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**Artículo Original**

# Cardiometabolic risk profile in relation to the practice of healthy habits in a sample of Spanish workers

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**Abstract: Cardiometabolic risk profile in relation to the practice of healthy habits in a sample of Spanish workers. Introduction:** Insulin resistance is a pathological entity that can lead to alterations in lipid metabolism and can increase cardiovascular risk. **Objective.** The aim of this study was to assess the influence of different sociodemographic variables such as age, sex and social class and healthy habits such as smoking, physical activity and adherence to the Mediterranean diet on the cardiometabolic profile of Spanish workers. **Material and methods.** A descriptive, cross-sectional study was carried out in 1457 Spanish workers in an attempt to evaluate the effect of healthy habits (physical exercise determined with the IPAQ questionnaire, Mediterranean diet and tobacco consumption) and sociodemographic variables (age, sex and social class) on the values of different insulin resistance scales. **Results.** The progressive increase in the level of physical activity and high adherence to the Mediterranean diet achieved an improvement in the mean values and in the prevalence of elevated values in all the insulin resistance scales analyzed in this study. Age over 50 years and belonging to the least favored social classes (social classes II-III) were the variables that increased the risk of presenting insulin resistance. Male sex also increased the risk of presenting insulin resistance. **Conclusions.** The different healthy habits such as vigorous physical exercise and high adherence to the Mediterranean diet improve the values of the different scales that assess insulin resistance. **Arch Latinoam Nutr 2021; 71(4): 261-269.**

**Keywords:** Mediterranean diet, physical activity, insulin resistance.

**Resumen: Perfil de riesgo cardiometabólico en relación a la práctica de hábitos saludables en una muestra de trabajadores españoles. Introducción:** La resistencia a la insulina es una entidad patológica que puede provocar alteraciones en el metabolismo de los lípidos y puede aumentar el riesgo cardiovascular. **Objetivo.** En este trabajo se pretende valorar la influencia de diferentes variables sociodemográficas como la edad, el sexo y la clase social y hábitos saludables como el consumo de tabaco, la actividad física y la adherencia a la dieta mediterránea en el perfil cardiometabólico de trabajadores españoles. **Material y métodos**. Se realizó un estudio descriptivo y transversal en 1457 trabajadores españoles intentando evaluar el efecto de los hábitos saludables (ejercicio físico determinado con el cuestionario IPAQ, dieta mediterránea y consumo de tabaco) y las variables sociodemográficas (edad, sexo y clase social) sobre los valores de diferentes escalas de resistencia a la insulina. **Resultados.** El aumento progresivo del nivel de actividad física y la alta adherencia a la dieta mediterránea consiguieron una mejoría en los valores medios y en la prevalencia de los valores elevados en todas las escalas de resistencia a la insulina analizadas en este estudio. La edad por encima de los 50 años y la pertenencia a las clases sociales menos favorecidas (clases sociales II-III) fueron las variables que aumentaron el riesgo de presentar resistencia a la insulina. El sexo masculino también incrementó el riesgo de presentar resistencia a la insulina. **Conclusiones.** Los diferentes hábitos saludables como el ejercicio físico vigoroso y la alta adherencia a la dieta mediterránea mejoran los valores de las diferentes escalas que valoran resistencia a la insulina.**Arch Latinoam Nutr 2021; 71(4): 261-269.**

**Palabras clave:** dieta mediterránea, actividad física, resistencia a la insulina.

## Introduction

Insulin resistance (IR) is characterized by a decrease in the capacity of insulin to perform its normal physiological functions. It usually appears before type 2 diabetes mellitus or metabolic syndrome and is associated with overweight and obesity (1). Other factors also associated

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with it are age, gestation, and polycystic ovary – where IR also plays an important role (2).

At first, IR creates compensatory mechanisms so that, for a time, increased insulin secretion manages to keep blood glucose levels under control (3). This period, which we could call pre-diabetic, is difficult to detect clinically, because blood glucose levels are normal; however, this situation progressively worsens when pancreatic failure appears, that is, when the beta cells of the pancreas are not only incapable of maintaining insulin hypersecretion, but also begin to deteriorate, thereby decreasing insulin secretion. In this situation most cases of type 2 diabetes mellitus and metabolic syndrome are diagnosed. It is also known that genetic (4) and oxidative stress (5) mechanisms are involved in the genesis of IR.

Insulin not only regulates glucose homeostasis, but also plays an important role in lipid and protein metabolism, which in turn can be altered in states of insulin resistance (6).

The aim of this study was to determine how healthy habits (physical activity, Mediterranean diet, and tobacco consumption) and sociodemographic variables (age, sex, and social class) affect cardiometabolic profile.

## Material and methods

A retrospective, cross-sectional study was performed in 1584 Spanish workers during the period from January 2017 to December 2017. Of these, 127 were excluded (69 for not agreeing to participate and 58 for being under 18 years of age) remaining 1457 workers who were the ones finally included in the study; 718 of these were women (mean age 43.30 years) and 739 men (mean age 46.02 years). The workers were selected from among those who attended periodic occupational medical check-ups.

*Inclusion criteria*

- Aged between 18 and 67 years.
- Being an active worker.
- Belonging to one of the companies collaborating in the study.
- Accepting to participate in the study.

Anthropometric measurements of height and weight, both clinical and analytical, were performed by the health personnel of the different occupational health units participating in the study, after standardizing the measurement techniques. These measurements are performed according to ISAK criteria (7).

To measure weight, expressed in kilograms, and height, which is expressed in m, a scale with a measuring rod was used: SECA brand 700 with a SECA 220 telescopic measuring rod attached.

Abdominal waist circumference was measured with a SECA model measuring tape with the person in a standing position, feet together, trunk erect, and abdomen relaxed. The tape was placed parallel to the floor at the level of the last floating rib. Hip circumference is measured at the level of the femoral trochanters coinciding with the point where the buttocks reach the greatest development. Waist to height ratio and waist to hip ratio indices were obtained by dividing the waist circumference by height and hip circumference, respectively. The cut-off point for the former was 0.50 and for the latter 0.85 for women and 0.95 for men (8).

Blood pressure was measured lying down with a calibrated OMRON M3 automatic sphygmomanometer after 10 minutes of rest. Three measurements were taken at one-minute intervals and the mean of the three was used. Blood tests were obtained by peripheral venipuncture after a 12-hour fast. Samples were sent to reference laboratories and processed within 48-72 hours. Automated enzymatic methods were used for blood glucose, total cholesterol, and triglycerides. Values are expressed in mg/dl. HDL was determined by precipitation with dextran sulfate $Cl_2Mg$, and values were expressed in mg/dl. LDL was calculated using the Friedewald formula (provided that triglycerides were below 400 mg/dl). Values are expressed in mg/dl.

Friedewald formula: LDL= total cholesterol – HDL – triglycerides/5

Glycemia figures were classified based on the recommendations of the American Diabetes Association (9); patients with a previous diagnosis, those who after obtaining a glycemia figure higher than 125 mg/dl presented glycosylated hemoglobin ≥ 6.5%, and those on hypoglycemic treatment were qualified as diabetic.

Body mass index (BMI) is calculated by dividing weight by height in meters squared (BMI= Weight (kg)/Height² (m)). The cut-off point for obesity according to WHO criteria is 30.

Lipid accumulation product (LAP) (10) is calculated:

- In men: (waist circumference (cm) – 65) x (triglyceride concentration (mMol)).
- In women: (waist circumference (cm) – 58) x (triglyceride concentration (mMol)).

The cut-off point for it to be considered high is 30.40 in women and 56.70 in men (11).

Cardiometabolic index (12) is obtained by multiplying the waist-to-height ratio by the triglyceride/HDL-c atherogenic index. The cut-off point for considering it high is 0.80 for women and 1.75 for men.

Waist triglyceride index (13) is calculated by multiplying the waist circumference in cm by triglycerides in mmol. The cut-off point is 190.40. triglyceride glucose index – BMI, triglyceride glucose index – waist circumference

Ty G index (14) = LN (TG [mg/dL] × blood glucose [mg/dL]/2). With a cut-off point of 8.72 in men and 8.92 in women (15).

Other indices are derived from it (16).

Ty G index-BMI = Ty G index x BMI

Ty G index- waist circumference = Ty G index x waist circumference

Ty G index-waist to height ratio= Ty G index x waist/height

Ty G index-waist/hip

Tobacco consumption was considered as a dichotomous variable and could have the value of yes/no. A smoker was a person who had regularly consumed at least 1 cigarette/day (or the equivalent in other types of consumption) in the previous month or had quit smoking less than a year before. A person who had not smoked for more than 12 months or had never smoked was considered a non-smoker.

Social class was obtained from the 2011 National Classification of Occupations (CNO-11), based on the proposal made by the social determinants group of the Spanish Society of Epidemiology (17). We opted for classification in 3 categories: Class I, Directors/managers, university professionals, athletes and artists. Class II, Intermediate occupations and self-employed workers without employees. Class III, Unskilled workers.

Diet was assessed by means of the questionnaire on adherence to the Mediterranean diet (18) based on the Predimed test, which consists of 14 questions that are scored with 0 or 1 point each. Values below 9 are considered low adherence and values of 9 or higher are considered good adherence.

The International Physical Activity. Questionnaire (19) (IPAQ) consists in questions about the frequency, duration and intensity of activity (moderate and intense) performed in the last seven days, as well as walking and sitting time in a working day. The short 7-item version is used in this study.

TEST VALUE:

1. Walking: 3'3 METx minutes of walking x days per week.
2. Moderate Physical Activity: 4 MET*x minutes x days per week
3. Vigorous Physical Activity: 8 MET*x minutes x days per week.

The three values obtained are then added together

CLASSIFICATION CRITERIA:

Moderate Physical Activity:

- 3 or more days of moderate physical activity and/or walking at least 30 minutes per day.
- 5 or more days of any combination of walking, moderate or vigorous physical activity achieving at least a total of 600 METs.

Vigorous Physical Activity:

- Vigorous Physical Activity at least 3 days per week achieving a total of at least 1500 METs.

- 7 days of any combination of walking, moderate physical activity and/or vigorous physical activity, achieving a total of at least 3000 METs.

MET is the Unit of Measurement of the test

*Statistical analysis*

A descriptive analysis of the categorical variables was performed, by calculating the frequency and distribution of responses for each one. For quantitative variables, the mean and standard deviation were calculated, while for qualitative variables, the percentage was calculated. The bivariate association analysis was performed using the Chi squared test (with correction of Fisher's exact statistic when conditions required it) and Student's t test for independent samples. For the multivariate analysis, binary logistic regression was used with the Wald method, with calculation of the Odds ratio and the Hosmer-Lemeshow goodness-of-fit test. Statistical analysis was performed with the SPSS 27.0 program, with an accepted statistical significance level of 0.05.

*Ethical considerations and aspects*

The study was approved by the Clinical Research Ethics Committee of the Balearic Islands Health Area no. IB 4383/20. All procedures were performed in accordance with the ethical standards of the institutional research committee and with the 2013 Declaration of Helsinki. All patients signed written informed consent documents before participating in the study.

Table 1. Characteristics of the population

| | Women (n=718) | Men (n=739) | Total (n=1457) | p-value |
|---|---|---|---|---|
| | mean (SD) | mean (SD) | mean (SD) | |
| Age (years) | 43.30 (8.44) | 46.02 (8.50) | 44.68 (8.57) | <0.0001 |
| Weight (kg) | 66.29 (12.29) | 82.24 (13.81) | 74.38 (15.32) | <0.0001 |
| Height (m) | 1.62 (0.06) | 1.73 (0.07) | 1.68 (0.09) | <0.0001 |
| BMI (kg/m²) | 25.36 (4.61) | 27.40 (4.13) | 26.39 (4.49) | <0.0001 |
| Waist (cm) | 89.44 (16.36) | 97.00 (10.65) | 93.27 (14.27) | <0.0001 |
| Hip (cm) | 105.78 (13.22) | 108.77 (10.27) | 107.29 (11.91) | <0.0001 |
| Systolic Blood Pressure (mm Hg) | 121.31 (17.05) | 133.76 (18.11) | 127.62 (18.66) | <0.0001 |
| Diastolic Blood Pressure (mm Hg) | 75.03 (10.58) | 80.63 (11.43) | 77.87 (11.36) | <0.0001 |
| Total cholesterol (mg/dl) | 186.02 (31.14) | 183.37 (31.72) | 184.67 (31.46) | 0.108 |
| HDL (mg/dl) | 60.18 (13.55) | 49.83 (12.16) | 54.93 (13.86) | <0.0001 |
| LDL (mg/dl) | 107.88 (28.16) | 108.94 (29.15) | 108.42 (28.66) | 0.483 |
| Triglycerides (mg/dl) | 86.57 (43.59) | 119.55 (87.42) | 103.30 (71.28) | <0.0001 |
| Glycemia (mg/dl) | 92.16 (16.31) | 98.68 (19.54) | 95.47 (18.30) | <0.0001 |
| | Percentage | Percentage | Percentage | p-value |
| <35 years | 16.71 | 10.42 | 13.52 | <0.0001 |
| 35-49 years | 57.80 | 51.01 | 54.36 | |
| ≥ 50 years | 25.49 | 38.57 | 32.12 | |
| Social class I | 18.94 | 8.80 | 13.80 | <0.0001 |
| Social class II | 63.65 | 82.67 | 73.30 | |
| Social class III | 17.41 | 8.53 | 12.90 | |
| No tobacco | 71.87 | 72.94 | 72.41 | <0.0001 |
| Yes tobacco | 28.13 | 27.06 | 27.59 | |
| MET low | 23.68 | 19.08 | 21.35 | <0.0001 |
| MET moderate | 48.05 | 36.4 | 42.14 | |
| MET high | 28.27 | 44.52 | 36.51 | |
| Predimed low | 36.49 | 48.17 | 42.42 | <0.0001 |
| Predimed high | 63.51 | 51.83 | 57.58 | |

BMI Body mass index. HDL High Desity Lipoprotein. LDL. Low Density Lipoprotein. MET Unit of Measurement of the IPAQ questionnaire. MET low under 600 METS, MET moderate between 600-2999 MET, MET high at least 3000 MET Predimed low ≤ 8 points Predimed high ≥ 9 points.

## Results

Values of the anthropometric, clinical, analytical, sociodemographic, and healthy habit variables, with the exception of cholesterol, were worse among the men in our study population. The complete data are presented in Table 1.

Most of the scales studied showed an improvement in mean values as the level of physical activity increased; this situation was observed in both sexes. The complete data are presented in Table 2.

Something similar was observed with adherence to the Mediterranean diet, such that people, both men and women, with high adherence presented better values in the scales analyzed. All the data are shown in Table 3.

As occurred with the mean values, the prevalence of altered values in these scales decreased in parallel with an increase

Table 2. Mean values in the different scales according to physical activity by gender

| | Women | | | | Men | | | |
|---|---|---|---|---|---|---|---|---|
| | MET low | MET moderate | MET high | p-value | MET low | MET moderate | MET high | p-value |
| | n=170 | n=345 | n=203 | | n=141 | n=269 | n=329 | |
| | mean (SD) | mean (SD) | mean (SD) | | mean (SD) | mean (SD) | mean (SD) | |
| Lipid accumulation product | 37.75 (28.95) | 31.04 (25.65) | 30.97 (31.62) | <0.0001 | 58.57 (55.36) | 45.84 (34.19) | 37.34 (34.75) | <0.0001 |
| Waist Triglyceride index | 104.67 (60.64) | 86.74 (47.87) | 84.40 (57.33) | <0.0001 | 165.61 (123.31 | 138.74 (94.49) | 115.96 (94.77) | <0.0001 |
| TyG index | 8.36 (0.47) | 8.15 (0.46) | 8.09 (0.42) | <0.0001 | 8.75 (0.52) | 8.57 (0.58) | 8.38 (0.53) | <0.0001 |
| Ty G index-BMI | 221.59 (42.60) | 207.38 (46.39) | 199.37 (41.67) | <0.0001 | 253.02 (46.61) | 235.73 (43.60) | 224.66 (37.76) | <0.0001 |
| Ty G index-waist circumference | 753.33 (137.25) | 729.95 (164.68) | 727.31 (149.96) | <0.0001 | 876.53 (120.43) | 835.08 (118.54) | 801.12 (108.27) | <0.0001 |
| Ty G index-WtHR | 4.67 (0.90) | 4.53 (1.06) | 4.49 (0.95) | <0.0001 | 5.05 (0.68) | 4.84 (0.73) | 4.63 (0.64) | <0.0001 |
| Ty G index-WtHipR | 7.08 (0.82) | 6.82 (0.85) | 6.78 (0.86) | <0.0001 | 7.89 (0.69) | 7.62 (0.74) | 7.47 (0.73) | <0.0001 |
| Cardiometabolic index | 1.12 (0.95) | 0.85 (0.62) | 0.79 (0.67) | <0.0001 | 2.04 (1.79) | 1.59 (1.28) | 1.24 (1.05) | <0.0001 |

Ty G Triglyceride Glucose index WtHR Waist to Height Ratio. WtHipR Waist to Hip Ratio. BMI Body mass index. MET Unit of Measurement of the IPAQ questionnaire. MET low under 600 METS, MET moderate between 600-2999 MET, MET high at least 3000 MET

in the level of physical activity, which could be seen in both women and men (see Table 4).

Adherence to the Mediterranean diet had a similar effect on the prevalence of the values studied in these scales, with better results in people with a high adherence, as shown in Table 5.

Age over 50 years, male sex, smoking, low physical activity, low adherence to the Mediterranean diet, and social classes II and III were established as covariates in the multivariate analysis, with sex and physical activity as the only variables that displayed an influence in all the scales analyzed.

Table 3. Mean values in the different scales according to healthy food by gender

| | Women | | | Men | | |
|---|---|---|---|---|---|---|
| | Predimed low | Predimed high | p-value | Predimed low | Predimed high | p-value |
| | n=262 | n=456 | | n=356 | n=383 | |
| | mean (SD) | mean (SD) | | mean (SD) | mean (SD) | |
| Lipid accumulation product | 36.59 (30.27) | 30.32 (26.93) | <0.0001 | 48.16 (43.08) | 41.07 (36.73) | <0.0001 |
| Waist Triglyceride index | 96.40 (59.00) | 86.83 (51.27) | <0.0001 | 142.36 (105.88) | 125.70 (98.30) | <0.0001 |
| TyG index | 8.22 (0.47) | 8.17 (0.46) | <0.0001 | 8.59 (0.57) | 8.46 (0.55) | <0.0001 |
| TyG index-BMI | 214.59 (42.78) | 204.97 (45.72) | <0.0001 | 229.37 (40.43) | 239.18 (45.02) | <0.0001 |
| TyG index-waist circumference | 763.97 (145.05) | 717.95 (157.52) | <0.0001 | 843.13 (118.49) | 813.68 (115.33) | <0.0001 |
| TyG index-WtHR | 4.75 (0.93) | 4.44 (1.02) | <0.0001 | 4.86 (0.69) | 4.71 (0.70) | <0.0001 |
| TyG index-WtHipR | 7.06 (0.87) | 6.80 (0.83) | <0.0001 | 7.69 (0.75) | 7.52 (0.72) | <0.0001 |
| Cardiometabolic index | 1.00 (0.82) | 0.84 (0.67) | <0.0001 | 1.67 (1.48) | 1.38 (1.17) | <0.0001 |

Ty G Triglyceride Glucose index WtHR Waist to Height Ratio. WtHipR Waist to Hip Ratio. BMI Body mass index Predimed low ≤ 8 points Predimed high ≥ 9 points

Of these, the one showing the greatest influence was sex, with odds ratios ranging from 0.36 (95% CI 0.28-0.46) for LAP to 4.34 (95% CI 2.90-6.50) for high Waist Triglyceride index. On the other hand, tobacco only showed a relationship with Ty G index-BMI. All the results are presented in Table 6.

Table 4. Prevalence of altered values in the different scales according to physical activity by gender

| | Women | | | | Men | | | |
|---|---|---|---|---|---|---|---|---|
| | MET low | MET moderate | MET high | | MET low | MET moderate | MET high | |
| | n=170 | n=345 | n=203 | | n=141 | n=269 | n=329 | |
| | Percentage | Percentage | Percentage | p-value | Percentage | Percentage | Percentage | p-value |
| Lipid accumulation product high | 49.41 | 39.42 | 38.42 | <0.0001 | 36.17 | 27.88 | 17.02 | <0.0001 |
| Waist Triglyceride index high | 7.65 | 4.06 | 3.45 | <0.0001 | 29.08 | 18.22 | 9.73 | <0.0001 |
| Ty G index high | 18.24 | 13.04 | 5.91 | <0.0001 | 45.39 | 36.80 | 24.62 | <0.0001 |
| Ty G index-BMI high | 41.76 | 30.72 | 18.72 | <0.0001 | 74.47 | 56.88 | 46.50 | <0.0001 |
| Ty G index-waist circumference high | 60.59 | 53.04 | 50.65 | <0.0001 | 93.62 | 83.64 | 76.29 | <0.0001 |
| Cardiometabolic index high | 55.88 | 40.29 | 34.98 | <0.0001 | 41.84 | 32.34 | 20.67 | <0.0001 |

Ty G Triglyceride Glucose index. BMI Body mass index. MET Unit of Measurement of the IPAQ questionnaire. MET low under 600 METS, MET moderate between 600-2999 MET, MET high at least 3000 MET

Table 5. Prevalence of altered values in the different scales according to healthy food by gender

| | Women | | | Men | | |
|---|---|---|---|---|---|---|
| | Predimed low | Predimed high | | Predimed low | Predimed high | |
| | n=262 | n=456 | | n=356 | n=383 | |
| | Percentage | Percentage | p-value | Percentage | Percentage | p-value |
| Lipid accumulation product high | 47.71 | 37.94 | <0.0001 | 28.37 | 21.15 | <0.0001 |
| Waist Triglyceride index high | 6.11 | 3.95 | <0.0001 | 18.26 | 14.88 | <0.0001 |
| Ty G index high | 13.74 | 11.40 | <0.0001 | 38.20 | 28.20 | <0.0001 |
| Ty G index-BMI high | 36.26 | 26.32 | <0.0001 | 61.24 | 50.39 | <0.0001 |
| Ty G index-waist circumference high | 63.36 | 51.54 | <0.0001 | 85.39 | 79.37 | <0.0001 |
| Cardiometabolic index high | 45.80 | 40.57 | <0.0001 | 34.27 | 24.02 | <0.0001 |

Ty G Triglyceride Glucose index. BMI Body mass index Predimed low ≤ 8 points Predimed high ≥ 9 points

Table 6. Logistic regression analysis

| | Men | Age ≥50 years | Smokers | MET low-moderate | Predimed low | Social class II-III |
|---|---|---|---|---|---|---|
| | OR (CI 95%) | OR (CI 95%) | OR (CI 95%) | OR (CI 95%) | OR (CI 95%) | OR (CI 95%) |
| Lipid accumulation product high | 0.36 (0.28-0.46) | 2.32 (1.80-2.98) | ns | 1.55 (1.21-2.00) | 1.40 (1.10-1.77) | 4.02 (2.60-6.24) |
| Waist Triglyceride index high | 4.34 (2.90-6.50) | ns | ns | 2.52 (1.70-3.73) | ns | 2.59 (1.28-5.24) |
| Ty G index high | 3.58 (2.70-4.76) | 1.93 (1.48-2.53) | 1.40 (1.06-1.86) | 1.85 (1.38-2.47) | 1.43 (1.10-1.86) | ns |
| Ty G index-BMI high | 2.88 (2.28-3.64) | 2.44 (1.91-3.10) | ns | 1.92 (1.50-2.45) | 1.56 (1.24-1.96) | 1.63 (1.14-2.34) |
| Ty G index-waist circumference high | 3.18 (2.44-4.15) | 3.88 (2.80-5.38) | ns | 1.41 (1.08-1.86) | 1.44 (1.11-1.88) | 6.40 (4.42-9.26) |
| Cardiometabolic index high | 0.50 (0.39-0.63) | 1.81 (1.42-2.30) | 1.30 (1.01-1.67) | 1.68 (1.31-2.15) | 1.34 (1.07-1.69) | 1.71 (1.20-2.44) |

Ty G Triglyceride Glucose index. BMI Body mass index. Ns. Non significance. MET Unit of Measurement of the IPAQ questionnaire Predimed low ≤ 8 points . MET low under 600 METS, MET moderate between 600-2999 MET.

## Discussion

In our study, both the mean values and the prevalence of altered values in the different scales that assess insulin resistance decreased as the level of physical activity assessed with the IPAQ questionnaire and adherence to the Mediterranean diet increased.

In the studies consulted, following our review of the literature, few address the influence of healthy habits and sociodemographic variables on the values of the scales that determine insulin resistance as we do in this study.

When it comes to assessing the effect of physical activity on insulin resistance, we find different results, although most of them consider that it has a beneficial effect. Thus, a cross-sectional study performed in 90 Brazilian patients in 2015 (20) that evaluated lipid accumulation product values and their relationship with different variables, including physical activity determined with the IPAQ questionnaire, showed that this parameter increased as the level of exercise decreased in a similar way to what we found in our work, although the mean age of the population in our study is younger. This same beneficial effect has been observed in other research such as that of Sampath Kumar (21) who in a meta-analysis of 2019 where data from 846 people included in structured physical exercise programs were analyzed, concluded that the mean insulin resistance values decreased in the group that performed exercise compared to those who did not. In the same sense we find the study by Whillier (22), although in this case it is not clear whether the positive effect on insulin resistance is due to the physical exercise itself or whether it is due to the loss of weight or visceral fat.

Amanat *et al* (23) conducted a study in 66 overweight women with metabolic syndrome in which they assessed the effect of different types of physical exercise for 12 weeks (aerobic, resistance and combined) and observed that in all three cases there was a decrease in insulin resistance when compared to the control group that did not do physical exercise. Dalmazzo *et al* (24) compared the impact of a high intensity intervallic training program versus a muscular resistance training program on insulin resistance in 28 Chilean adults, observing a lower insulin resistance in both cases (25). Other studies found this same beneficial effect of high-intensity interval training on insulin resistance (26-28), as well as with muscular endurance programs (29-30).

However, we also found research that did not find any improvement in insulin resistance values in people who performed physical exercise. A study by Fedewa *et al*. (31) carried out in 44 overweight people who performed moderate or vigorous physical exercise found improvements in HDL and LDL cholesterol values but not in insulin resistance values.

If we focus on the effects of the Mediterranean diet on insulin resistance, we find two studies that corroborate the beneficial effect of this type of diet as we have found. Mirabelli (32) observed that in obese people the Mediterranean diet improved insulin resistance values when compared with other types of diet. On the other hand, Papadaki (33) in a meta-analysis involving almost 37,000 people found beneficial effects of the Mediterranean diet on the different components of the metabolic syndrome, including insulin resistance.

Other studies have assessed the combined effect of physical activity and the Mediterranean diet on insulin resistance values. Sánchez-Escudero *et al* studied 60 young people aged 7 to 16 years (34) whose adherence to the Mediterranean diet and amount of physical activity were assessed using the International Sedentary Assessment Tool (ISAT) and Actigraph wGT3X+ accelerometers, revealing lower values of insulin resistance -determined with the Triglyceride Glucose index- in those who performed moderate-vigorous physical activity. These data are similar to those of our study, although here too the age of the population is different. Malakou (35) carried out a systematic review with meta-analysis in more than 1600 people and also observed this beneficial effect on insulin resistance.

A fundamental limitation of the study is the fact that, being a working population, it does not include unemployed, retired, under 18 years of age or over 67 years of age, so that the results cannot be extrapolated to the general population as they are not representative of it.

Among the strengths of this study are the large sample size, the high number of insulin resistance scales analyzed, and the fact that the assessment of physical activity and adherence to the Mediterranean diet was performed with validated questionnaires (IPAQ and Predimed).

## Conclusions

The cardiometabolic profile, including insulin resistance, of persons with high levels of physical activity determined with the IPAQ questionnaire and of persons with high adherence to the Mediterranean diet is better than that of sedentary persons with low adherence to the Mediterranean diet.

This beneficial effect is observed separately with each of these healthy habits and a synergistic effect is also observed when both are presented together.

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