. The EG had lower postprandial glucose levels at the end of pregnancy (p < 0.001). There was no significant difference between groups in the level of fasting glucose at the end of pregnancy.	10/11
Youngwanichsetha et al., 2014 [35]	ECA Randomization method: computer program and opaque envelopes. Place: tertiary hospital in southern Thailand.	CG: standard diabetes care. EG: standard diabetes care+ diet+ yoga during 8 w. 2 exercise sessions of 50′. Measures: fasting, postprandial glucose, and HbcA1.	180 (90 CG; 90 EG) Inclusion criteria: pregnant women with GDM between 24–30 w (no insulin). Pregnant women who have no more complications in their pregnancy. Characteristics: mean age 32.58 (SD = 5.01) CG; 31.24 (SD = 4.54) EG. Plasma glucose after 100g test CG = 89.18 (SD = 12.84) and EG = 89.36 (SD = 13.19).	Fasting glucose average: EG: 83.39 mg/dL (SD = 17.69). CG: 85.85 mg/dL (SD = 17.94). (p = 0.012) Postprandial glucose average: EG: 105.67 mg/dL (SD = 12.93). CG: 112.36 mg/dL (SD = 13.15). (p = 0.001) HbA1C average: EG: 5.23% (SD = 0.72). CG: 5.68% (SD = 0.68). (p = 0.038) EG < fasting, postprandial glucose, and HbcA1.	The exercise intervention program is effective in improving glycemic control.	10/11
Bo et al., 2014 [32]	ECA Randomization method: web (www.epiclin.it) Place: hospital Sant'Anna (Torino)	Multiple interventions: GD, GB, GBE, GE Diet: carbohydrates 48–50%; protein 18–20%; fat 30–35%; fiber 20–25 g/day, not alcohol. GD → diet. GB: diet + behavior→oral or written recommendations. GBE: diet +exercise → walk 20′/da slightly. GE2: diet +recommendations + exercise → walk 20′ vigorously every day + group b recommendations. Duration: until the end of pregnancy (approx. 16 w).	400 participants Inclusion criteria: pregnant women with GDM between 18–50 years and 24–26 w of gestation.	Weight, BMI, insulin, and dietary values (triglycerides and CPR concentration) → < in all groups. Postprandial glucose (p < 0.001) and HbA1c (p < 0.001) → < in the E/BE groups. Groups that do exercise (n = 101): Fasting glucose: 72.4 ± 10.3. Postprandial glucose: 106.1 ± 19.0. HbAc1: 4.6 ± 0.5. Groups that do not exercise (n = 99): Fasting glucose: 74.1 ± 10.7 Postprandial glucose: 117.2 ± 16.5 HbAc1: 4.9 ± 0.4. Groups that do exercise + diet + not recommendations (n = 101): Fasting glucose: 73.3 ± 10.1 Postprandial glucose: 113.0 ± 20.0 HbAc1: 4.8 ± 0.5 Groups that do exercise + diet + recommendations (n = 99): Fasting glucose: 73.2 ± 11.0 Postprandial glucose: 110.2 ± 17.1 HbAc1: 4.8 ± 0.4	Exercise → ↓ postprandial glucose, triglycerides and CRP concentrations. Exercise + recommendations→ no significance (p > 0.3). Group D → > maternal/neonatal complications. Exercise + diet → ↓ maternal/neonatal complications. Recommendations or recommendations + exercise→ no ↓ maternal/neonatal complications.	10/11

Table 2. *Cont.*

Author—Year	Type of Study	Type of Intervention	Sample Size	Results	Conclusions	Quality
Halse et al., 2014 [36]	ECNA Place: King Edward Memorial Hospital, Perth, Western Australia	Analyze fasting, postprandial glucose levels, HbA1c and glucose and insulin response to an oral glucose load of 75 g. Conventional care based on glycemic control 2 h after breakfast, lunch and dinner + educator advice + dietitian + food and beverage daily in the 1st and last. GE → 3 sessions of supervised exercise (exercise bike at home: 5′ low intensity 55-65% warm-up + 20–30′ pedalling of > intensity with intervals between 15–60′ higher intensity every 2′. The intensity was individualized for each woman The duration of the session was increased up to 45′ in the last + 5–10′ of low intensity and gentle stretching) + 2 sessions without the supervision of 30′ until s 34 + conventional care. Supervision: TA, pre and post-exercise glucose and intake of the last meal before exercise. GC→ 35 ± 8, → walking (52%), exercise bike (40%), water exercise (5%) and yoga (3%) + conventional care.	40 participants (20 EG; 20 CG) Inclusion criteria: women with GDM, between 26–30 w of gestation, who had had an exploration of the normal anatomy in w 18, with a BMI < 45, non-smokers and not enrolled in any exercise program and who could perform physical activity. Characteristics: age (32 ± 3 → CG; 34 ± 5 → EG).	W 34 → glucose measurement and insulin response at 30, 60, 90, 120′ fasting according to GTT, HbcA1, physical activity level and nutritional status. EG → glucose response to exercise was 6.3 ± 08.mM pre-exercise at 4.9 ± 0.7mM post-exercise ($p < 0.001$). 62% of participants → capillary glucose was 1.0 mM pre to post. Half cc fasting blood glucose EG → more than the CG ($p = 0.083$) → No significance. CC postprandial glucose < in EG than in CG ($p = 0.046$). Glucose after breakfast < EG ($p = 0.036$); dinner ($p = 0.054$); lunch ($p = 0.312$) Post-intervention glucose not significant differences between EG and CG, insulin response CG (4.2 ± 2.3) and EG (5.0 ± 3.0) →($p > 0.05$). HbcA1 → % > in post-intervention values in CG than in EG ($p = 0.012$) compared with pre-intervention values, without differences between groups ($p > 0.05$). Physical activity → EG > number of hours/w vs. CG. Feeding → CG > protein intake in the 1st s ($p = 0.033$) and last w ($p = 0.009$). HC > intake in EG in the last w ($p = 0.035$).	Cycling at home helps control postprandial glucose levels in women with GDM along with a proper diet. Supervision helps > adherence to exercise and change the lifestyle of these women. + research with + population and + exercise variety	8/11
De Barros et al., 2010 [33]	ECA Randomization method: web and opaque envelopes. Place: obstetric clinic, the university hospital of Sao Paulo (Brazil).	Diet: 7 servings → 35 cal/Kg per day + 300 Kcal/day in the day 2nd and 3rd quarter. CG → usual care. EG → wait for 90′ after eating and perform blood glucose. Exercise: resistance circuit of 8 exercises with an elastic band with 15 repetitions each exercise with a minimum of 30′ of rest and a maximum of 1′. 2nd quarter → 2 series of the circuit and 3rd quarter → 3 series. 3 times in w (1 under supervision). Moderate Intensity Glycemic profile every w. Insulin if > 30% glucose measurements > recommended value, hyperglycemia or baby weight > 75th percentile.	64 participants (32 CG; 32 EG) Inclusion criteria: women with GDM, non-smokers, sedentary between 18–45 years, without the disease, gestational age between 24–34 w. Characteristics: age CG → 32.4 ± 5.40; EG → 31.81 ± 4.87.	Insulin requirement: CG → 18 (56,3%) EG→ 7 (21.9%) Amount of insulin required IU/kg: CG → 0.49 ± 0.14 EG → 0.44 ± 0.11 Average glucose levels: CG → 102.89 ± 7.88 EG→ 100.30 ± 9.37	The resistenace exercise program with elastic band was effective in reducing the number of patients requiring insulin and to control glucose levels in women with GDM	11/11
Davenport et al., 2008 [34]	Case-control study Place: London.	2 groups were established: CG: conventional treatment: nutritionist advice every 2 w. Objectives: 2000 Kcal/day. 200 g CH in 3 meals and 3 drinks + glucose measurement + regular monitoring with your doctor. EG: hike (3–4 times at w increasing from 2′ to reach 40′ the last w. Duration: 6 w) + conventional treatment. Inclusion criteria: women with GDM, without pathology in pregnancy, and with follow-up from their doctor.	30 women → 10 EG and 20 CG. Characteristics: age → CG: 33.3 ± 5.3; EG: 33.48 ± 7.1. BMI before pregnancy → CG: 32.8 ± 5.9; EG: 32.92 ± 7.1.; Weight gained during pregnancy → CG: 12.7 ± 8.4. EG: 12.0 ± 9.7	Participants that require insulin: CG: 70%. EG: 70%. Glucose values at treatment: EG: < at the end of pregnancy tan the CG. CG capillary glucose 1 h after dinner increased at the end of the arm compared to the beginning. Amount of insulin: EG: 0.16 ± 0.13 U/kg → required less frequently. CG: 0.5 ± 0.37 U/kg.	Glucose concentration can be improved, as well as reducing the amount and frequency of insulin injection in women with GDM who walk.	7/9

Table 2. *Cont.*

Author—Year	Type of Study	Type of Intervention	Sample Size	Results	Conclusions	Quality
Daniel et al., 2014 [37]	ECA Randomization method: random assignment to the GE/GC. Place: Owerri, Nigeria.	EG: dance exercises for 8 w. Warm-up (low-intensity aerobic exercises) and 5–10′ stretching + Dance: 10–20′ cardio-respiratory exercises (low-moderate intensity) such as fast walking. The duration increased from 40 to 60′ after 4 w + strengthening exercises (pelvic floor and abdominal muscle exercise)+ stretching and cooling 5–10′. CG: no exercise program. Fasting glucose level at the beginning. 4 and 8 w.	30 participants (15 EG; 15 CG) Inclusion criteria: women with > 24 w of gestation diagnosed with GDM suitable for exercise. Charactristics: age → EG 32 ± 3.42; CG 32.93 ± 4.61. Gestational age (weeks) → EG: 26.8 ± 0.94; CG 26.33 ± 0.98.	Fasting glucose: Start: EG(144.53; SD: 6.96); CG (145.07; SD: 8.19), (p = 0.85). S 4: EG (118.63; SD:10.73); CG (142.73; SD: 6.96) (p = 0.001) S 8: EG (87.67; SD: 11.84); CG (141.53; SD: 6.82) (p = 0.001)	Significant effect of the exercise program. Exercises 3 times per w between 40–60′ per session at moderate intensity reduces blood glucose.	8/11

RCT: randomized controlled study; w: week; GDM: gestational diabetes mellitus; EG: experimental group; CG: control group; BMI: body mass index; CRP: c-reactive protein; ECNA: non-randomized controlled study; GTT: glucose tolerance test; tto: treatment; cc: concentration; n: number; HbcA1: glycosylated haemoglobin; SD: standard deviation; p: a measure of statistical significance; g: grams; GD: group D; GB: group B; GBE: BE group; GE2: group E; <: minor; >: major; ′: minute; HC: carbohydrate.

The duration of the interventions varies between 6 and 16 weeks; therefore, a specific duration cannot be established. Regarding exercise, there are two types of modalities different from this: aerobic activity (AA) and resistance exercise (RE) or a combination of both, as in the study by Sklempe et al. [31] Three of the seven interventions mention aerobic activity as an intervention measure in the control of GDM [34,36,37]. The aerobic activity of the study by Halse et al. [36] consists of using a stationary bicycle with intervals of greater intensity with a final duration of training 45 min in the last quarter. However, the activity of Davenport et al. [34] consists of walking 3–4 times a week for about 40 min. In another study [33], the effect of an elastic band used to perform a circuit of 8 resistance exercises is analyzed, where the duration of the training increases as the pregnancy progresses.

Sklempe et al. combine both modalities (AA and RE) and also include pelvic and stretching exercises with corresponding relaxation [31]. This study includes the most exercises concerning the type of intervention and reflects that at the end of pregnancy there is no significant difference between groups in the fasting glucose levels but there is a significant difference in postprandial glucose levels in the EG, as shown in Table 2. However, it is necessary to take into account the limitations of the study by Sklempe et al.: the study population is small, and there is no indication of participants requiring insulin during the intervention. Even so, it presents strengths such as fasting and postprandial glucose values which are lower in the intervention group, with a greater difference in postprandial glucose. It should be noted that the intensity of exercise was moderate.

The type of study activity done in Thailand is yoga [35]. This form of exercise has been included within the resistance exercise modality. For eight weeks, the studied population performed this exercise twice a week for 50 min. The variables analyzed are fasting, postprandial glucose, and glycated haemoglobin (HbA1c). These three variables are lower in the intervention group, with a significant difference ($p = 0.012$; $p = 0.001$; $p = 0.038$, respectively). Therefore, it can be affirmed that yoga is an effective exercise to control these variables. On the other hand, Bo et al. [32] studied four groups specified in Table 2, but only group B (GB) and group BE (GBE) exercised. Thus, when comparing the variables, we differentiate between those who exercise and those who do not. Their exercise is walking every day for 20 min, and the results of fasting, postprandial glucose, and HbAc1 are lower in the exercise groups, but also with significant differentiation ($p < 0.001$).

Finally, the randomized controlled study of Daniel et al. [37] analyzes two randomly chosen groups, experimental and control. The experimental group performs the aerobic exercise, in this case, dance, for eight weeks. Compared to the control group who do not perform physical activity during this period the results are better for the experimental group for fasting glucose levels at the fourth and eighth week of physical activity, however, there are no differences between groups at the beginning. Thus, performing this type of exercise 40–60 min a week at a moderate intensity considerably reduces fasting glucose in pregnant women with GDM.

4. Discussion

This systematic review confirms the benefits of physical activity on fasting, postprandial glucose, and HbAc1 control in pregnant women with GDM during pregnancy. However, we cannot recommend a specific type of exercise, since the results of all the studies show similar benefits of physical activity during pregnancy in women with GDM. Only two studies [33,34] analyze the amount of required insulin to control the GDM. Both studies agree that the amount of insulin is less in the group that performs the physical activity. However, this requirement remains controversial since Davenport et al. [34] show that both the walking group and the one that does not walk still require insulin. At the same time, the study by De Barros et al. [33] indicates that the insulin requirement is lower in the exercise group that has a more intense physical activity.

However, the two authors [33,34] agree that aerobic and resistance physical activity or a combination of both are beneficial to control GDM values.

4.1. Physical Activity and Psychological Factors in Pregnant Women

In addition to the benefits of physical activity on GDM, other benefits of physical activity in pregnant women have been found, e.g., the psychological benefits [38,39]. In one of the studies [38] of the 50 pregnant women who exercised, 35 indicated that their perception of health was excellent, and only 5 of 51 women who did not exercise perceived their health to be very good. Furthermore, Nakamura [39] states that exercise reduces the appearance of depressive symptoms in pregnant women and helps to improve mood.

4.2. Physical Activity and GDM Prevention

When performing the search string, some of the articles were discarded because they analyzed the influence of physical activity on the prevention of GDM [40–46]. These studies deviated from the objective of this review—to analyze how physical activity influenced the control of GDM—and were discarded. However, prevention of GDM through physical exercise is a topic of importance closely related to the present review. Physical activity helps prevent GDM by improving glycemic control, insulin resistance, and pre-pregnancy weight gain [47]. A study indicates that an increase of 100 min of moderate to vigorous physical activity per week could reduce the risk of GDM by 9% [48]. However, the highest probability of preventing GDM by physical exercise is for pregnant women with morbid obesity [49].

In addition, the latest study claims that prevention depends on the intensity of physical activity [49]. This intensity must be moderate to reduce the risk of GDM and to improve glucose uptake. Still, another study confirms that activity levels among pregnant women are low for various reasons, e.g., lack of time, fear of injury, or willpower. In addition, physical exercise depends on the educational level, so having a low socioeconomic standard status contributes to being inactive during pregnancy [47].

4.3. Strengths and Limitations

The present review has some limitations, e.g., a sample size that does not allow us to generalize our results. The variability of the exercises for different interventions together with the variability of the shape of the different pregnant women makes it difficult to establish clear recommendations on the specific intensity and a specific type of exercise as the most appropriate one to control the GDM.

The strengths include the time frame of the investigation (the last 12 years), so the information is current. Furthermore, the results of the studies are similar, and their quality is high. Added to this is the considerable variability of countries where the studies have been carried out, which provides a more global vision.

Due to the paucity of articles in the last 12 years on how physical activity or exercise affects the control of GDM, more research should be done, taking into account a more representative population. In this regard, clinical trials with different types of exercise and diet are needed to assess the impact on glucose, insulin, and HbcA1 levels and to determine the most effective exercise in GDM.

4.4. Implications for Clinical Practice

Physical activity protocols could improve the nursing and midwifery consultations as a support measure for pregnant patients. These protocols can prevent different problems associated with a sedentary lifestyle in pregnant women, e.g., excessive weight gain during pregnancy [14], GDM [7], high blood pressure, respiratory distress syndrome, and hypocalcaemia [21–24]. These protocols can also prevent fetus-related complications, e.g., macrosomia, impaired intrauterine growth, obstetric trauma, hyperbilirubinemia, hypoglycemia, intection, and length of stay in the intensive care unit [12]. Monitoring of pregnancy would improve, complications could be minimized, and the health costs associated with these complications would be reduced. The nurse and midwife consultation will receive all pregnant women to monitor the pregnancy, so implementing these programs from the beginning of the pregnancy will increase physical activity in this population group. Currently, such programs are not offered in the health system. These programs offered by the nurse or midwife consultation can be directed according to the stage of the pregnancy, while monitoring the potentially harmful effects of excessive physical activity.

5. Conclusions

Aerobic, resistance exercise, or a combination of both are effective in controlling glucose, HbcA1, and insulin. Due to the variability of the exercises of the analyzed studies and the variability of the shape of the different pregnant women, it does not allow recommending a particular type of exercise. However, any type of physical activity of sufficient intensity and duration can have benefits for pregnant women with DMG.

Pregnant women with GDM should exercise at least 20–50 min a minimum of two times a week. The intensity of the activity should be at least moderate.

While exercise provides the greatest benefit according to the analyzed studies, diet is also important to control glucose values, HbcA1, and the required amount of insulin.

Due to the scarcity of articles found on the subject under investigation, the influence of physical activity for the control of GDM requires further investigation by different professionals for better control of GDM.

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Regular Exercise to Prevent the Recurrence of Gestational Diabetes Mellitus

A Randomized Controlled Trial

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OBJECTIVE: To investigate the effect of a supervised home-based exercise program on the recurrence and severity of gestational diabetes mellitus (GDM) together with other aspects of maternal health and obstetric and neonatal outcomes.

METHODS: This randomized controlled trial allocated women with a history of GDM to an exercise intervention (14-week supervised home-based stationary cycling program) or to a control group (standard care) at 13±1 weeks of gestation. The primary outcome was a diagnosis of GDM. Secondary outcomes included maternal fitness, psychological well-being, and obstetric and neonatal outcomes. A sample size of 180 (90 in each group) was required to attain 80% power to detect a 40% reduction in the incidence of GDM.

RESULTS: Between June 2011 and July 2014, 205 women provided written consent and completed baseline assessments. Of these, 33 (16%) were subsequently excluded as a result of an elevated baseline oral glucose tolerance test (OGTT), leaving 172 randomized to exercise (n=85) or control (n=87). Three women miscarried before the assessment of outcome measures (control=2; exercise=1). All remaining women completed the post-intervention OGTT. The recurrence rate of GDM was similar between groups (control 40% [n=34]; exercise 40.5% [n=34]; P=.95) and the severity of GDM at diagnosis was unaffected by the exercise program with similar glucose and insulin responses to the OGTT (glucose 2 hours post-OGTT 7.7±1.5 compared with 7.6±1.6 mmol/L; P>.05). Maternal fitness was improved by the exercise program (P<.01) and psychological distress was reduced (P=.02). There were no differences in obstetric and neonatal outcomes between groups (P>.05).

CONCLUSION: Supervised home-based exercise started at 14 weeks of gestation did not prevent the recurrence of GDM; however, it was associated with important benefits for maternal fitness and psychological well-being.

CLINICAL TRIAL REGISTRATION: ClinicalTrials.gov, https://clinicaltrials.gov, NCT01283854.

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Women diagnosed with gestational diabetes mellitus (GDM) are at increased risk of pregnancy complications[1] as well as developing type 2 diabetes and metabolic syndrome in later life.[2] For the fetus, elevated maternal glucose concentrations promote excessive growth and increased birth weight, increasing the risk of macrosomia, birth injury, and admission to a neonatal care unit.[1] Later in life, these offspring have an increased prevalence of obesity, type 2 diabetes, and metabolic syndrome, perpetuating the burden of diabetes across generations.[2]

Epidemiological data indicate that being physically active before and during pregnancy is associated with a reduced risk of GDM,[3] and experimental studies have shown that regular exercise during pregnancy may attenuate the typical decline in glucose tolerance.[4] However, few randomized controlled trials have investigated whether regular exercise can prevent GDM,[5–7] and no trials have focused on women with a history of the condition who have a high risk of recurrence (approximately 48%).[8] Furthermore, compliance to prescribed exercise interventions has been reported as a limiting factor during pregnancy.[7] Common barriers to exercise in this population include a lack of time associated with managing a household and caring for existing children, tiredness, physical limitations, and concerns about safety.[9,10] Supervised, home-based exercise training may overcome many of these barriers.[4,11] Accordingly, the aim of this study was to investigate the effect of a 14-week supervised, home-based exercise program started at 14 weeks of gestation on the recurrence of GDM. The effect of the intervention on maternal cardiovascular fitness, body anthropometrics, psychological well-being, and obstetric and neonatal outcomes was also examined.

MATERIALS AND METHODS

This single-centered randomized controlled trial was conducted in Perth, Australia, and registered at www.clinicaltrials.gov (identifier: NCT01283854). The study was approved by the Women and Newborn Health Service Ethics Committee and conducted in accordance with the Consolidated Standards of Reporting Trials Statement with the first patient enrolled on June 22, 2011. Pregnant women with a history of GDM in a previous pregnancy were recruited through antenatal clinics, obstetricians, general practitioners, and ultrasound practices. Participants were eligible for inclusion if they were less than 14 weeks of gestation, older than 18 years of age, and able to participate in a 14-week exercise program. Women with pre-existing diabetes, elevated baseline oral glucose tolerance test (OGTT), multiple pregnancy or a medical condition that restricted exercise participation, those taking oral hypoglycemic agents, or those who were already engaged in a structured exercise program were not eligible for the study. All participants provided written informed consent.

Eligible women were randomized between 12 and 14 weeks of gestation to an exercise intervention or control using a custom-designed computer program on a dedicated laptop that stratified by body mass index (calculated as weight (kg)/[height (m)]^2, less than 30, 30–34.9, or greater than 35) and maternal age (younger than or 35 years or older). Randomization was performed during the first visit to the laboratory with the woman entering the stratification factors into the program to be informed of her allocation by the next screen. Participants randomized to exercise engaged in a 14-week stationary cycling program starting 7 days later. An upright cycle ergometer was delivered to each participant's home for her use during the intervention. All sessions were supervised by an exercise physiologist who would travel to the woman's home three times each week to monitor the duration and intensity of exercise.

Each session commenced with a 5-minute warm-up consisting of pedaling at an intensity that equated to 55–65% of age-predicted maximum heart rate and a rating of perceived exertion of 9–11 on the Borg scale.[12] This scale ranges from 6 (no exertion) to 20 (where exercise is perceived to be "very very hard"). The subsequent conditioning period was divided into 5-minute periods of continuous moderate-intensity cycling (65–75% maximum heart rate; rating of perceived exertion 12–13) alternating with 5-minute periods of interval cycling. Two types of intervals were used; one involved an increase in pedaling rate for 15 seconds and the other involved an increase in cycling resistance for 30 seconds (target intensity 75–85% maximum heart rate; rating of perceived exertion 14–16) repeated every 2 minutes. A 5-minute cool down concluded each session (55–65% maximum heart rate; rating of perceived exertion 9–11) followed by light stretching. The duration of each session was progressively increased by 5-minute increments every 2–3 weeks, as tolerated, from 20 to 30 minutes to a maximum session duration of 60 minutes. The degree of progression was dependent on the baseline fitness level of the woman and her ongoing pregnancy symptoms.

Each participant was required to visit an independent local accredited pathology center (PathWest Laboratory Medicine, Perth, Australia) in the fasted state to complete a 75-g OGTT both preintervention and postintervention (at least 48 hours after the last exercise session). Diagnosis of GDM at the post-intervention OGTT was based on the criteria adopted in Western Australia at the time of the trial (fasting venous blood glucose 5.5 mmol/L or greater [99 mg/dL] or a 2-hour OGTT glucose 8.0 mmol/L or greater [144 mg/dL] or both). Fasting glucose and insulin concentrations, together with glucose tolerance and insulin sensitivity, were determined from the 75-g OGTT. Insulin sensitivity was determined using the homeostatic model of assessment[13] and the insulin sensitivity index.[14] Glycosylated hemoglobin, serum c-peptide, and cholesterol concentrations were also measured from the fasting venous blood sample. Post-intervention testing was completed within a week of cessation of the intervention, but at least 48 hours after the last exercise session.

On a separate occasion, participants visited our laboratory for the assessment of secondary outcome measures preintervention and postintervention. Height, body mass, five peripheral skinfolds (biceps, triceps, subscapular, midthigh, and calf), four limb girths (upper relaxed arm, upper flexed arm, thigh, and calf), resting heart rate, and blood pressure were measured. In addition, cardiovascular fitness was assessed based on the heart rate and oxygen consumption responses to submaximal exercise on a stationary cycle ergometer. Briefly, this test involved progressive exercise until a heart rate equivalent to 75% of age-predicted maximum was attained.[11] Oxygen consumption was measured for the duration of the test with fitness expressed as both power output (W) and oxygen consumption at 75% of maximum heart rate. During the same session, the Edinburgh Postnatal Depression Scale[15] was administered along with the 21-item Depression Anxiety Stress Scale[16] to assess general psychological distress,[17] and the Social Physique Anxiety Scale[18] monitored social anxiety relating to physique.

Each participant also completed a 7-day food diary preintervention and postintervention for assessment of mean daily nutritional intake (total energy, carbohydrate, fat, protein, sugar, and fiber. Physical activity (daily steps, time spent sedentary and in moderate-intensity activity) was monitored for the same 7-day period using an accelerometer. Changes in exercise habit strength (patterning of action, automaticity, stimulus-response bonds, and negative consequences for nonperformance) were assessed using the Exercise Habit Strength Questionnaire.[19] After delivery, relevant obstetric and neonatal outcomes were extracted from hospital records.

Data from King Edward Memorial Hospital (Perth, Western Australia) indicated that the risk of GDM recurrence was 55% in our population, a figure consistent with the published literature.[8] A sample size of 180 (90 women in each group) was required to attain 80% power to detect a 40% reduction in the incidence of GDM, from 55% to 33%, when performing a test of proportions at the 5% significance level. Continuous data were summarized using means and standard deviation, or medians and interquartile ranges, depending on data normality, and were univariately compared using a *t* test or Mann-Whitney test. Categorical data were summarized using frequency distributions. The incidence of GDM and other categorical outcomes was compared using a χ^2 test, except for low-frequency outcomes, which were compared using a Fisher exact test. The glucose and insulin responses to the OGTT were compared using three-way (group×pre–post×time) repeated-measures analysis of variance. Maternal fitness, body anthropometrics, psychological well-being, physical activity levels, and daily nutritional intake were compared using two-way (group×pre-post) repeated-measures analysis of variance. Extreme underreporters were identified using the Goldberg method as per Black[20] and excluded from the dietary analysis (8% of entries). Statistical analysis was conducted based on intention-to-treat using SPSS. All hypothesis tests were two-sided and conducted at a 5% significance level.

RESULTS

A total of 318 women were assessed for eligibility for the study between June 1, 2011, and July 31, 2014 (Fig. 1), and 205 provided written consent to participate and completed baseline assessments at 13±1 weeks of gestation. Of these 205 women, 33 were excluded from the trial as a result of an elevated OGTT at baseline, leaving 172 randomized to exercise (n=85) or control (n=87). The baseline characteristics of these women are shown in Table 1. The majority were of Caucasian ethnicity and lived in geographic areas in the top quintile for relative socioeconomic advantage. There were no differences in glucose regulation between groups at baseline. Two women experienced pregnancy loss at 19 weeks of gestation and one at 21 weeks of gestation (control=2; exercise=1). All remaining women completed the postintervention OGTT (28±1 weeks of gestation); however, 12 women failed to complete the postintervention assessment of fitness, body anthropometrics, and psychological well-being (secondary outcomes). The final participant delivered on January 26, 2015, completing the period of data collection. Compliance to the exercise intervention was high (median 86% of sessions completed; interquartile range 79–95%). The mean heart rate during exercise was 130±10 beats per minute (70±5% age-predicted maximum). Participants reported a mean session rating of perceived exertion of 13±1 indicating that exercise intensity was perceived as "somewhat hard." Exercise duration increased from 28±4 minutes per session in the first week to 47±11 minutes in the last week of the intervention.

The recurrence rate of GDM was similar between groups (40% control; 40.5% exercise; relative risk 1.01, 95% confidence interval 0.70–1.46; *P*=.950; Table 2) and there was no difference in the severity of GDM based on the overall degree of glucose tolerance or insulin response to the OGTT between groups postintervention. Homeostatic model of assessment, insulin sensitivity index, glycosylated hemoglobin, and serum C-peptide were also similar between

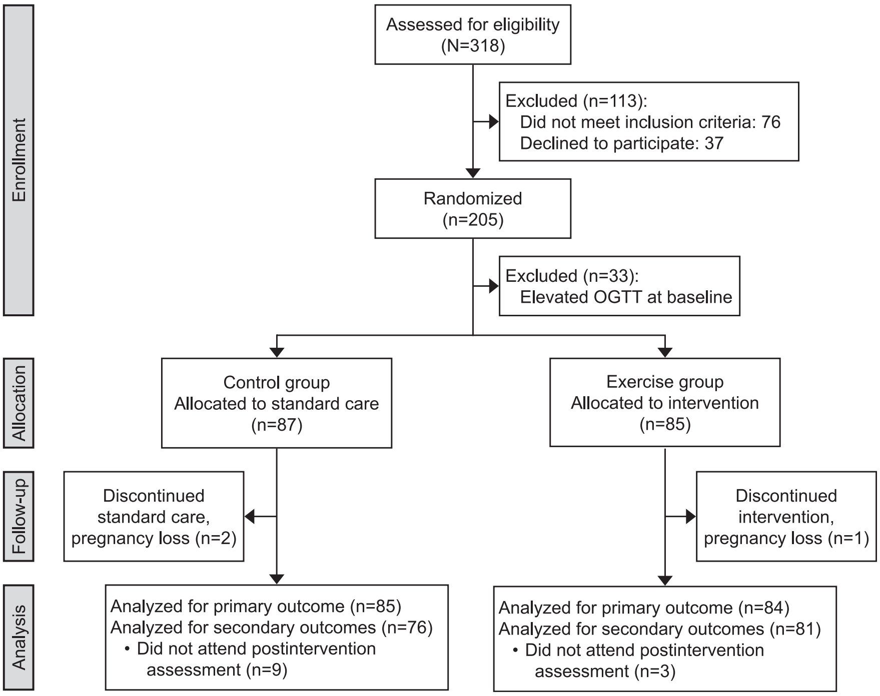

Fig. 1. Consolidated Standards of Reporting Trials (CONSORT) flow diagram. OGTT, oral glucose tolerance test.

Guelfi. Cycling to Break the Cycle of Diabetes. Obstet Gynecol 2016.

groups postintervention (Table 2). Advancing pregnancy was associated with an increase in resting heart rate, blood triglycerides, low-density lipoprotein and high-density lipoprotein cholesterol, and a decrease in systolic and diastolic blood pressure ($P<.001$); however, there were no differences between groups (Table 3). Similarly, body mass, sum of skinfolds, and girths increased as pregnancy progressed

Table 1. Baseline Characteristics of Women Randomized to a 14-Week Supervised Home-Based Exercise Intervention or Standard Care

Characteristic	Control (n=87)	Exercise (n=85)	*P*
Maternal age (y)	33.8±3.9	33.6±4.1	.750
Caucasian ethnicity*	68 (78)	76 (89)	.071
Parity			
1	71 (82)	58 (68)	.077
2 or more	16 (18)	27 (32)	
BMI (kg/m^2)			
24.9 or less	48 (55)	37 (44)	.138
25–29.9	19 (22)	30 (35)	
30 or higher	20 (23)	18 (21)	
Highest SEIFA IRSD quintile	49 (56.3)	49 (57.6)	.768
Smoking			
Yes	—	4 (5)	.096
Unknown	4 (5)	6 (7)	
Fasting glucose (mmol/L)	4.3±0.3	4.3±0.4	.780
Fasting insulin (milliunits/L)	5.8±3.7	6.1±3.2	.623
HOMA-IR	1.1±0.8	1.2±0.7	.549
Insulin sensitivity index	9.8±4.6	9.3±5.2	.553
HbA_{1c} (%)	5.4±0.3	5.4±0.3	.427
Serum C-peptide (nmol/L)	0.35 (0.29–0.51)	0.39 (0.29–0.52)	.696

BMI, body mass index; SEIFA IRSD, Socio-Economic Indices for Areas Index of Relative Socio-Economic Advantage and Disadvantage (highest quintile represents the most advantaged); HOMA-IR, the homeostatic model of assessment insulin resistance; HBA_{1c}, glycosylated hemoglobin.

Data are mean±standard deviation, n (%), or median (interquartile range) unless otherwise specified.

* Other ethnicities include Asian, Eurasian, Hispanic, and Polynesian.

Table 2. Gestational Diabetes Mellitus Diagnosis, Measures of Insulin Sensitivity, and Glucose Regulations After a 14-Week Supervised Home-Based Exercise Intervention or Standard Care

	Postintervention	
Outcome	Control (n=85)	Exercise (n=84)
Diagnosed with GDM	34 (40.0)	34 (40.5)
Fasting glucose (mmol/L)	4.4±0.5	4.5±0.5
Fasting insulin (milliunits/L)	7.9±4.4	9.1±5.7
Glucose 2-h post-OGTT (mmol/L)	7.7±1.5	7.6±1.6
HOMA-IR	1.25 (0.84–2.05)	1.56 (1.09–2.18)
ISI	5.6 (3.9–7.8)	5.0 (3.5–7.7)
HbA_{1c} (%)	5.3±0.3	5.3±0.3
Serum C-peptide (nmol/L)	0.53 (0.37–0.71)	0.54 (0.41–0.71)

GDM, gestational diabetes mellitus; OGTT, oral glucose tolerance test; HOMA-IR, homeostatic model of assessment-insulin resistance; ISI, insulin sensitivity index; HbA_{1c}, glycosylated hemoglobin.

Data are n (%), mean±standard deviation, or median (interquartile range) unless otherwise specified.

($P<.001$) with no difference between groups. Maternal cardiovascular fitness, based on the power output at 75% maximum heart rate, was increased in response to exercise ($P<.01$), resulting in higher fitness in the exercise group compared with women in the control group postintervention ($P<.01$). Oxygen consumption at 75% maximum heart rate also tended to increase after the exercise intervention ($P=.05$; Table 3).

There were no changes in Edinburgh Postnatal Depression Scale scores over time and no differences between groups (Table 4). Similarly, the number of participants with Edinburgh Postnatal Depression Scale scores 12 or greater (indicating higher risk for depression in pregnancy) was similar between groups. In contrast, a significant difference in the 21-item Depression Anxiety Stress Scale psychologic distress scores was noted between groups postintervention ($P=.04$) with a reduction in response to exercise but no change in the control group. Social Physique Anxiety did not change over time and was similar between groups (Table 4). Daily nutritional intake was unaltered over time and was similar between groups preintervention and postintervention ($P>.05$; Table 5). With respect to daily physical activity levels, the mean number of steps taken decreased and the time spent sedentary increased as pregnancy progressed ($P<.05$; Table 5), but there were no differences preintervention or postintervention between groups. Time spent in moderate activity outside of the intervention was similar over time and between groups. Of note, women performing more than 20 minutes of moderate-intensity physical

Table 3. Maternal Health, Body Anthropometrics, and Cardiovascular Fitness Before and After a 14-Week Supervised Home-Based Exercise Intervention or Standard Care

	Preintervention		Postintervention	
Outcome	Control	Exercise	Control	Exercise
Resting heart rate (beats per min)*	80±8	78±9	85±9	84±10
Systolic BP (mm Hg)*	106±13	106±11	104±12	103±12
Diastolic BP (mm Hg)*	64±9	63±8	61±8	60±8
Total cholesterol (mmol/L)*	4.9±0.8	5.0±0.8	6.3±0.9	6.4±1.1
HDL cholesterol (mmol/L)*	1.7±0.3	1.7±0.3	1.8±0.3	1.8±0.3
LDL cholesterol (mmol/L)*	2.7±0.7	2.8±0.7	3.6±0.8	3.7±1.1
Triglyceride (mmol/L)*	1.4±0.6	1.2±0.5	2.2±0.8	2.2±0.8
Body mass (kg)*	69.0±16.2	70.5±15.4	75.7±16.0	76.9±14.9
Weight gain (kg) at 28 wk of gestation	—	—	6.7±2.6	6.4±2.1
BMI (kg/m^2)*	25.7±5.4	26.3±5.1	28.2±5.3	28.6±4.9
Sum of 4 girths (cm)*	157±20	159±19	160±19	161±18
Sum of 5 skinfolds (mm)*	113±40	122±47	122±43	131±45
Maternal fitness (power output [W] at 75% maximum heart rate)	109±21	112±24	107±19	120±29†
Maternal fitness (oxygen consumption [L/min] at 75% maximum heart rate)*	1.50±0.21	1.55±0.29	1.52±0.24	1.65±0.38

BP, blood pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein; BMI, body mass index.

Data are mean±standard deviation.

* Indicates significant main effect for time ($P<.01$).

† Indicates significant difference between groups postintervention ($P<.05$).

Table 4. Maternal Psychological Well-Being Assessed Through the Edinburgh Postnatal Depression Scale, Depression, Anxiety and Stress Scales, and Social Physique Anxiety Scale Before and After a 14-Week Supervised Home-Based Exercise Intervention or Standard Care

	Preintervention		Postintervention	
Outcome	Control	Exercise	Control	Exercise
EPDS	4 (1–6)	4 (2–6)	4 (2–7)	4 (1.5–6)
EPDS score 12 or greater	2 (2.3)	5 (5.9)	3 (3.5)	1 (1.2)
Missing	—	—	8 (9.4)	3 (3.5)
DASS-21	8 (4–11)	6 (4–12)	7 (4–11)	6 (2–10)*
SPAS total	28.5 (18–37)	32 (23–39.5)	26 (18–35)	29 (19–38)

EPDS, Edinburgh Postnatal Depression Scale; DASS-21, Depression, Anxiety and Stress Scales; SPAS, Social Physique Anxiety Scale.
Data are median (interquartile range) or n (%).
* Indicates significant difference between groups postintervention ($P<.05$).

activity (50th percentile) at study entry had a reduced incidence of GDM independent of their group allocation compared with women performing less than 20 minutes of daily moderate activity (29% compared with 49%; $P=.013$). The Habit Strength Questionnaire revealed an increase in the patterning of action and exercise automaticity from preintervention to postintervention in the exercise group but no change in women in the control group ($P<.05$; Table 5). There were no differences in obstetric or neonatal outcomes between groups (Table 6) except that there were more male neonates born to participants in the exercise group compared with women in the control group ($P<.01$).

DISCUSSION

A 14-week supervised, home-based exercise program started at 14 weeks of gestation did not reduce the recurrence of GDM nor did it alter the overall degree of glucose intolerance or insulin sensitivity. However, the intervention was associated with improvements in maternal cardiovascular fitness, increases in exercise automaticity, and a reduction in general psychological distress indicated by the 21-item Depression Anxiety

Table 5. Daily Nutritional Intake, Physical Activity, and Exercise Habit Strength Before and After a 14-Week Supervised, Home-Based Exercise Intervention or Standard Care

	Preintervention		Postintervention	
Outcome	Control	Exercise	Control	Exercise
Daily energy intake (kJ)	7,627±1,779	7,625±1,832	7,808±1,709	7,351±1,488
Carbohydrate intake (g)	198±50 (43)	192±51 (42)	201±58 (42)	188±48 (42)
Sugar intake (g)	79±29	80±34	87±35	77±27
Protein intake (g)	87±24 (20)	91±28 (20)	92±19 (20)	88±18 (21)
Fat intake (g)	70±23 (33)	72±22 (35)	72±22 (34)	69±19 (34)
Saturated fat (g)	27±9	30±9	29±10	28±9
Monounsaturated fat (g)	26±10	26±9	27±9	25±8
Dietary fibre (g)	23±7	22±10	24±7	21±6
Daily steps taken*	6,488±1,988	6,072±1,688	5,910±1,767	5,520±1,651
Sedentary time (min/d)*	1,179±81	1,182±78	1,187±91	1,195±82
Moderate activity (min/d)	24±14	21±14	24±15	23±16
Exercise habit strength				
Patterning of action*	20.07±5.65	19.93±5.38	20.23±5.·66	22.95±3.85†‡
Automaticity*	20.52±5.65	19.32±5.48	20.68±5.40	21.33±4.80‡
Stimulus–response bonds	15.97±4.73	16.49±4.98	15.95±4.44	16.62±4.87
Negative consequences for nonperformance	16.93±5.82	17.72±6.31	17.01±5.30	18.33±5.90

Data are mean±standard deviation or mean±standard deviation (%).
* Indicates significant main effect for time ($P<.01$).
† Indicates significant difference between groups postintervention ($P<.05$).
‡ Indicates significant difference within group preintervention to postintervention ($P<.05$).

Table 6. Obstetric and Neonatal Outcomes of Women Randomized to Standard Care or a Supervised Home-Based Exercise Program

Outcome	Control	Exercise	*P*
Onset of labor			
Spontaneous	28 (32.9)	25 (29.8)	.457
Induced or augmented	30 (35.3)	33 (39.3)	
No labor	27 (31.8)	26 (31.0)	
Mode of delivery			
Standard vaginal delivery	36 (42.4)	38 (45.2)	.984
Assisted vaginal delivery	12 (14.1)	11 (13.1)	
Elective cesarean	26 (30.6)	25 (29.8)	
Emergency cesarean	11 (12.9)	10 (11.9)	
Obstetric complications			
Preeclampsia	1 (1.2)	2 (2.4)	1.000
Postpartum hemorrhage	3 (3.5)	2 (2.4)	1.000
Sepsis requiring antibiotics	3 (3.5)	3 (3.5)	1.000
Neonate outcomes			
Preterm birth	4 (4.7)	3 (3.6)	1.000
Gestational age at delivery (wk)	38.5±1.3	38.9±21.1	.101
Apgar score less than 7 at 5 min	1 (1.2)	1 (1.2)	1.000
Special care nursery admission	14 (16.5)	8 (9.4)	.180
Birth weight (g)	3,419±518	3,552±469	.082
Head circumference (cm)	34.7±2.2	35.0±2.3	.436
Large for gestational age	10 (11.8)	12 (14.2)	.336
Small for gestational age	2 (2.4)	—	
Male neonate	35 (41.2)	54 (64.3)	.003

Data are n (%) or mean±standard deviation unless otherwise specified.
P values for categorical variables are χ^2 test or Fisher exact test in the case of low-frequency outcomes.

Stress Scale. Impaired glucose tolerance was identified before 14 weeks of gestation in 16% of women consenting to the study, suggesting that screening for GDM in women with a history of the condition may need to start earlier than is currently practiced.

The lack of effect of the intervention on the recurrence of GDM is surprising given the epidemiological data to support a reduction in GDM risk with increasing physical activity[3] together with experimental studies reporting benefits of regular exercise during pregnancy for glucose tolerance.[4] However, the few randomized controlled trials investigating the effect of exercise for GDM prevention have reported conflicting results, with some trials observing no effect of antenatal exercise (moderate-intensity aerobic, strength and flexibility exercises performed three times a week for 45–60 minutes) on the incidence of GDM,[5,7] whereas Cordero et al[6] reported reduced prevalence of GDM with a program of aerobic, strength, and flexibility exercises performed three times per week started from 10 to 14 weeks of gestation. The lack of benefit of our intervention for decreasing the recurrence of GDM was unlikely as a result of low compliance given the fully supervised home-based design. The exercise prescription was based on previous work in women with and without GDM[4,11,21]; however, it is possible that increasing the frequency of exercise may have altered the results, and the optimal duration and intensity of exercise for the prevention of GDM is not known. It is also unlikely that the lack of effect of exercise on GDM was the result of compensatory changes in daily nutritional intake or physical activity levels outside of the intervention given the lack of difference between groups, although it should be acknowledged that these measures were taken preintervention and postintervention only, and that self-reported food diaries are susceptible to underreporting, which is likely given the lower than expected energy intake seen here. It must also be noted that the exercise group gave birth to significantly more male neonates. This coincidental occurrence may have influenced the rate of GDM given that women carrying a male fetus may have an increased risk of GDM.[22]

The present intervention started at 14 weeks of gestation. Although this was initially considered a strength of the trial, it has recently been suggested that placental function and gene expression are programmed by the first trimester.[23] Accordingly, future research could focus on overcoming the challenges of recruiting earlier in pregnancy and even before conception. In support of this notion, women performing more than 20 minutes of moderate-intensity physical activity at study entry had a reduced incidence of GDM independent of their group allocation. Consideration of the baseline physical activity levels of our sample also highlights that the women studied here may not be representative of the general population of pregnant women at risk of GDM. At study entry, the present sample accumulated a mean of 24 minutes of daily moderate-intensity physical activity, which is higher than that reported in the general population of pregnant women in Australia.[24] Moreover, 57% of our sample lived in geographic areas of social advantage, 72% were under private obstetric care, and approximately 80% had body mass indexes less than 30 kg/m^2. These indicators of socioeconomic status may influence awareness and commitment to health.[9,25] In support of this notion, the GDM recurrence rate of 40% observed in our sample is lower than the expected recurrence rate based on our hospital data (55%). Indeed, volunteering for a 14-week exercise intervention itself may introduce self-selection bias, potentially suggesting a proactive approach to avoiding a second GDM diagnosis.

Despite a lack of effect of the exercise intervention on the recurrence or severity of GDM, the improvement in cardiovascular fitness is of great importance given the beneficial relationship between exercise during pregnancy and higher fitness and reduced cardiovascular risk factors later in life.[26] Meanwhile, the reduction in general psychological distress indicated by the 21-item Depression Anxiety Stress Scale in the exercise group is of interest given the adverse effects of maternal distress on development in utero.[27] Regardless of these benefits, there was no difference in obstetric and neonatal outcomes between groups, although the present study was not powered for these outcomes. The present intervention ceased at 28 weeks of gestation to coincide with assessment of the primary outcome measure; however, the effect of continuing an intervention of this nature until delivery remains to be determined.

In summary, supervised home-based exercise started after the first trimester of pregnancy does not reduce the recurrence of GDM or the degree of decline in glucose tolerance in women with a history of the condition at 28 weeks of gestation; however, it does benefit maternal fitness and psychological well-being. Future studies should seek to implement exercise interventions before conception, extend through to delivery, and focus on women with the lowest health, socioeconomic status, and baseline physical activity levels. Regardless of the lack of benefit observed here for the prevention of GDM, the benefits of regular exercise for the management of GDM after diagnosis are well-established.[11,21]

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REVIEW ARTICLE

Benefits of exercise in pregnancies with gestational diabetes

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ABSTRACT

A significant proportion of pregnancies are complicated by diabetes mellitus. Most of them concern women with gestational diabetes mellitus, while proportionally are presented with preexisting DM 1 and DM 2. Metabolic derangements of the diabetic syndrome are likely to generate serious complications for both the mother and the fetus with a significant impact on their later health. Undoubtedly, all appropriate interventions that will contribute to the smoothest and most uncomplicated course of pregnancy are considered essential. Healthy diet adjustments, glucose monitoring and an appropriate insulin regimen, if needed, are considered effective tools for a safe gestation. Courses with aerobic, anaerobic stretching and relaxation exercises are presented with significant benefits in the therapeutic struggle for the general public. Extended research has been conducted assessing the role of exercise incorporation in a diabetic pregnancy. As evidence would support based on recent literature, exercise is an important mean in the prevention of carbohydrate intolerance during gestation and even more facilitates a smoother management of a diabetic pregnancy. Thus, exercise poses an essential role for maternal and neonatal health.

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Introduction

Diabetes mellitus (DM) remains a disorder characterized by derangements primarily of carbohydrate metabolism, as well as of the fat and protein biological pathways. Hyperglycemia occurs either solely due to an insufficient insulin action in the target tissues or in a combination with an inadequate secretion of insulin [1]. Diabetes mellitus cases during pregnancy are referred to as preexisting diabetes mellitus or gestational diabetes [2]. Pregnancies of women with type 1 DM (insulin dependent) or type 2 DM (non-insulin dependent) constitute the preexisting diabetes cases, while Gestational Diabetes Mellitus (GDM) is hyperglycemia detected during routine testing in pregnancy [1]. The oral glucose tolerance test (OGTT) either with the consumption of a 75 mg or 100 mg glucose solution, which is performed between the 24th and 28th gestational week in all pregnant mothers, is recommended for the diagnosis of GDM [3]. Placenta plays a major role in the pathogenesis of gestational diabetes, producing hormones that contribute in the carbohydrate dysregulation [4]. However, this unfriendly hormonal environment during gestation does not necessarily predispose to the development of GDM in all pregnant women. Undoubtedly, the presence of certain risk factors, namely increased body mass index, age, familial inheritance and race, represent a major burden that may trigger the progression to GDM [5–8]. A preexisting DM or GDM represents a serious condition if proper care is not given to both the mother and the fetus [9]. According to the International Diabetes Federation, the incidence of hyperglycemia in pregnancy worldwide is calculated at 16.2% and it is estimated that 86.4% of these cases represent mothers with GDM [5]. Experts point out that pregnancy in women with diabetes should be well programed and particular emphasis should be given to a strict glycemic control prior to conception with recommended HbA1c levels much lower than 6.5% for the significant reduction of possible congenital abnormalities [10]. The means by which the desired

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glycemic control can be achieved, include proper nutrition, medication and exercise.

Gestation and exercise recommendation

There is considerable evidence that exercise during a healthy pregnancy has positive effects on the mother and the fetus, as well as possibly in the forthcoming childhood. All major Scientific Societies encourage mothers to adopt an exercise regiment during pregnancy if not contraindicated. The American College of Obstetricians and Gynecologists (ACOG) reaffirmed this year that "physical activity in pregnancy has been shown to benefit most women although some modification to exercise routines may be necessary because of normal anatomic and physiologic changes and fetal requirements. According to the Canadian Guidelines for Physical Activity in Pregnancy, all women without contraindications should be physically active throughout their pregnancy [11]. It seems that benefits are more intense when the exercise program occurs during the whole pregnancy and includes a combination of aerobic, toning, resistance, strength, and flexibility exercises [12]. Prior to the recommendation of any form of exercise it is important to take into account the pregnant woman's physical activity history as well as her cardiopulmonary capacity and endurance. Women with reduced physical activity before pregnancy are advised to start slowly and gradually increase their activity. They may start with just 5 min a day by adding 5 min each week until they can be exercised for 30 min a day. Women with a high physical activity level before pregnancy may continue to follow their regular exercise routines with the approval of their healthcare professional [13]. An exercise program that leads to an eventual goal of moderate-intensity exercise for at least 20–30 min per day on most or all days of the week should be developed with the patient and adjusted as medically indicated [12]. Physical activity, although encouraged daily, is recommended to be performed at least three days a week [11]. The guidelines from the Centers for Disease Control and Prevention are similar and recommend that pregnant women should have at least 150 min of moderate intensity (heart rate increases and sweating begins) aerobic exercise (involving large body muscles) each week. In particular, aerobic exercise is preferable to be performed 3–5 times a week. Aerobic exercise favors weight control [14] maintenance of physical conditioning, and it also seems to reduce risks of gestational diabetes mellitus (GDM) [15] in specific groups. Aerobic exercise can be of medium as well as high intensity for women who have been exercising long before pregnancy. The time may range from 150 min/week of moderate intensity exercise or 75 min/week of intense aerobic exercise, distributed over different days. The 150 min can be divided into 30 min exercises 5 days a week or into smaller 10 min exercises each day. As for light- to moderate intensity resistance exercises, they may improve muscle resistance and flexibility with no complications to pregnancy [16,17]. Regarding the participation of the pregnant woman in resistance training programs (free weights, machines or body weight) it is preferable to be performed 2–3 times a week on nonconsecutive days. The intensity of the exercise should be such that pregnant women can perform 1–2 sets of 8–10 repetitions for the big muscle groups when they are beginners and 2–3 sets of 10–12 repetitions when they are advanced [18]. Although the highest intensity level of safe exercise has not been documented, according to ACOG, women who regularly exercised before pregnancy and who have simple, healthy pregnancies may participate in high-intensity exercise programs such as jogging or aerobics without adverse effects. Absolute contraindications to aerobic exercise during pregnancy consist of serious conditions, such as disordered heart disease, restrictive lung disease, incompetent cervix or cerclage, multiple gestation at risk of premature labor, persistent bleeding, placenta previa, premature labor, ruptured membranes preeclampsia and severe anemia. Thus, a thorough clinical evaluation should be conducted before participation in an increased physical activity program to ensure that the expecting mother does not have absolute or relative medical reasons to avoid exercise. Healthy, trained pregnant women and their fetuses can tolerate somewhat higher exercise intensity. Dehydration, hypoglycemia and exercise hyperthermia following a prolonged strenuous exercise program are of special concern for the fetus. Finally, although physical activity in pregnancy has been associated with a small increase in uterine contractions, we are lacking evidence that it may cause preterm labor and delivery [19]. Despite the perceived risk to the vulnerable fetus while exercise turns exhaustive through competition for oxygen and substrates, literature supports the fact that moderate intensity exercise can modify the development of excessive gestational weight gain, may prevent the development of gestational diabetes or preeclapsia, enhances psychologic well-being and reduces the need for cesarean sections [20]. Moreover, exercise incorporation during pregnancy has been shown to provide long-term health benefits to the offspring in their adulthood and to future generations, modifying various epigenetic mechanisms.

Exercise and GDM prevention

Exercise has proven to be a powerful means of preventing the onset of diabetes even during pregnancy. Research results describe an inverse relationship between vigorous activity, higher weekly levels of physical activity, and GDM appearance. In a large study conducted to investigate the association between physical activity and sedentary lifestyle with the risk of GDM development, 21.765 pregnant women were screened, of whom 1428 had GDM. As recorded, women who adopted a sedentary lifestyle had at least twice the rate of GDM development (RR = 2.30) [15]. Results of another randomized controlled trial involving pregnant women at high risk of GDM development, revealed the positive effect of a 25 min, three to four times a week, walking program on the capillary blood glucose levels of pregnant women [15]. In addition, as presented by a meta-analysis of randomized controlled trials, structured moderate exercise programs during pregnancy appear to reduce excessive increase of maternal weight, one of the most important risk factors for developing GDM, thereby reducing the rates of its occurrence [21]. Furthermore, evidence-based data suggest that moderate-intensity physical activity reduces the risk of excessive weight gain during pregnancy, which is a risk factor for both the mother and the fetus, linked to the onset of GDM and serious complications [22].

In fact, participation in exercise programs even before pregnancy seems particularly effective for the prevention of GDM, hypertension, and preeclampsia. More specifically, moderate-intensity exercise programs of at least 600 MET-min/week (e.g. 140 min of walking, water aerobics, cycling or resistance training) was shown to contribute to a 25% decrease in the development of GDM, hypertension and preeclampsia. In addition, sufficient information has been recorded in favor of an inverse relationship between physical activity and the risk of pregnancy hypertension and preeclampsia [23]. As the occurrence of GDM in a woman is directly related with the subsequent appearance of DM type 2, the beneficial role of exercising in combination with a healthy diet in diabetic pregnancy is of particularly importance [24].

Exercise and glycemic control

The benefits of exercise are unquestionable due to its recognized ability to improve insulin sensitivity and muscle glucose uptake [25]. In particular, exercise facilitates an increased pace of intracellular glucose flux into muscle cells, even when insulin levels are impaired. Muscle contractions during exercise stimulate the movement of GLUT4 glucose transporters from the intracellular compartment to the surface of the muscle cell by activating AMP kinase, increasing NO – nitric oxide and increasing the free oxygen radicals (ROS – reactive oxygen species). There is also evidence that exercise may increase both the activity and the number of GLUT4s by stimulating their gene expression. The action of insulin is quite similar as it also stimulates the movement of GLUT4 glucose transporters to the surface of muscle cells. However, the transfer of the insulin signal into the muscle cells follows a different metabolic pathway, at least in its initial stages, than that of the muscle contraction signal. There is, of course, one common endpoint in the two metabolic pathways involved in the activation of two intracellular proteins, TBC1D1/TBC1D4. Therefore, exercise increases the uptake of glucose by the muscle cell mainly by moving GLUT4 through a mechanism different from the one of insulin in the early stages while at the same time because there is a common point between the two metabolic pathways, exercise also increases the sensitivity of muscle cells in the action of insulin [26]. Exercise has, therefore, a beneficial effect in reducing elevated HbA1c levels and insulin needs in DM type 2 patients and meta-analysis data describe a linear correlation between exercise intensity and glycemic control [27]. Moreover, exercise has a positive effect on glycemic control in pregnant women with diabetes mellitus. Results of a randomized clinical trial showed that a structured exercise program that included aerobic and resistance exercises had a beneficial effect on postprandial glucose levels of pregnant women. Participants followed the exercise program which consisted of 50–55 min sessions twice a week, from the time of the diagnosis of diabetes until childbirth [28]. Compared to the lack of exercise, the combination of aerobic and resistance exercises is thought to help improve glycemic control for women with gestational diabetes. In a supervised and personalized exercise program twice a week for at least six weeks, it appeared to result in lower postprandial glucose levels (−0.64 mmol/l) to the study population. The program consisted of 20 min of aerobic exercise at 60–75% of maximum heart rate, six resistance exercises using elastic straps or body weight in a set of 10–15 repetitions, stretching exercises and pelvic floor exercises. In addition, women in the exercise group were advised to complete 30 min of vigorous walking daily [29]. Statistical results of many more studies reveal that exercise, as a supplement to routine care, significantly improves postprandial glycemic control, reducing fasting blood glucose for pregnant women with GDM and may even delay the need for insulin use [30,31]. Undoubtedly, regular and scheduled exercise remains of vital importance for the appropriate glucose control for pregnant women with GDM and it is proven to lead to improved pregnancy outcomes with fewer negative side effects [18]. Exercise as an effective strategy to improve glucose homeostasis can lower blood glucose levels and improve insulin sensitivity during pregnancy [30].

Exercise and long-term health for mother and neonate

As regular exercise decreases weight gain in pregnant women who are naturally active during pregnancy there is a lower risk of maintaining the excessive weight after childbirth, while finally reducing the rates of maternal obesity in the future. Furthermore, regular exercise during pregnancy has been associated with a lower chance of giving birth to a baby with macrosomia [32,33]. Babies showed improved insulin sensitivity, decreased body fat with increased lean mass, augmented autonomic nervous system development, and improved vascular endothelial and smooth muscle function [32,33]. In a study regarding the relationship between maternal physical activity and infant birth weight in Canada, it was observed that an increase of 1 MET/hour/week in the exercise program in the first trimester of a pregnancy was associated with a reduction of 2.5 g. in infant weight [34]. In addition, women with GDM with physical activity levels above 7.5 METs/week, showed a 47% lower risk in developing postpartum diabetes [35].

Blaize et al. suggest that maternal exercise during pregnancy improves offspring cardiovascular health while reducing offspring risk for type 2 diabetes and cardiovascular disease later in life [36]. Therefore, a healthy diet during pregnancy combined with an active lifestyle are important factors for preventing long-term risk of obesity for two generations [37]. In a study with 5,125 children assessing maternal lifestyle characteristics during pregnancy and the risk of obesity in the offspring, authors found that the high weight levels of children at the age of 8 years was associated with pregnancy maternal habits [38]. Researchers suggest evidence that ample maternal physical activity in conjunction with stress reduction and proper nutrition during pregnancy and the childbearing period could have an impact on early development of the CNS and immune system and contribute to the prevention of neurodevelopmental and psychiatric disorders in offspring [39].

Exercise and epigenetics

In addition to the general health benefits and the crucial role in the management of diabetes mellitus, exercise's effect to the genome has generated particular interest lately. As it turns out, our genes are not static as once believed, but are dynamic units whose expression adapts to the conditions of the environment. The field of epigenetic studies illustrates that these gene adaptations to environment are reversible changes in gene function. It is then clear that diabetes and its complications develop not only as a combination of variants of the DNA sequence but with the imprinting of the environmental effects on our genetic material that leads to changes in the cellular phenotype [40]. There is a rapidly expanding literature to support the impact of *in utero* environment on adult health and the health of future generations [41]. The metabolic dysfunction crosses generations by epigenetic mechanisms even more significantly. Diet and exercise during pregnancy act in combination to direct normal epigenetic homeostasis.

A study examined if maternal exercise could reverse the detrimental effects of maternal high-fat feeding on offspring metabolism of female mice. The authors concluded that maternal exercise negates the detrimental effects of a maternal high-fat diet on glucose tolerance and hepatocyte glucose metabolism in female offspring [42]. Another study in female mice investigated whether maternal exercise during pregnancy could protect offspring from adverse effects of a maternal high-fat diet with a focus on the metabolic outcomes and epigenetic regulation of the metabolic master regulator, peroxisome proliferator-activated receptor γ coactivator-1α (Pgc-1α). Investigators found that maternal exercise prevented maternal high fat diet-induced Pgc-1α hypermethylation and enhanced Pgc-1α and its target gene expression with amelioration of age-associated metabolic dysfunction at 9 months of age in the offspring [43]. Of particular interest are the results of a study conducted at East Carolina University in Greenville, N.C, indicating that exercise during pregnancy can positively influence developing systems allowing for improved neuromotor function in infants who are more adept at movement with a reduced risk for future childhood obesity [33]. In addition, adolescent mice born to mothers that had exercised during pregnancy were about 50 percent more active than genetically identical adult mice whose mothers had not used a running wheel before and during pregnancy implying that maternal exercise could influence fetal brain development [44]. Furthermore, other studies have revealed that maternal swimming during pregnancy enhances short-term memory and neurogenesis in the hippocampus of rat pups [45]. Offspring of women who continued vigorous exercise during pregnancy, when evaluated 5 years after birth, concerning five neurodevelopment characteristics – general intelligence, oral language skills, academic readiness skills, motor performance and perceptual motor skills – showed higher scores in general intelligence and oral language skills than the control group of children born in the same period of time [46].

Conclusions

In conclusion, combined with dietary interventions and medication if needed, exercise as an essential means of preventing and managing diabetes in a pregnancy, proves to be necessary for the smooth course and better outcomes of pregnancy, ensuring the precious health of the mother and the newborn that will come into the world. In addition, there are increasing numbers of studies revealing the extremely beneficial role of exercise in humans, as it can prevent and even reverse the course to disease development or simply have an effect to body changes that may have been "written" in our DNA [47].

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Effect of antenatal exercise on mode of delivery in gestational diabetic females: a single-blind randomized controlled trial

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Abstract

Introduction. Gestational diabetes mellitus (GDM) is common in pregnancy. Maternal consequences might include an increased rate of caesarean delivery. This study was conducted to determine the effect of an exercise program on the mode of delivery in gestational diabetic females.

Methods. A prospective, randomized, single-blind, pre-post-test, controlled trial was performed. Overall, 60 pregnant females with GDM were included, at their 20–24 weeks of gestation, aged 25–35 years, with body mass index not exceeding 40 kg/m^2. The participants were randomly assigned into 2 equal groups: group A, undergoing an exercise program with a moderately restricted diet and insulin therapy, and group B (control group), receiving solely the same diet protocol with insulin therapy.

Results. The chi-square test revealed significant differences between the groups in the mode of delivery ($p < 0.05$), with a significant decrease in caesarean deliveries in group A. Group A showed a statistically significant difference in neonates' Apgar scores at the 1st and 5th minute of life ($p < 0.05$) compared with the participants in group B.

Conclusions. It can be concluded that antenatal exercises can be considered effective in decreasing labour complications and shifting the mode of delivery towards normal, complication-free delivery in females with GDM and their offspring.

Key words: antenatal exercises, gestational diabetes, neonates, pregnancy, Apgar score, physical activity

Introduction

Diabetes mellitus is one of the most common medical complications in pregnancy. Gestational diabetes mellitus (GDM) is defined as carbohydrate intolerance of variable severity with onset or first recognition during pregnancy [1, 2]. GDM affects 3–9% of pregnancies, depending on the population studied. It is especially common during the last 3 months of pregnancy [3]. It is associated with adverse outcomes not only for the mother, but also for the child, whether as a foetus, a neonate, a child, or an adult. Maternal consequences include an increased rate of operative and caesarean delivery, hypertensive disorders during pregnancy, and future risk for type 2 diabetes mellitus, as well as other aspects of metabolic syndrome, such as obesity, cardiovascular morbidities, and recurrent GDM [4, 5]. Also, there are maternal implications secondary to a delivery of a macrosomic foetus, such as an increased rate of caesarean delivery, postpartum haemorrhage, birth trauma, and shoulder dystocia [6–8]. It is widely assumed that caesarean delivery results in higher rates of maternal morbidity and mortality compared with vaginal delivery. Additional evidence exists for a 2–4-fold greater risk of maternal death in women who delivered by caesarean delivery compared with vaginal delivery [9]. In the foetus or neonate, the disorder is associated with higher rates of perinatal mortality, macrosomia, birth trauma, hyperbilirubinemia, and neonatal hypoglycaemia [10, 11]. In general, screening and diagnostic tests are performed between 24 and 28 weeks because it is at this point in gestation that the diabetogenic effect of pregnancy is usually manifested [12]. GDM is treated with a diabetic diet, exercise, and possibly insulin injections [3]. Researches have shown that the most physically active women have the lowest prevalence of GDM [13]. The American Diabetes Association and the International Federation of Gynecology and Obstetrics both recommended that lifestyle management including physical activity should be the first choice in the treatment of GDM [14]. Some authors concluded a 1/3 reduction in comorbidities associated with GDM, particularly the risk of acute or elective caesarean delivery [15]. Others reported a reduction in complications associated with pregnancy in GDM women [16]. Despite these conclusions and recommendations, relatively few are studies examining the effect of regular exercise with dietary intervention in the management of GDM and/or in preventing complications associated with GDM. Therefore, the aim of the current study was to determine the effect of a selected exercise program on the delivery mode in GDM women.

Subjects and methods

Design

The study was designed as a controlled trial that compared 2 groups: group A included participants who performed the

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exercise program starting from 24 weeks of gestation till the date of delivery, with a moderately restricted diet, typically with 2000–2500 kcal, and insulin therapy [17], while group B involved control participants, who received solely the same diet as group A with insulin therapy. Anonymity was assured through coding of all data. The women were randomly assigned into 2 groups by a blinded and an independent research assistant, who opened sealed envelopes that contained a computer-generated randomization card. No subjects dropped out of the study after randomization.

Sampling

During the 2-year recruitment period from May 2015 to May 2017, 60 pregnant females diagnosed with GDM at their 20–24 weeks of gestation were recruited from the Outpatient Clinic of Bab El-Sharia Hospital, Cairo, Egypt. Their age ranged between 25 and 35 years and their body mass index (BMI) did not exceed 40 kg/m^2. Females diagnosed with vascular complications, unstable diabetes mellitus, peripheral neuropathy, autonomic dysfunction, nephropathy or retinopathy, twins, placenta praevia, foetal anomalies, intrauterine growth retardation, as well as with a previous history of preterm labour, repeated abortions, antepartum haemorrhage, or preeclampsia were excluded from the study.

Procedure

The participants were randomly assigned into 2 groups equal in number; each group included 30 pregnant women on the basis of a block-style randomization scheme [18]. Additional screening for specific inclusion and exclusion criteria and demographic data was taken, including age and BMI. A full assessment of history was performed for each patient in both groups prior to the start of the study in accordance with the items of the data recording sheet. The 3-hour oral glucose tolerance test was conducted for both groups before starting the treatment and at 37 weeks of gestation.

All exercise sessions were held by the same physiotherapist. The exercise program parameters were in concordance with the American College of Obstetricians and Gynecologists (ACOG) guidelines for exercise during pregnancy for sedentary women and with the FITT principle (frequency, intensity, time, and type). The exercise undertaken was characterized by a frequency of minimum 3 times per week, intensity set at moderately hard perceived exertion, time of 60 minutes per day, and type of low impact. These exercise guidelines were utilized for both aerobic and strength exercises for 12 weeks [19]. Moderate-intensity physical activities referred to activities that required moderate physical effort, which made the pregnant women's breath slightly harder and their heart beat a little faster than normal.

Group A participants performed the exercise 3–4 times per week, starting the active phase of aerobic training with 15 minutes at a target heart rate intensity and increasing the time gradually to a maximum of 30 minutes per exercise session. Each aerobic activity was preceded by a 10–15-minute warm-up and followed by a 10–15-minute cool-down. The exercise intensity was monitored with the use of target heart rate zones, the Borg scale (rating of perceived exertion), or the 'talk test' [20]. Heart rate zones provided in the ACOG guideline corresponded to moderate-intensity exercise (i.e. 60–80% of maximal aerobic capacity, VO_2max). The type of aerobic exercise was walking on treadmill to train large muscle groups. Next, circuit resistance training (CRT) exercises were performed with 2 circuits, each of 10 repetitions (with a 2-minute rest between each circuit), with the use of the green colour band (green colour: 1.36 kg, during the first 4 weeks of the training program) and then the blue colour band (blue colour: 1.8 kg, until the end of 37 weeks gestation), with elastic resistance performed at 100% elongation for 15 minutes. The main muscle groups exercised were chest, deltoid, quadriceps, and calf muscles. CRT was performed from a sitting position; one end of the band was fixed beneath the feet, held for 5 seconds, and then released. The exercises included chest push, shoulder flexion, shoulder abduction, knee extension, and ankle planter flexion exercise [21]. The subjects were taught to monitor their own heart rate during exercise to ensure that it did not rise above 140 beats/min. The pregnant women were advised to immediately stop exercising if they exhibited symptoms such as dizziness, dyspnoea, amniotic fluid leaking, or vaginal bleeding [22]. Moreover, group A participants wore a loose-fitting clothing and kept hydrated while exercising in an environment with appropriate temperature and humidity [23]. All exercise sessions were recorded in a log book.

Outcome measures

Mode of delivery

It involved normal vaginal delivery, instrumental vaginal delivery that required the use of special devices such as forceps or a vacuum extractor to deliver the foetus vaginally, and caesarean section.

Apgar score

The Apgar score was applied to assess the neonates' condition during the critical 1st and 5th minutes of life in both groups, A and B. The Apgar score was determined by evaluating the newborn on 5 simple criteria, referred to as appearance, pulse, grimace, activity, and respiration to aid mnemonic learning. The resulting Apgar score ranged from 0 to 10. Scores below 3 were generally considered critically low, 4–6 as fairly low, and higher than 7 as generally normal [24].

Data analysis

All statistical procedures were performed with the Statistical Package for the Social Sciences (SPSS) software, version 23 for Windows. The test involved two independent variables. The first one was the tested group, a between-subject factor which had 2 levels (group A receiving exercise, diet, and insulin, while group B only receiving diet and insulin therapy). The second variable was the neonates' Apgar score (measuring periods), a within-subject factor which had 2 levels (after 1 minute and after 5 minutes). Additionally, the test involved one dependent variable: the neonates' Apgar score between groups. Preliminary assumption checking revealed that data were normally distributed, as assessed by a normal Q-Q plot. The examination of studentized residuals for values greater than ± 3 proved that there were no outliers. Homogeneity of variances ($p > 0.05$) and covariances ($p > 0.05$) was observed in Levene's test of homogeneity of variances and Box's M test, respectively. All these findings allowed the researchers to conduct parametric analysis. So, 2 × 2 mixed design ANOVA was used to compare the tested variables of interest in different tested groups and measuring periods. The alpha level was set at 0.05.

Ethical approval

The research related to human use has been complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the ethical committee at the Physical Therapy Department of Bab El-Sharia University Hospital and by the institutional review board at the Faculty of Physical Therapy, Cairo University.

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

There were no statistically significant differences ($p > 0.05$) between the subjects in both groups concerning age, BMI, or gestational age. However, the chi-square test revealed significant differences between the groups in the mode of delivery distribution ($p < 0.05$) (Table 1).

The statistical analysis with mixed design ANOVA analysed 60 patients assigned into 2 equal groups. It revealed a significant within-subject effect ($F = 306.82$, $p = 0.0001$) and between-subject effect ($F = 50.129$, $p = 0.0001$). However, there was no significant treatment*time effect ($F = 0.58$, $p = 0.449$). Table 2 presents the descriptive statistics (mean ± SD) and multiple pairwise comparison tests (post-hoc tests) of the detective variable. In the same context regarding the within-subject effect, the multiple pairwise comparison tests revealed that there was a significant increase ($p < 0.05$) in the Apgar score after 5 minutes compared with that after 1 minute in the neonates of both groups. As for the between-subject effects, multiple pairwise comparisons showed a significant increase in favour of group A as compared with group B at 1 minute and 5 minutes ($p < 0.05$).

Discussion

A significant number of pregnant women are affected by GDM every year. Its growing prevalence and established relationship to numerous complications and disorders during and after pregnancy demand identification of factors that can prevent the incidence and influence its course. Therefore, this study was conducted to determine the effect of a specialized antenatal exercise program on the mode of delivery and neonatal condition among 60 females suffering from GDM.

The results revealed a statistically significant difference in the mode of delivery distribution, with a significant decrease in the number of caesarean deliveries in the study group compared with the control group. Also, there was a statistically significant increase in the neonates' Apgar scores at the critical 1st and 5th minutes after delivery, which favoured the neo-

Table 1. Demographic characteristics of both groups

	Group A	Group B	Comparison	
	Mean ± *SD*	Mean ± *SD*	*t*-value	*p*-value
Age (years)	28.23 ± 2.87	29 ± 3.07	0.112	0.326
BMI (kg/m²)	33.01 ± 1.73	33.83 ± 1.88	0.54	0.085
Gestational age (weeks)	21.33 ± 1.49	21.33 ± 1.49	0.00	1.00

Mode of delivery distribution, *n* (%)	Group A	Group B	X^2	*p*-value	S
Caesarean delivery	5 (16.6%)	19 (63.4%)	14.105	0.001	NS
Normal delivery	19 (63.4%)	7 (23.4%)			
Operative vaginal delivery	6 (20%)	4 (13.4%)			

SD – standard deviation, BMI – body mass index, S – significance, NS – non-significant

Table 2. Descriptive statistics and 2 × 2 mixed design ANOVA for Apgar score at different measuring periods in both groups

Apgar score	Group A (Mean ± *SD*)	Group B	Mean difference	95% CI
At 1st minute	7.23 ± 0.43	6.43 ± 0.5	0.8	(0.558–1.042)
At 5th minute	8.7 ± 0.46	8.03 ± 0.68	0.66	(0.369–0.965)
Mean difference	–1.46	–1.6		
95% CI	(from –1.714 to –1.219)	(from –1.848 to –1.352)		
Multiple pairwise comparisons between Apgar score values after 1 minute and after 5 minutes				
1st minute vs. 5th minute	Group A		Group B	
p-value	0.0001*		0.0001*	
Multiple pairwise comparison tests (post-hoc tests) for the Apgar score between both groups at different measuring periods				
	At 1st minute		At 5th minute	
Group A vs. group B	0.0001*		0.0001*	

* significant at alpha level < 0.05
SD – standard deviation, 95% CI – 95% confidence interval

nates of group A. These observations are in agreement with other reports stating that physical exercise is highly recommended to the broad population before and during pregnancy, and to women suffering from or at risk for GDM [25]. Women suffering from diabetes during pregnancy are more liable to develop hypertensive disorders and pre-eclampsia and have a higher risk of an induction of labour or caesarean section delivery [26]. Our findings are also supported by those who presented a 1/3 reduction in the risk of undergoing acute or elective caesarean delivery among women who developed GDM and conformed to a regular moderate-intensity antenatal exercise program [15].

GDM is associated with an elevated risk for delivering a large-for-gestational-age or macrosomic infant. As a consequence of their size, the offspring of GDM mothers are more likely to suffer from significant birth trauma, such as shoulder dystocia, perinatal asphyxia, bone fractures, and nerve palsy. High foetal birth weight has also been claimed to impose additional risks of caesarean section and cephalopelvic disproportion [27].

Our findings are also supported by Lawani et al. [28], who reported a strong positive effect of adding aerobic and resistance antenatal exercises to the classical antenatal exercise programs on health behaviours and a vaginal low-risk birth in females diagnosed with GDM. Antenatal exercise is a non-pharmacological childbirth preparation method. It is considered both a physical and a psychological training method in accordance with the natural mechanisms of childbirth. Antenatal exercises led to a lower rate of prolonged first stage of labour compared with women who received no training and also resulted in fewer delivery complications as poor muscle tone may cause incontinence, unusual pain during birth, prolonged first and second stages of labour. Regular exercise in the third trimester was associated with lower incidence of high foetal birth weight [29].

However, the results of our study are not in line with several others reporting no effects of exercise or lifestyle (combining diet and exercise) interventions during pregnancy on Apgar score or head circumference [30–32]. In a randomized controlled trial of 105 women, higher mean Apgar scores were observed at the 1st minute, but not at the 5th minute, among newborns of women allocated to training [30]. This was observed in a per-protocol analysis and not in an intention-to-treat analysis, and the Apgar score at the 5th minute is considered a better sign of newborn wellbeing than that at the 1st minute [33, 34].

The results of our study provide grounds for provision of advice as well as organizing exercise training groups for females diagnosed with GDM and emphasizing the importance of a healthy diet and being physically active to gain the recommended weight during pregnancy and after giving birth and to prevent pregnancy and delivery complications in resource-limited countries.

Limitations

Despite the design of the present study (a randomized controlled clinical trial), the small sample size recruited could be its potential limitation. On the basis of sample size estimation with the power of the study 1–B = 80% to detect the effect size of d = 0.5 with a significance level of < 0.05, 50 participants were needed for each group. At present, it is not possible to study the effect of each antenatal exercise on common risks associated with GDM.

Conclusions

It can be concluded that maintaining a physically active lifestyle throughout pregnancy protects patients against GDM complications. Many scientific and professional reports stress the importance of exercise as an adjunct therapy for GDM women. Antenatal exercises are proven to be effective in decreasing labour complications and shifting the mode of delivery towards normal, complication-free delivery in females diagnosed with GDM and their offspring.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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