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ORIGINAL

Relationship between physical activity and adherence to the mediterranean diet with metabolic syndrome, hypertriglyceridemic waist phenotype and hypertensive waist

Relación entre la actividad física y la adherencia a la dieta mediterránea con el síndrome metabólico, el fenotipo de cintura hipertrigliceridémica y la cintura hipertensiva

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Abstract

Introduction: Metabolic syndrome is a very common clinical condition that includes a series of anthropometric, analytical and clinical alterations that result in an increased risk of cardiovascular disease and diabetes type 2.

Methods: Cross-sectional study carried out in 1457 persons assessing the effect of physical activity determined with the IPAQ questionnaire and the Mediterranean diet assessed with the PREDIMED questionnaire on the values and prevalence of metabolic syndrome calculated with the NCEP ATPIII, IDF and JIS scales and the hypertriglyceridemic waist penotype and hypertensive waist determined with the NCEP ATPIII and IDF criteria.

Results: The prevalence of metabolic syndrome with the three scales, hypertriglyceridemic waist phenotype and hypertensive waist decreases as the level of physical activity determined with the IPAQ questionnaire increases. A decrease is also observed in people with high adherence to the Mediterranean diet compared to those with low adherence in both metabolic syndrome (also with the three scales) and in both waistlines. In the multivariate analysis, physical activity decreases the risk of metabolic syndrome, hypertriglyceridemic waist phenotype and hypertensive waist while high adherence to the Mediterranean diet only decreases the risk of metabolic syndrome.

Conclusion: Both physical activity and the Mediterranean diet decrease the risk of metabolic syndrome, hypertriglyceridemic waist phenotype and hypertensive waist in the Spanish Mediterranean population.

Keywords: Metabolic syndrome, physical exercise, healthy food, Hypertriglyceridemic waist phenotype, hypertensive waist. Mediterranean diet, PREDIMED.

Resumen

Introducción: El síndrome metabólico es una condición clínica muy común que incluye una serie de alteraciones antropométricas, analíticas y clínicas que resultan en un mayor riesgo de enfermedad cardiovascular y diabetes tipo 2.

Métodos: Estudio transversal realizado en 1457 personas valorando el efecto de la actividad física, determinada con el cuestionario IPAQ, y la dieta mediterránea, evaluada con el cuestionario PREDIMED, sobre los valores y la prevalencia del síndrome metabólico calculado con las escalas NCEP ATPIII, IDF y JIS y el fenotipo de cintura hipertrigliceridémica y cintura hipertensiva determinados con los criterios NCEP ATPIII e IDF.

Resultados: La prevalencia del síndrome metabólico con las tres escalas, el fenotipo de cintura hipertrigliceridémica y la cintura hipertensiva disminuye a medida que aumenta el nivel de actividad física determinado con el cuestionario IPAQ. También se observa una disminución en las personas con alta adherencia a la dieta mediterránea en comparación con las de baja adherencia tanto en el síndrome metabólico (también con las tres escalas) como en ambas cinturas. En el análisis multivariante, la actividad física disminuye el riesgo de síndrome metabólico, fenotipo de cintura hipertrigliceridémica y cintura hipertensa, mientras que la alta adherencia a la dieta mediterránea sólo disminuye el riesgo de síndrome metabólico.

Conclusiones: Tanto la actividad física como la dieta mediterránea disminuyen el riesgo de síndrome metabólico, fenotipo de cintura hipertrigliceridémica y cintura hipertensiva en la población mediterránea española.

Palabras clave: Síndrome metabólico, ejercicio físico, alimentación saludable, fenotipo de cintura hipertrigliceridémica, cintura hipertensa. Dieta mediterránea, PREDIMED.

Introduction

Metabolic syndrome (MS), also called Reaven's syndrome, insulin resistance syndrome, plurimetabolic syndrome, or syndrome X, is a group of disorders that occur simultaneously and lead to an increased risk of heart disease, stroke, and type 2 diabetes. This syndrome includes insulin resistance, excess abdominal fat, atherogenic dyslipidemia, endothelial dysfunction, arterial hypertension, hypercoagulability and chronic stress.

The pathophysiology of MS is very complex and only part of it is known[1,2]. In general, patients are older, obese, have little physical exercise, and have a certain degree of insulin resistance. Insulin resistance is known to play an essential role in the development of this syndrome. Currently, the majority of calories consumed come from carbohydrates, especially so-called "simple carbohydrates", i.e. sugar, sweets and processed foods with added sugar (cakes, sodas, cookies, etc.). These foods are absorbed faster, which causes the pancreas to release more of them to keep blood glucose in normal values. If this food intake is maintained and no physical exercise is performed, the cells lose the ability to respond to insulin, becoming insulin resistant or glucose intolerant so that blood glucose will increase, when this occurs the pancreas releases more insulin to normalize blood glucose. The end result is an elevation of insulin in the blood.

Different factors are involved in the etiology of this syndrome, namely an excess consumption of calories, sugars, fats and salt, together with a decrease in the level of physical activity due to a great technological development that reduces the level of effort required to perform most tasks, to which we must add the increase in passive entertainment based on the use of electronic devices[3-6].

The prevalence of the metabolic syndrome will depend on the criteria used to define it, age, sex, race, and lifestyle. In the general population, the prevalence ranges from 15% to 40%[7], increasing to almost 50% in patients with ischemic heart disease or some other vascular condition[8]. The prevalence is higher in persons of Hispanic origin[9].

The aim of this study was to assess the influence of physical activity as determined by the IPAQ questionnaire and adherence to the Mediterranean diet on the appearance of metabolic syndrome as determined by the NCEP ATPIII, IDF and JIS criteria.

Methods

Retrospective and cross-sectional study of 1584 workers in the Balearic Islands and the Valencian Community (Spain) carried out between January 2017 and December 2017. A total of 127 were excluded (69 did not accept to participate and 58 due to ages not included in the study) leaving 1457 workers who are the ones finally included in the study, of whom 718 were women (mean age 43.30 years) and 739 were men (mean age 46.02 years). The workers were selected from among those who attended periodic occupational medical check-ups.

Inclusion criteria

- Age between 18 and 67 years old.
- Belong to one of the companies collaborating in the study.
- Agree to participate in the study.

The anthropometric, clinical and analytical determinations are performed by the health personnel of the different occupational health units participating in the study, after homogenizing the measurement techniques.

For the measurement of weight, which is expressed in kilograms, and height, which is expressed in cm, a scale with measuring rod is used: SECA model 700. The abdominal waist circumference (in cm) is measured with a measuring tape: SECA model 20 with the person in a standing position, feet together and trunk straight, abdomen relaxed and upper limbs hanging on both sides of the body. The tape measure is placed parallel to the floor at the level of the last floating rib. Hip circumference is measured with the same tape measure and adopting the same position as for the waist circumference and passing the tape horizontally at hip level. The waist/height and waist/hip indices are obtained by dividing the waist circumference by the height and hip circumference respectively. The cut-off point for the former is 0.50 and for the latter 0.85 for women and 0.95 for men[10].

Blood pressure was obtained in the supine position with a calibrated OMRON M3 automatic sphygmomanometer and after 10 minutes of rest. Three measurements are taken at one-minute intervals and the mean of the three is obtained. Blood tests are obtained by peripheral venipuncture after a 12-hour fast. Samples are sent to reference laboratories and processed within 48-72 hours. Automated enzymatic methods are used for blood glucose, total cholesterol and triglycerides. Values are expressed in mg/dl. HDL is determined by precipitation with dextran sulfate Cl2Mg, and values are expressed in mg/dl. LDL is calculated using the Friedewald formula (provided that triglycerides are less than 400 mg/dl). Values are expressed in mg/dl.

Friedewald's formula: LDL= total cholesterol -HDL-triglycerides/5

Glycemia figures were classified according to the recommendations of the American Diabetes Association[11]; hyperglycemia was considered to be 125 mg/dl or higher or if receiving hypoglycemic treatment.

A smoker was considered to be a person who had regularly consumed at least 1 cigarette/day (or the equivalent in other types of consumption) in the last month, or had stopped smoking less than a year ago.

For social class, we used the 2011 National Classification of Occupations (CNO-11) and the proposal made by the social determinants group of the Spanish Society of Epidemiology[12]. 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 is assessed by means of the Mediterranean diet adherence questionnaire[13] which is based on the Predimed test and consists of 14 questions scored with 0 or 1 point each. Scores below 9 are considered low adherence and above 9 good adherence.

Physical activity is determined by means of the International Physical Activity Questionnaire (IPAQ)[14]. This is a 7-question self-administered questionnaire that assesses the type of physical activity performed in daily life during the last 7 days.

The metabolic syndrome is determined with three models:

(a) NCEP ATP III (National Cholesterol Educational Program Adult Treatment Panel III). Metabolic syndrome is considered to be present when three or more of the following factors are present: waist circumference greater than 88 cm in women and 102 in men, triglycerides greater than 150 mg/dl or specific treatment of this lipid alteration, blood pressure greater than 130/85 mm Hg, HDL less than 50 mg/dl in women or less than 40 in men or specific treatment, and fasting blood glucose greater than 100 mg/dl or specific treatment of blood glucose.

b) International Diabetes Federation (IDF)[15] It requires the presence of central obesity (waist circumference above 80 cm in women and 94 cm in men), in addition to two of the other factors mentioned above for ATP III (triglycerides, HDL, blood pressure and glycemia).

c) JIS[16] model uses the same criteria as NCEP ATPIII but with waist circumference cut-off points from 80 cm in women and 94 cm in men.

Hypertriglyceridemic waist (ATPIII and IDF criteria)[17] The ATPIII model requires: waist circumference >102 cm (men) and >88 cm (women) and triglycerides greater than 150 mg/dL or treatment of hypertriglyceridemia. The IDF model requires: waist circumference >94 cm (men) and >80 cm (women) and triglycerides >150 mg/dl or treatment of hypertriglyceridemia.

Hypertensive waist circumference (ATPIII and IDF criteria)[18]. The ATPIII criteria include: waist circumference from 102 cm (men) and 88 cm (women) or more, plus Systolic blood pressure (SBP) from 130 mmHg or Diastolic blood pressure (DBP) from 85 mmHg or a history of hypertension under treatment. The IDF criteria require: waist circumference of 94 cm or more (men) and 80 cm or more (women), and na SBP of 130 mm Hg or a DBP of 85 mm Hg or more, or a history of hypertension in treatment.

Statistical analysis

A descriptive analysis of the categorical variables was performed, calculating the frequency and distribution of responses for each of them. For quantitative variables, the mean and standard deviation were calculated, and for qualitative variables, the percentage was calculated. The bivariate association analysis was performed using the 2 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. The statistical analysis was performed with the SPSS 27.0 program, with an accepted statistical significance level of 0.05

Ethical aspects

The study was approved by the Clinical Research Ethics Committee of the Illes Balears 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.

Results

The values of the anthropometric, clinical, analytical, sociodemographic and healthy habits variables of our population are more unfavorable, except for total cholesterol, among men. Most of the persons included in the study belong to social class III. Slightly more than 27% are smokers, more than 36% engage in intense physical activity and slightly less than 58% have a high adherence to the Mediterranean diet. In all cases except for total cholesterol and LDL cholesterol values, the differences observed were statistically significant. The complete data are presented in **table I**.

The prevalence of altered values of the metabolic scales (metabolic syndrome, Hypertriglyceridemic waist and hypertensive waist) decreases as the level of physical activity increases, and this can be observed in both sexes, the differences being statistically significant in all cases. The prevalence of all the variables are, in general, higher in men. (see **Table II**).

Table I: Characteristics of the population.

	Women (n=718) mean (SD)	Men (n=739) mean (SD)	Total (n=1457) mean (SD)	p-value
Age (years)	43.30 (8.44)	46.02 (8.50)	44.68 (8.57)	<0.0001
Height (kg)	66.29 (12.29)	82.24 (13.81)	74.38 (15.32)	<0.0001
Weight (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
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	

Table II: Prevalence of altered values of the different metabolic and diabetes risk scales according to physical activity by gender.

	Women				Men			
	MET low n=170 %	MET moderate n=345 %	MET high n=203 %	p-value	MET low n=141 %	MET moderate n=269 %	MET high n=329 %	p-value
Metabolic syndrome NCEP ATPIII	22.94	18.84	7.88	<0.0001	34.04	27.88	12.46	<0.0001
Metabolic syndrome IDF	27.06	19.71	9.85	<0.0001	42.55	35.69	18.24	<0.0001
Metabolic syndrome JIS	27.65	20.29	9.85	<0.0001	46.10	39.03	20.36	<0.0001
Hypertriglyceridemic waist NCEP ATP III	10.59	4.64	2.96	0.003	13.48	8.55	4.56	0.002
Hypertriglyceridemic waist IDF	10.59	5.51	3.45	0.013	24.82	18.59	10.33	<0.0001
Hypertensive waist NCEP ATP III	31.18	23.19	14.78	0.001	29.79	21.93	17.33	0.010
Hypertensive waist IDF	36.45	26.38	16.75	<0.0001	50.35	46.84	32.22	<0.0001

Table III: Prevalence of altered values of the different metabolic and diabetes risk scales according to healthy food by gender.

	Women			Men		
	Predimed low n=262 mean (SD)	Predimed high n=456 mean (SD)	p-value	Predimed low n=356 mean (SD)	Predimed high n=383 mean (SD)	p-value
Metabolic syndrome NCEP ATPIII	19.85	14.91	0.097	26.40	18.29	0.010
Metabolic syndrome IDF	22.90	16.23	0.027	33.43	25.33	0.016
Metabolic syndrome JIS	23.28	16.67	0.030	36.52	27.94	0.013
Hypertriglyceridemic waist NCEP ATP III	6.49	5.04	0.038	8.71	6.79	0.042
Hypertriglyceridemic waist IDF	7.63	5.26	0.031	18.82	13.58	0.043
Hypertensive waist NCEP ATP III	24.43	21.71	0.041	23.60	19.32	0.015
Hypertensive waist IDF	28.24	24.78	0.033	42.98	39.16	0.021

Table IV: Logistic regression analysis.

	Men OR (CI 95%)	Age ≥50 years OR (CI 95%)	Tobacco consumption OR (CI 95%)	MET low-moderate OR (CI 95%)	Predimed low OR (CI 95%)	Social class II-III OR (CI 95%)
Metabolic syndrome NCEP ATPIII	1.38 (1.05-1.83)	2.13 (1.61-2.81)	ns	2.84 (2.05-3.94)	1.42 (1.08-1.87)	2.35 (1.42-3.91)
Metabolic syndrome IDF	1.73 (1.32-2.25)	2.51 (1.93-3.26)	ns	2.61 (1.95-3.51)	1.42 (1.10-1.84)	3.47 (2.04-5.90)
Metabolic syndrome JIS	1.98 (1.52-2.57)	2.39 (1.85-3.09)	ns	2.61 (1.96-3.47)	1.43 (1.11-1.85)	2.22 (1.41-3.50)
Hypertriglyceridemic waist NCEP ATP III	ns	1.68 (1.10-2.56)	ns	2.26 (1.37-3.72)	ns	5.42 (1.69-17.41)
Hypertriglyceridemic waist IDF	1.85 (1.45-2.36)	3.22 (2.53-4.10)	ns	1.99 (1.54-2.57)	ns	4.06 (2.54-6.49)
Hypertensive waist NCEP ATP III	ns	2.62 (2.02-3.40)	0.74 (0.55-0.99)	1.87 (1.40-2.49)	ns	5.01 (2.73-9.21)
Hypertensive waist IDF	1.85 (1.45-2.36)	3.22 (2.53-4.10)	ns	1.99 (1.54-2.57)	ns	4.06 (2.54-6.49)

Something similar to that obtained with physical activity can be found with the prevalence of high values of these scales in people with a high adherence to the Mediterranean diet as shown in **table III**.

In the multivariate analysis using binary logistic regression, male, age 50 years, and older, tobacco consumption, MET low-moderate, low adherence to mediterranean diet and social class II-III were established as covariates. Age, physical activity assessed with the IPAQ questionnaire and social class are the only variables that show an influence on all the scales analyzed. Of these, the one showing the greatest degree of influence is social class, with odds ratios ranging from 2.22 (95% CI 1.41-3.50) for metabolic syndrome with JIS criteria and 5.42 (95% CI 1.69-17.41-14.24) for Hypertriglyceridemic waist with NCEP ATP III criteria. All results are presented in **table IV**.

Discussion

In our investigation, persons who do intense physical activity have better values on the scales of metabolic syndrome, hypertriglyceridemic waist and hypertensive waist than those who do moderate physical exercise and these better than those who do sporadic physical exercise or do not exercise at all. Something similar occurs between people with high adherence to the Mediterranean diet and those with low adherence.

In the multivariate analysis, intense physical activity reduces the risk of suffering from metabolic syndrome (with the three scales), hypertriglyceridemic waist and hypertensive waist, while high adherence to the Mediterranean diet only protects from suffering from metabolic syndrome.

Most of the studies analyzed show a clear association between the level of physical activity and the presence of metabolic syndrome, with the higher the level of exercise, the lower the prevalence of metabolic syndrome, i.e. most studies coincide with the results obtained by us.

Several studies have used a methodology similar to ours and obtained similar results. For example, a study of 5040 people analyzed data from the 2009-10 Chilean national health survey, relating the level of physical activity measured with the GPAQ (Global Physical Activity Questionnaire) to the presence of metabolic syndrome using the ATP III criteria. The study associated a new and integrative classification of physical activity and sedentary lifestyle, as it not only considered the time spent exercising but also the time spent sitting down. The study concluded that there was a lower probability of presenting metabolic syndrome when the international physical activity recommendations were met, i.e., the person was physically active (>150 minutes/week) regardless of the time spent sitting down[19]. In this case, the association between leisure-time physical activity, cardio-respiratory fitness and metabolic syndrome was assessed and it was concluded that those with a low level of fitness (<29.1 ml x kg/min) were at least 7 times more likely to present metabolic syndrome than those above 35.5 ml x kg/min[20]. Lastly, an Australian study in 1563 adults showed that men who were inactive in their leisure time were twice as likely to be diagnosed with metabolic syndrome using the ATP-III model, while in women the risk was three times higher compared to those with a high level of physical activity[21].

Data similar to the above were obtained in studies that used methodologies different from ours. In a longitudinal study with a 4-year follow-up, Laaksonen et al. examined the relationship between the change in physical activity and the diagnosis of metabolic syndrome, in which men who performed more than 3 hours of moderate or vigorous physical exercise per week had half the risk of developing metabolic syndrome compared to those who were sedentary[22]. The KORA study evaluated physical activity by interview in 1653 adults aged 55-74 years and found that those who regularly engaged in sports activities, even at a frequency of 1 day/week, reduced the risk of metabolic syndrome according to the IDF criteria by 42%, while those with 2 hours or more per week reduced it by 61%[23].

Other studies have assessed the relationship between metabolic syndrome and physical exercise measured with accelerometers and have found results similar to those obtained in our work and in the studies cited above. Sisson et al found that the risk of metabolic syndrome decreased by 10% for every 1000 steps walked and that the probability of developing metabolic syndrome was 3, 5 times lower in very active adults, i.e., those who walked more than 10,000 steps/day, and 1.6 times lower in moderately active adults, between 5-10,000 steps/day, compared to those who were not very active and walked less than 5,000 steps/day[24]. Another study, in this case in 483 Japanese adults showed similar results, such that those who took less than 24 MET-h per week or 3-6 MET-h per day had a 2.2 times higher risk than those who took more than 24 MET-h/week[25].

However, we have also found research in which this beneficial effect of exercise is not found. Chimbo-Yunga et al. analyzed physical activity using the IPAQ questionnaire and the prevalence of metabolic syndrome with the ATPIII criteria in 387 older Colombian adults and observed that there were no differences between the different groups according to the level of exercise they performed[26]. Three other studies carried out in similar populations and also using the IPAQ questionnaire also found no differences in the prevalence of metabolic syndrome according to the level of physical activity[27-29].

We have found little literature evaluating the effect of the Mediterranean diet on the prevalence of metabolic syndrome, specifically only one study, in which high adherence to this diet reduced the risk of presenting metabolic syndrome, as we observed in our study. Gouveri et al performed a cross-sectional study in 2074 adults and found that high adherence to the Mediterranean diet resulted in a 20% reduction in the risk of developing metabolic syndrome after adjusting for the main confounding factors[30].

Other studies have found an increase in the prevalence of metabolic syndrome in adults with a low consumption of vegetables and a high consumption of sugar-sweetened beverages[31,32].

Among the strengths of this study are the large sample size, the number of metabolic syndrome scales analyzed (specifically 3), the inclusion of two variables that assess cardiometabolic risk, such as the hypertriglyceridemic waist and hypertensive waist, and the fact that the assessment of physical activity and adherence to the Mediterranean diet was carried out with validated questionnaires (IPAQ and Predimed).

The main limitation of the study is that it was carried out in a very specific geographical area, which may make it difficult to extrapolate the results to other countries.

Conflict of Interest

The authors declare no conflict of interest.

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