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ORIGINAL

Influence of physical activity and mediterranean diet on the values of different scales of overweight and obesity

Influencia de la actividad física y la dieta mediterránea en los valores de diferentes escalas de sobrepeso y obesidad

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Abstract

Introduction: Obesity is the most common metabolic disorder in developed society and has a multifactorial origin. In this paper, we assess that affects how the Mediterranean diet and regular physical exercise in the prevalence of obesity in the population studied.
Materials and methods: A descriptive, cross-sectional study was carried out in 1457 workers in the Spanish Mediterranean area to determine the influence of adherence to the Mediterranean diet, assessed with the PREDIMED questionnaire, and physical activity, quantified with the IPAQ questionnaire, on the values of different scales of overweight and obesity.
Results: Most of the overweight and obesity scales and body fat estimation scales analyzed show an improvement in values as the level of physical activity increases, both in men and women. A similar situation is observed with adherence to the Mediterranean diet.
Conclusions: Physical activity and heart-healthy eating improve overweight and obesity-related scales

Keywords: Physical activity, healthy food, mediterranean food, obesity, body fat.

Resumen

Introducción: La obesidad es el trastorno metabólico más frecuente en la sociedad desarrollada y tiene un origen multifactorial. En este trabajo, se evalúa cómo afecta la dieta mediterránea y el ejercicio físico regular en la prevalencia de la obesidad en la población estudiada.
Material y métodos: Se realizó un estudio descriptivo y transversal en 1457 trabajadores del área mediterránea española para determinar la influencia de la adherencia a la dieta mediterránea, evaluada con el cuestionario PREDIMED, y de la actividad física, cuantificada con el cuestionario IPAQ, en los valores de diferentes escalas de sobrepeso y obesidad.
Resultados: La mayoría de las escalas de sobrepeso y obesidad y de estimación de la grasa corporal analizadas muestran una mejora de los valores a medida que aumenta el nivel de actividad física, tanto en hombres como en mujeres. Una situación similar se observa con la adherencia a la dieta mediterránea.
Conclusiones: La actividad física y la alimentación cardiosaludable mejoran las escalas relacionadas con el sobrepeso y la obesidad.

Palabras clave: Actividad física, Alimentación saludable, Alimentación mediterránea, Obesidad, Grasa corporal.

Introduction

It is currently accepted that the main cause of obesity is an energy imbalance between calories ingested and calories expended with exercise and daily activities, resulting in a significant storage of calories in the form of fat[1].

The etiology of obesity is complex and involves multiple factors. It is known that excess weight is not simply due to an increase in food intake, different epidemiological studies have found that there are factors related to obesity. Among them, we can highlight age[2], noting that as we get older, hormonal changes and a less active life will favor it. Also the female sex[3], especially related to pregnancy[4] and menopause[5]. It is common to observe a higher prevalence of obesity in women with polycystic ovary syndrome[6], which prevents correct ovulation. Race[7] also influences the occurrence of obesity, with a higher incidence observed in African-American and Hispanic ethnic groups. Sociocultural factors also play a role in obesity, with people with lower levels of education or income[8] having a higher prevalence, probably related to lower availability to consume healthy foods. Another factor associated with obesity is certain addictive behaviors, especially excessive alcohol consumption[9]. Some studies have assessed the influence of genetics on obesity, concluding that there may be a genetic predisposition that affects the amount of body fat and its distribution[10]. Certain medications[11] such as antidepressants, anticonvulsants, steroids, antipsychotics, oral antidiabetics and beta-blockers can increase weight.

The two factors that have most influenced the increase in obesity have been unhealthy eating and sedentary lifestyles. In the last five decades we have witnessed an increase in fast food and the consumption of foods rich in fats, salt and sugars with the consequent increase in calories. Our society follows a sedentary lifestyle due to the automation of work activities, modern means of transport and increased urban life, which leads to a decrease in the practice of physical exercise.

In view of the above, a study is proposed to assess the influence of healthy eating, represented by the Mediterranean diet, and physical activity on obesity.

Materials and methods

A retrospective and cross-sectional study is carried out in 1584 workers in the Balearic Islands and Valencian Community in companies of different productive sectors during the period between January 2017 and December 2017. Of these 127 are excluded (69 for not accepting to participate and 58 for being under 20 years old) leaving 1457 workers who are the ones finally included in the study, of them 718 are women (mean age 43.30 years) and 739 are 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 69 years.
- To be an active worker.
- Belonging to one of the companies collaborating in the study.
- Accepting to participate in the study.

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

To measure weight, which is expressed in kilograms, and height, which is expressed in cm, a scale with measuring rod is used: model SECA 700 with a capacity of 200 kg and 50-gram divisions, which has a SECA 220 telescopic measuring rod with millimetric division and a 60-200 cm interval.

The abdominal waist circumference is measured in cm with a measuring tape: SECA model 20, with an interval of 1-200 cm and millimetric division. The person is placed in a standing position, feet together and trunk erect, 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: it is measured with a SECA model 200 tape with a measuring interval of 12-200 cm and millimeter division. The same position is adopted as for the waist circumference and the measuring tape is passed 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.

Blood pressure was measured 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

BMI is calculated by dividing weight by height in meters squared. Obesity is considered to be over 30.

We have used 4 formulas to estimate the percentage of body fat:

- CUN BAE(12) (Clínica Universidad de Navarra Body Adiposity Estimator) The formula is:

-44.988 + (0.503 x age) + (10.689 x gender) + (3.172 x BMI) - (0.026 x BMI2) + (0.181 x BMI x gender) - (0.02 x BMI x age) - (0.005 x BMI2x gender) + (0.00021 x BMI2 x age).

Where male sex equals 0 and female sex equals 1.

The CUN BAE cut-off points for obesity are from 25% in men and 35% in women.

- ECORE-BF1[13] (Equation Córdoba for Estimation of Body Fat) It is calculated by the formula: -97.102 + 0.123 (age) + 11.9 (gender) + 35.959 (LnIMC).

Being male is valued as 0 and female as 1. The same cut-off points as CUN BAE are proposed.

-Palafolls formula[14]. It is calculated as

Men = ([BMI/PA]*10) + BMI. Women = ([BMI/PA]*10) + BMI + 10.

The authors propose the same cut-off points as CUN BAE.

- Deuremberg fat mass index[15].

Fat mass %= 1.2 x (BMI) + 0.23 x (Age in years) - 10.8 x (gender) - 5.4

Women are given a value of 0 and men a value of 1. Obesity is considered to be 25% or more in men and 32% or more in women.

- The normalized weight-adjusted index[16] (NWAI) is calculated by the formula :

(weight/10) - (10 x height) + 10] weight is expressed in kg and height in meters.

- The body adiposity index (BAI)[17] is determined by the formula:

BAI = ((waist circumference)/((height)1.5)-18)

- The abdominal volume index (AVI)[18] is calculated:
AVI=[2 cm (waist)2+0.7 cm (waist-hip)2]/1000

-Visceral adiposity index (VAI)[19]

Females:

$$VAI = \left(\frac{WC}{36{,}58 + (1{,}89 \times BMI)}\right) \times \left(\frac{TG}{0{,}81}\right) \times \left(\frac{1{,}52}{HDL}\right)$$

Males:

$$VAI = \left(\frac{WC}{39{,}68 + (1{,}88 \times BMI)}\right) \times \left(\frac{TG}{1{,}03}\right) \times \left(\frac{1{,}31}{HDL}\right)$$

- Body roundness index (BRI)[20]
BRI = 364.2-365.5x√1-[(WC/(2π)2)/(0.5 x Height)2]

-Body Surface Index (BSI)[21] and Body Surface Area (BSA). w is weight and h is height

$$BSA = w^{0{,}425} * h^{0{,}725} * 0{,}007184$$

$$BSI = \frac{WEIGHT}{\sqrt{BSA}}$$

Body fat was determined by bioelectrical impedance measurement using a Tanita BC-420MA monitor. The Gallagher[22] criteria were used to classify this percentage.

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.

Social class was determined from the 2011 National Classification of Occupations (CNO-11) and based on the proposal made by the social determinants group of the Spanish Society of Epidemiology[23]. We opted for a classification into 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"[24] which is based on the PREDIMED test and consists of 14 questions rated 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)[25]. This is a 7-question self-administered questionnaire that assesses the type of physical activity performed in daily life during the last 7 days.

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. 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 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 are generally more unfavorable in males. The characteristics of the sample are presented in **table I**.

Most of the overweight and obesity scales analyzed show an improvement in the mean values as the level of physical activity increases; this situation is observed in both men and women. The complete data are presented in **table II**.

Something similar to that observed with physical activity occurs with the Mediterranean diet, such that those persons, both men and women, with high adherence to

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
Glycaemia (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: Mean values of the different overweight-obesity scales according to physical activity by gender.

	Women				Men			
	MET low n=170	MET moderate n=345	MET high n=203		MET low n=141	MET moderate n=269	MET high n=329	
	mean (SD)	mean (SD)	mean (SD)	p-value	mean (SD)	mean (SD)	mean (SD)	p-value
Waist to height ratio	0.56 (0.09)	0.55 (0.11)	0.55 (0.10)	0.157	0.58 (0.06)	0.56 (0.07)	0.55 (0.06)	<0.0001
Waist to hip ratio	0.85 (0.07)	0.83 (0.08)	0.85 (0.09)	ns	0.90 (0.05)	0.89 (0.06)	0.89 (0.06)	ns
Normalized weight adjusted index	0.73 (1.12)	0.45 (1.27)	0.24 (1.16)	<0.0001	1.34 (1.39)	0.91 (1.26)	0.71 (1.11)	<0.0001
Body adiposity index	21.28 (7.17)	20.71 (7.19)	20.93 (6.23)	ns	18.29 (5.74)	18.83 (5.64)	17.40 (6.47)	<0.0001
Abdominal volume index	16.76 (4.98)	16.76 (6.39)	16.76 (6.39)	ns	20.37 (4.55)	19.28 (4.29)	18.56 (3.90)	<0.0001
Visceral adiposity index	1.69 (1.43)	1.31 (0.88)	1.22 (0.86)	<0.0001	2.08 (1.72)	1.65 (1.35)	1.32 (1.09)	<0.0001
Body surface index	39.08 (2.98)	38.19 (3.47)	37.71 (3.21)	<0.0001	42.31 (3.38)	41.19 (3.14)	40.74 (2.81)	<0.0001
Body mass index	26.38 (4.20)	25.34 (4.88)	24.55 (4.31)	<0.0001	28.85 (4.58)	27.42 (4.19)	26.75 (3.70)	<0.0001
Deuremberg formula	36.70 (5.76)	34.90 (6.63)	33.71 (5.75)	<0.0001	29.30 (6.01)	27.54 (5.77)	26.16 (5.36)	<0.0001
Palafolls formula	39.37 (4.39)	38.20 (4.96)	37.31 (4.40)	<0.0001	31.73 (4.76)	30.23 (4.35)	29.56 (3.84)	<0.0001
CUN BAE	37.68 (5.65)	35.77 (6.45)	34.67 (5.89)	<0.0001	29.28 (5.82)	27.39 (5.77)	26.23 (5.33)	<0.0001
ECORE-BF	37.64 (5.91)	35.72 (6.77)	34.56 (6.03)	<0.0001	29.19 (5.68)	27.36 (5.68)	26.25 (5.18)	<0.0001
Body roundness index	5.15 (1.97)	5.12 (2.47)	5.10 (2.18)	ns	5.47 (1.39)	5.20 (1.48)	4.95 (1.29)	<0.0001
Body fat bioimpedance	35.76 (8.53)	34.33 (10.63)	33.17 (9.63)	<0.0001	32.29 (8.10)	30.41 (7.80)	28.61 (8.27)	<0.0001
Visceral fat bioimpedance	9.46 (3.17)	8.60 (3.98)	8.03 (3.41)	<0.0001	16.54 (6.47)	14.98 (5.88)	13.22 (6.06)	<0.0001

this type of diet have better values on the overweight and obesity scales. All the data are shown in **table III**.

As was the case with the mean values, the prevalence of altered values of overweight and obesity scales decreased in parallel with the increase in the level of physical activity, and this was observed in both women and men. The prevalence of high values of these scales also presents better results in those people with high adherence to the Mediterranean diet as shown in **table IV**.

In the multivariate analysis using binary logistic regression, male, age 50 years and older, smokers, social class II-III, MET low-moderate and low adherence to Mediterranean diet were established as covariates. Gender, age and social class are the only variables that show influence in all the scales analyzed. Of these, the one showing the greatest influence is social class, with odds ratios ranging from 1.98 (95% CI 1.42-2.75) for CUN BAE and 9.92 (95% CI 6.92-14.24) for Waist to height ratio high. All results are presented in **table V**.

Table III: Mean values of the different overweight-obesity scales according to healthy food by gender.

	Women			Men		
	Predimed low n=262	Predimed high n=456		Predimed low n=356	Predimed high n=383	
	mean (SD)	mean (SD)	p-value	mean (SD)	mean (SD)	p-value
Waist to height ratio	0.58 (0.10)	0.54 (0.11)	<0.0001	0.57 (0.06)	0.56 (0.07)	ns
Waist to hip ratio	0.86 (0.08)	0.83 (0.08)	<0.0001	0.90 (0.06)	0.89 (0.06)	ns
Normalized weight adjusted index	0.65 (1.17)	0.35 (1.23)	<0.0001	1.02 (1.33)	0.80 (1.15)	<0.0001
Body adiposity index	21.72 (6.60)	20.44 (7.06)	<0.0001	18.08 (6.05)	18.09 (6.10)	ns
Abdominal volume index	17.87 (5.88)	16.12 (5.89)	<0.0001	19.57 (4.31)	18.80 (4.10)	<0.0001
Visceral adiposity index	1.50 (1.14)	1.30 (0.98)	<0.0001	1,74 (1.50)	1.44 (1.19)	<0.0001
Body surface index	38.70 (3.26)	38.02 (3.33)	ns	41.51 (3.30)	40.92 (2.87)	ns
Body mass index	26.03 (4.42)	24.98 (4.68)	<0.0001	27.78 (4.40)	27.04 (3.83)	<0.0001
Deuremberg formula	35.68 (6.01)	34.60 (6.40)	<0.0001	27.64 (6.06)	26.91 (5.43)	<0.0001
Palafolls formula	38.85 (4.58)	37.86 (4.78)	<0.0001	30.60 (4.58)	29.86 (3.97)	<0.0001
CUN BAE	36.80 (6.07)	35.40 (6.22)	<0.0001	27.67 (5.97)	26.83 (5.40)	<0.0001
ECORE-BF	36.75 (6.26)	35.32 (6.52)	<0.0001	27.63 (5.82)	26.83 (5.29)	<0.0001
Body roundness index	5.59 (2.23)	4.89 (2.27)	ns	5.24 (1.36)	5.05 (1.42)	<0.0001
Body fat bioimpedance	36.35 (8.92)	33.19 (10.28)	<0.0001	31.26 (8.36)	28.77 (7.82)	<0.0001
Visceral fat bioimpedance	8.96 (3.82)	9.09 (3.65)	ns	15.01 (6.69)	13.82 (5.58)	<0.0001

Table IV: Prevalence of altered values of the different overweight-obesity scales according to physical activity and Mediterranean diet by gender.

	Women				Men			
	MET low n=170	MET moderate n=345	MET high n=203		MET low n=141	MET moderate n=269	MET high n=329	
	Percentage	Percentage	Percentage	p-value	Percentage	Percentage	Percentage	p-value
Waist to height ratio high	68.24	65.80	63.46	<0.0001	87.23	83.27	79.64	<0.0001
Waist to hip ratio high	46.47	44.96	43.74	<0.0001	14.18	13.01	12.37	<0.0001
BMI obesity	17.65	15.36	6.40	<0.0001	31.21	23.05	16.41	<0.0001
CUN BAE obesity	68.24	51.30	44.83	<0.0001	76.60	65.43	57.14	<0.0001
ECORE-BF obesity	67.06	50.43	43.35	<0.0001	76.57	65.41	57.75	<0.0001
Deuremberg formula obesity	80.00	62.61	58.13	<0.0001	78.72	66.17	54.41	<0.0001
Palafolls formula obesity	85.88	73.63	68.47	<0.0001	95.74	91.82	91.19	<0.0001
Body fat bioimpedance very high	36.47	35.94	28.57	<0.0001	56.03	51.67	41.95	<0.0001
	Women				Men			
	Predimed low n=262	Predimed high n=456			Predimed low n=356	Predimed high n=383		
	Percentage	Percentage	p-value		Percentage	Percentage	p-value	
Waist to height ratio high	78.62	60.96	<0.0001		83.71	81.20	<0.0001	
Waist to hip ratio high	45.42	44.08	<0.0001		14.32	13.48	<0.0001	
BMI obesity	17.18	11.18	<0.0001		25.56	18.02	<0.0001	
CUN BAE obesity	58.78	50.44	<0.0001		65.45	62.40	<0.0001	
ECORE-BF obesity	57.63	49.34	<0.0001		65.45	62.92	<0.0001	
Deuremberg formula obesity	69.47	63.16	<0.0001		63.48	63.19	<0.0001	
Palafolls formula obesity	79.01	72.81	<0.0001		92.70	91.91	<0.0001	
Body fat bioimpedance very high	38.93	31.14	<0.0001		56.46	40.47	<0.0001	

Table V: Logistic regression analysis.

	Male	Age ≥50 years	Smokers	MET low-moderate	Predimed low	social class II-III
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Waist to height ratio high	1.59 (1.21-2.11)	3.90 (2.71-5.59)	ns	ns	1.56 (1.17-2.07)	9.92 (6.92-14.22)
Waist to hip ratio high	0.13 (0.10-0.17)	1.36 (1.04-1.79)	1.39 (1.06-1.83)	ns	ns	8.23 (4.90-13.82)
BMI obesity	1.72 (1.28-2.30)	1.69 (1.27-2.25)	0.67 (0.48-0.93)	2.06 (1.49-2.84)	1.54 (1.16-2.04)	2.03 (1.22-3.40)
CUN BAE obesity	1.31 (1.04-1.65)	4.32 (3.29-5.67)	ns	1.54 (1.22-1.96)	1.27 (1.01-1.60)	1.98 (1.42-2.75)
ECORE-BF obesity	1.44 (1.14-1.81)	3.99 (3.05-5.20)	ns	1.57 (1.24-1.99)	ns	2.07 (1.49-2.86)
Deuremberg formula obesity	0.66 (0.52-0.85)	9.85 (6.90-14.06)	ns	1.73 (1.35-2.22)	ns	2.71 (1.94-3.79)
Palafolls formula obesity	3.66 (2.63-5.11)	1.85 (1.27-2.69)	0.66 (0.48-0.92)	1.67 (1.22-2.30)	ns	2.80 (1.93-4.04)
Body fat bioimpedance very high	1.58 (1.26-1.99)	1.91 (1.51-2.42)	0.77 (0.60-0.99)	1.57 (1.23-2.00)	1.59 (1.27-1.99)	4.40 (2.88-6.73)

Discussion

All the overweight and obesity scales and body fat estimation scales analyzed in this study showed mean values that improved as the level of physical activity increased; this improvement was also observed in persons with high adherence to the Mediterranean diet. When the prevalence of obesity was assessed with all the scales, a similar trend was observed. In the multivariate analysis, the level of physical activity increased the risk of presenting obesity more than adherence to the Mediterranean diet and it was observed that both variables did not increase the risk in all the scales.

The review of the existing scientific literature shows that most studies find a relationship between the level of physical activity and/or adherence to the Mediterranean diet with the values of the scales related to overweight and obesity. In general, better values are observed in people with high levels of physical activity or healthy eating.

We have found a study that evaluates, as we do, the impact of physical activity determined with the IPAQ questionnaire and the Mediterranean diet with a large number of obesity-related scales (BMI, waist circumference, waist/height index, tightness index, body roundness index, body shape index and equations to estimate the percentage of body fat such as CUN BAE and Deuremberg), this work performed in 6672 middle-aged subjects with low to moderate cardiovascular risk belonging to the Ilerda Vascular (ILERVAS) project[26] showed that, independent of sex, lower physical activity indices were associated with higher values of total body fat and central adiposity. This result was consistent and independent of the indices used to estimate adiposity. However, the association between adherence to the Mediterranean diet and obesity indices was much less marked and more sex-dependent than that observed for physical activity. These results are in general very similar to those obtained by us.

In the rest of the studies we have analyzed, the number of overweight and obesity scales included is much lower than those presented in our work.

To compare our results with those obtained in other studies, we will separate those studies that evaluate the impact of physical activity from those that evaluate the effect of healthy eating on overweight and obesity scales. Other studies have also obtained results similar to ours: an investigation in 528 adults between 30 and 80 years of age with type 2 diabetes related waist circumference values to physical activity determined with accelerometers, measurements were taken at baseline and at 6 months and it was observed that each hour of sedentary activity was associated with an increase of 1.89 cm in waist circumference[27]. Along the same lines are the results of a cohort from the PREDIMED Plus study with a high degree of cardiovascular disease, in which it was observed that more time spent in moderate or vigorous physical activity and less time spent in sedentary behaviors was inversely associated with the prevalence of obesity and some components of the metabolic syndrome[28]. Along the same lines, the 2003-2006 National Health and Nutrition Examination Survey of the United States found that moderate or vigorous physical activity determined with an accelerometer was strongly and negatively associated with BMI and waist circumference[29]. Other studies follow the same pattern, as in a group of 138 sedentary, postmenopausal Colombian women who participated in a program of controlled physical activity with sessions of one hour three times a week for four months, observed a decrease of 1.2 kg of weight and 2.0 kg of body fat at the end of the program[30]. More recently, other authors[31] demonstrated in 298 overweight adults that moderate to vigorous physical activity was inversely associated with the percentage of body fat and visceral adipose tissue assessed by DXA. In this study, the inverse relationship between physical activity and body fat percentage was stronger for non-Latinos than for Latinos, a fact that introduces the possibility that differences in diet and eating habits may modulate the impact of physical activity on anthropometric indices. All these studies show, like ours, the beneficial effect of physical activity on excess weight and body fat.

Some research presents somewhat different results to those seen so far, for example a study that analyzed data from North American adults from the National Health and Nutrition Survey between the years 1988 and 2010 where the relationship between BMI and waist circumference with physical activity and diet was evaluated showed that there was a decrease in the two parameters in people who performed physical activity compared to those who did not, however, found no relationship with diet[32].

Several studies showed that physical activity did not improve all parameters related to overweight and obesity: the first, conducted in a group of Chilean women over 60 years old, analyzed the impact of a 12-week physical exercise program on different anthropometric parameters and saw that there was a significant decrease in waist circumference and waist/hip ratio and that the same did not occur with BMI[33].

When we evaluated the effect of adherence to the Mediterranean diet on overweight and obesity scales, we found that some randomized clinical trials and meta-analyses support that physical activity added to dietary intervention further improves the amount of weight loss achieved[34]. Other research has found that high adherence to the Mediterranean diet has been associated with weight loss and reduced long-term weight gain if energy restriction is present[35]. However other authors have presented conflicting results between high adherence to

the Mediterranean diet and weight changes[36]. A possible explanation would be that the amount of calories from the components of the Mediterranean diet (olive oil, whole grains and nuts), prevented finding differences in obesity rates in the high adherence categories included in the ILERVAS trial, as they possibly did not reach a negative energy balance26. Perhaps the traditional nutritional pattern that characterizes high adherence to the Mediterranean diet may exert its effect through different pathophysiological mechanisms unrelated to weight loss, such as improving the lipid profile, modulating inflammation, improving its antioxidant properties, and reducing blood pressure and insulin resistance, among others[37].

As strengths of this study we find the high sample size, almost 1500 people, the significant number of scales of overweight, obesity and body fat estimation analyzed (15 scales) and that both physical activity and adherence to the Mediterranean diet have been assessed with validated scales such as IPAQ and PREDIMED.

The main limitation of this study is that it was carried out in a very specific geographical area, which prevents us from extrapolating our results to other countries.

Conclusions

The increase in physical activity levels determined with the IPAQ questionnaire and the increase in adherence to the Mediterranean diet assessed with the PREDIMED questionnaire improve all scales of overweight, obesity and body fat in spanish mediterranean population.

Interests conflict

The researchers declare that they have no conflict of interest.

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