# Adherence to the Traditional Mediterranean Diet Is Inversely Associated with Body Mass Index and Obesity in a Spanish Population[1]

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ABSTRACT The Mediterranean diet is a healthy eating pattern with protective effects on chronic diseases. The purpose of this study was to assess the relation between BMI and obesity and the level of adherence to the traditional Mediterranean diet. The subjects were Spanish men ($n$ = 1547) and women ($n$ = 1615) aged 25–74 y who were examined in 1999–2000, in a population-based, cross-sectional survey in the northeast of Spain (Girona). Dietary intake was assessed using a FFQ. A Mediterranean diet score, including foods considered to be characteristic components of the traditional Mediterranean diet (vegetables, fruits, pulses, nuts, fish, meat, cereals, olive oil, and wine) was created. An increase of 5 U in the dietary score was associated with a change in the BMI of 0.43 ($P$ = 0.030) and 0.68 ($P$ = 0.007), after controlling for potential confounders, in men and women, respectively. The obesity risk decreased in men ($P$ = 0.010) and women ($P$ = 0.013) with increasing adherence to the traditional Mediterranean dietary pattern. The population in the top tertile of this score were less likely to be obese in both genders [odds ratio (OR) and (95% CI): 0.61 (0.40–0.92) in men; 0.61 (0.40–0.93) in women] after adjusting for potential confounders. These data suggest that the traditional Mediterranean dietary pattern is inversely associated with BMI and obesity. This finding may be useful in the development of dietary approaches for dietary counseling and the prevention of obesity. J. Nutr. 134: 3355–3361, 2004.

KEY WORDS: • *body mass index* • *obesity* • *Mediterranean diet* • *dietary pattern*

The prevalence of obesity is increasing in industrialized nations at an epidemic level (1). Obesity is associated in particular with the development of type II diabetes, hypertension, coronary heart disease (CHD),[3] and an increased incidence of several types of cancer (2–4). The health consequences of obesity in developed countries represent an economic load of between 2 and 7% of the total health cost, a substantial proportion of the national health cost. Awareness of the high prevalence of obesity increased in the United States during the last several years (5). A similar pattern can also be observed for several European countries (6–8) with strong regional variability. The highest values are found in southern Spain and the lowest in northeast Spain.

Obesity is not a single disorder, but a complex multifactorial disease involving environmental and genetic factors. Among the environmental factors, diet appears be an important contributor to the development of obesity. Epidemiologic evidence on the association of nutrients, particularly fat, with obesity remains controversial (9–12). Because of several shortcomings in traditional, nutrient-based diet and disease analysis (13), the focus has shifted from this type of analysis to one describing food intake patterns. Such analysis takes into account the complex combination of foods in a diet. The effect of such food-based defined dietary patterns might be more closely related to obesity than a single nutrient or food. Hence, food-based dietary patterns may be more useful than nutrient-based methods for dietary counseling and in public health efforts.

Several epidemiologic studies examined the association of dietary patterns and excessive weight (14–17). These food-based dietary patterns are created by several statistical methodologies (13). Identifying palatable dietary patterns that prevent weight gain is an important task for health policy in view of the social and economic burden of obesity. The Mediterranean diet is an eating pattern that successfully combines pleasant taste with positive health effects. The Mediterranean diet does not stand for a homogeneous exclusive model throughout the Mediterranean basin; rather, it represents a set of healthy dietary habits including high consumption of vegetables and fresh fruits, with olive oil as the main source of fat. However, whether adherence to this healthy dietary pattern might be protective against weight gain remains unclear. Hence, the aim of this study was to analyze the relation between BMI and obesity and adherence to the traditional Mediterranean diet, taking into account potential confounders in a representative population of a southern European Mediterranean region.

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[3] Abbreviations used: CHD, coronary heart disease; LTPA, leisure-time physical activity; MET, metabolic equivalent; OR, odds ratio; SES, socioeconomic status.



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## SUBJECTS AND METHODS

***Participants.*** The methods for the cardiovascular risk population-based cross-sectional survey conducted in Girona (Spain) in 2000 are identical to those of the cross-sectional survey of 1995, described in detail elsewhere (18). Free-living Spanish men and women from the province of Girona, between 25 and 74 y of age, participated in this study from 1999 to 2000. Subjects ($n = 6000$) were randomly selected from the general population of Girona according to the 1996 census. After excluding census errors, 4359 eligible subjects remained; 3179 men and women agreed to participate. Dietary data were available from 2930 participants. All participants signed an informed consent form to allow their personal data to be stored in a computer database, and the acquisition of biological samples for the necessary analyses. The protocol was approved by the Ethic Committee of the Institut Municipal Assistencia (IMAS, Barcelona), and the results of the examination were sent to all participants.

***Dietary assessment.*** Information on demographic and socioeconomic variables, lifestyle factors, including tobacco smoking and alcohol consumption, diet, and medical history was obtained through structured standard questionnaires, administered by trained personnel. Food consumption and nutrient intake were measured by a validated FFQ (19) administered by a trained interviewer. In brief, the validity of a questionnaire is defined primarily as its ability to classify study subjects according to a rank of nutrient intake. We determined the agreement in ranking of nutrient intake between our questionnaire and the standard (3-d record). The consistency of ranking was determined by the following: *1*) Pearson's correlation coefficients (mean of 0.37); *2*) intraclass correlation coefficients (mean of 0.43); and *3*) the proportion of correct classification (mean of 33.0%) into the same and extreme quartile and that of misclassification (mean of 6.8%). These data indicated acceptable relative validity of the FFQ. Furthermore, the range of correlation coefficients between dietary intakes of protein ($r = 0.26$), vitamin C ($r = 0.54$), $\beta$-carotene ($r = 0.17$), and selenium ($r = 0.26$) and their corresponding biomarkers in urine and plasma, were comparable to those found by other dietary assessment methods (19). The optical readable FFQ asked for the usual food intake over the past year. The food list contained 165 items, including foods, alcoholic, and nonalcoholic beverages. For each food item, participants were asked to indicate their usual consumption from the 10 frequency categories, ranging from never or <1 time/mo to ≥6 times/d. The FFQ did not include standard questions on portion size but rather specific medium servings, defined by natural (e.g., 1 orange, 1 slice of bread) or household units (e.g., 1 spoon, 1 cup, 1 glass) were indicated. Energy consumption and nutrient intake was calculated from the FFQ using the Medisystem 2000 software.

***The Mediterranean diet score.*** A Mediterranean diet score based on the intake of cereals, vegetables, fruits, legumes, nuts, fish, high-fat diary products, meat, and red wine was computed. Multiple food components were operationalized as a single dietary exposure variable in a way similar to that used by other authors (20–23). The characteristics of the present scoring system are based on the traditional food consumption of the Mediterranean region described by Trichopoulou (20). Adherence to this diet has been associated with a lower risk of cancer and CHD mortality (21), myocardial infarction (22), and longevity (20,23). The score was calculated, with the exception of red wine, according to the tertile distribution of consumption. The lowest tertile was coded as 1, medium as 2, and highest as 3 for cereals, fruits, vegetables, legumes, fish, and nuts. The highest tertile was coded as 1, medium as 2, and lowest as 3 for meat and high-fat diary products. Red wine consumption was computed as alcohol intake from red wine (0 g and >20 g of alcohol = 1, and up to 20 g of alcohol = 3). The values of distribution of all dietary components were calculated. The resulting Mediterranean diet score ranged from 9 to 27. Nutrient density was calculated by dividing absolute nutrient intake by total energy intake. We expressed the nutrient amount/4.18 MJ. The estimated basal metabolic rate was calculated according to the WHO equation separately for gender and age groups (24). Individuals with an energy intake to basal metabolic rate ratio < 1.2 were excluded from further analysis. This low ratio is rare; therefore, such values likely reflect underreporting of dietary intakes (25).

***Leisure-time physical activity (LTPA).*** LTPA was measured by the Minnesota LTPA questionnaire. This questionnaire was validated previously for Spanish men and women (26,27). The Spearman correlation coefficients between the estimated energy expenditure in LTPA and a fitness indicator obtained by a standardized exercise test were 0.57 and 0.39, in men and women, respectively (26,27), comparable to the results observed in other populations and with other questionnaires. In summary, the questionnaire was administrated by a trained interviewer. The interviewee was provided with detailed instructions and a list of physical activities. Participants were asked to mark those activities that they had undertaken during the last year. Then the number of times this activity was performed and the mean duration of its practice on each occasion was recorded. Each physical activity had an intensity code obtained in standardized experimental situations, based on the ratio between the metabolic rate during work and the basal metabolic rate (28). An estimation of energy expenditure in the LTPA in (MET · min)/d was obtained; 1 metabolic equivalent (MET), the energy expended by sitting quietly, is equivalent to 3.5 mL oxygen uptake/(kg body weight · min) (28). A sedentary lifestyle was defined as an energy expenditure during leisure time < 1000 (MET · min)/wk.

***Anthropometric measurements.*** An easily calibrated precision scale was used for weight measurement. Readings were rounded up to 200 g. Individuals wore only their underwear. Height was measured in the standing position, and measurements were rounded up to 0.5 cm. BMI was determined as weight divided by height squared ($kg/m^2$). Obesity was defined as a BMI ≥ 30.

***Smoking.*** Information on smoking habits of the participants was obtained by a structured interview. Participants were categorized as people who had never smoked, former smokers (<1 y), and current smokers (at least 1 cigarette/d on average during the last year). The latter were asked for the mean daily number of cigarettes smoked.

***Educational status.*** Maximum level of education attained was elicited; for purposes of analysis, it was recorded as illiterate, primary school, secondary school, and university.

***Statistical analysis.*** All analyses were conducted for men and women separately and were controlled for age. Differences in continuous variables were compared using Student's $t$ test. Categorical variables were tested using the $\chi^2$ test. General linear modeling procedures (PROC.GLM; SAS Institute; version 8.0) were used to estimate energy consumption, nutrient and food intakes, alcohol drinking behaviors, smoking habits, and LTPA according to adherence to the Mediterranean diet (quartiles).

Multiple linear regression models were fitted (PROREG, SAS Institute; version 8.0) to determine whether BMI was independently related to the Mediterranean diet score adjusting for potential confounders. In this model, BMI (continuous) was introduced as the exposure and the Mediterranean diet score (continuous) as the predictor variable. Age (y; continuous) and, energy consumption (kJ; continuous), LTPA (MET; continuous), educational status (illiterate, primary school, secondary school, and university; categorical), current smoking and alcohol drinking status (binary; categorical) were added as confounding covariates.

The associations of obesity with the Mediterranean diet score were estimated by logistic regression analysis with the use of the PROCLOGISTIC procedure of SAS (SAS Institute; version 8.0). For this purpose we calculated the quartiles of the distribution of the Mediterranean diet score for men and women. The lowest quartile refers to the lowest adherence to the traditional Mediterranean diet and was chosen as the reference category in the logistic regression models. The odds ratio (OR) for obesity was estimated for the diet score (quartiles; categorical) adjusting for age (y; continuous). In addition to age, energy consumption (kJ; continuous), LTPA (MET; continuous), educational status (illiterate, primary school, secondary school, and university; categorical), current smoking and alcohol drinking status (binary; categorical) were introduced in a second multiple logistic model to estimate the independent association of obesity and the Mediterranean diet score. Differences were considered significant if $P < 0.05$.

## RESULTS

Comparisons of the characteristics of the study population revealed no significant differences in age and levels of education between genders. Men had higher waist circumferences and a higher BMI than women. The prevalence of obesity was higher in women than in men. Women spent less time in LTPA, were more likely to be a nonsmoker and alcohol abstainer, and had a higher ratio of energy intake to basal metabolic rate than men (**Table 1**).

The consumption of fruits, fish, legumes, nuts, and olive oil, expressed as g/4.18 MJ of energy intake, increased significantly with higher adherence to the Mediterranean diet in both genders, whereas this trend was observed for the consumption of total cereals, whole grain cereals, and pulses only in men (**Table 2**). Conversely, the consumption of meat, sweets, and pastries in both genders and fast food in women decreased with higher adherence to the Mediterranean diet. Trends of energy consumption and nutrient and water intake, expressed as a percentage of energy consumption and as g/4.18 MJ, were similar in men and women. Energy and water consumption increased across quartiles of the Mediterranean diet score (Table 2). The dietary intakes of carbohydrate, protein, and fiber were directly associated with the Mediterranean diet score, whereas the opposite was found for fat and saturated fat. The ratio of unsaturated to saturated fat significantly increased across quartiles of the Mediterranean diet score.

Men and women with a high adherence to the Mediterranean diet were more active; they included fewer smokers and more alcohol consumers. There was no significant linear trend for the total alcohol consumed among alcohol drinkers across quartiles of the Mediterranean diet score in both genders (**Table 3**). The prevalence of underreporting was significantly higher in obese compared with nonobese men (32.8 vs. 20.6%, $P < 0.001$) and women (53.5 vs. 21.5%, $P < 0.001$).

Multiple linear regression analysis of the association between BMI and the Mediterranean diet score revealed an independent inverse association between these variables in both men ($n$ = 1329) and women ($n$ = 1397). An increment of 5 U in the dietary score was associated with a BMI decrease of 0.43 ($\beta$ coefficient: −0.043, SD: 0.040, $P = 0.030$, $R^2$ for model: 0.082) and 0.68 U ($\beta$ coefficient: −0.068, SD: 0.050, $P = 0.007$, $R^2$ for model: 0.171), in men ($n$ = 1329) and women ($n$ = 1397), respectively. Furthermore, confounding variables were associated with an increase of 1 U in the BMI as follows: men: [age (y): $\beta$ coefficient: 0.065, SD: 0.009: $P < 0.001$; energy intake (MJ): $\beta$ coefficient: 0.041, SD: 0.033, $P = 0.217$; LTPA [100 (MET · min)/d]: $\beta$ coefficient: −0.047, SD: 0.027, $P = 0.081$; smoking (binary): $\beta$ coefficient: −0.923, SD: 0.241, $P < 0.001$; alcohol drinking (binary): $\beta$ coefficient: 0.819, SD: 0.394, $P = 0.007$; educational level (continuous): $\beta$ coefficient: 0.357, SD: 0.152, $P = 0.019$]; women: [age (y): $\beta$ coefficient: 0.094, SD: 0.012, $P < 0.001$; energy intake (MJ): $\beta$ coefficient: 0.072, SD: 0.041, $P = 0.080$; LTPA [100 (MET · min)/d]: $\beta$ coefficient: −0.060, SD: 0.039, $P = 0.123$; smoking (binary): $\beta$ coefficient: −1.017, SD: 0.349, $P = 0.004$; alcohol drinking (binary): $\beta$ coefficient: −0.495, SD: 0.266, $P = 0.063$; educational level (continuous): $\beta$ coefficient: 1.173, SD: 0.184, $P < 0.001$.

We fitted logistic regression models to determine the relation between the adherence to the Mediterranean diet and obesity (**Table 4**). In the age-adjusted analysis, adherence to the Mediterranean diet, assessed by the score quartiles, tended to be associated with a lower prevalence of obesity in both genders. This association was significant in women but not in men ($P = 0.180$). Further adjustment for energy consumption, educational level, smoking, LTPA, smoking and alcohol consumption, showed a significant 39% lower risk of being obese, for both men and women, in a comparison of those in the



**TABLE 1**

*Characteristics of the study participants*[1]

| | Men $n$ = 1403 | Women $n$ = 1468 | $P$-value |
|---|---|---|---|
| Age, *y* | 50.4 ± 13.5 | 50.0 ± 13.5 | 0.386 |
| BMI, *kg/m²* | 27.8 ± 4.2 | 27.3 ± 5.7 | 0.003 |
| Waist circumferences, *cm* | 95.8 ± 11.5 | 84.5 ± 13.7 | <0.001 |
| EI:BMR[2] | 1.42 ± 0.60 | 1.63 ± 0.70 | 0.009 |
| Obese,[3] % | 25.6 | 26.3 | 0.752 |
| LTPA, *(MET · min)/d* | 373.6 ± 386.2 | 320.3 ± 322.8 | 0.002 |
| Mediterranean diet score, *units* | 17.8 ± 3.1 | 17.5 ± 3.1 | 0.009 |
| Low LTPA,[4] % | 27.4 | 28.3 | 0.574 |
| Current smoker, % | 29.0 | 18.0 | <0.001 |
| Cigarette consumption (smokers), *units/d* | 19.5 ± 11.1 | 14.7 ± 11.0 | <0.001 |
| Current alcohol consumers, % | 85.9 | 60.8 | <0.001 |
| Alcohol consumption (alcohol drinkers), *g/d* | 21.1 ± 20.9 | 8.7 ± 12.2 | <0.001 |
| Educational status, % | | | 0.009 |
| University | 11.2 | 13.2 | — |
| Secondary School | 21.2 | 23.9 | — |
| Primary School | 63.4 | 57.8 | — |
| Civil status, % | | | <0.001 |
| Single | 11.0 | 7.4 | — |
| Married | 85.0 | 80.7 | — |
| Separated | 2.2 | 3.1 | — |
| Widowed | 1.6 | 8.7 | — |

1 Values are means ± SD or %.
2 Energy intake:estimated basal metabolic rate.
3 BMI ≥ 30.
4 LTPA < 1000 (MET · min)/wk.

**TABLE 2**

*Mean daily age-adjusted food consumption and selected nutrient intake according to adherence to the Mediterranean diet*

| | Mediterranean diet score | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Men | | | | | Women | | | | |
| Quartile | Lowest | Second | Third | Top | *P* for linear trend | Lowest | Second | Third | Top | *P* for linear trend |
| *n* | 344 | 304 | 340 | 409 | | 409 | 358 | 313 | 386 | |
| | *g/4.18 MJ* | | | | | | | | | |
| Cereals[1] | 69.8 | 74.6 | 74.1 | 75.4 | 0.044 | 70.3 | 66.4 | 69.7 | 70.1 | 0.750 |
| Vegetables[1] | 134.8 | 157.8 | 181.6 | 222.3 | <0.001 | 195.7 | 228.5 | 246.1 | 257.9 | <0.001 |
| Fruits[1] | 121.5 | 160.4 | 188.8 | 222.6 | <0.001 | 194.7 | 249.6 | 267.4 | 289.4 | <0.001 |
| Meat[1] | 78.6 | 69.8 | 65.9 | 58.6 | <0.001 | 80.3 | 65.7 | 60.7 | 51.4 | <0.001 |
| Fish[1] | 24.5 | 30.1 | 34.0 | 37.2 | <0.001 | 28.9 | 35.5 | 33.6 | 37.8 | <0.001 |
| Pulses[1] | 20.5 | 23.1 | 23.4 | 25.3 | 0.010 | 19.7 | 21.6 | 21.2 | 21.9 | 0.078 |
| Nuts[1] | 2.9 | 5.0 | 6.9 | 8.8 | <0.001 | 3.1 | 5.3 | 8.1 | 10.0 | <0.001 |
| Olive oil[1] | 6.0 | 8.3 | 9.3 | 10.2 | <0.001 | 10.3 | 12.1 | 11.9 | 12.8 | <0.001 |
| Whole grain cereals[2] | 3.8 | 4.9 | 4.4 | 6.8 | 0.003 | 8.7 | 7.8 | 9.3 | 10.6 | 0.067 |
| Sweets and pastries[2] | 12.3 | 13.0 | 10.1 | 9.7 | <0.001 | 11.8 | 11.6 | 11.1 | 9.6 | 0.003 |
| Fast food[2] | 0.75 | 0.46 | 0.72 | 0.40 | 0.103 | 0.89 | 0.47 | 0.33 | 0.28 | 0.002 |
| Energy, *MJ/d* | 9.0 | 10.5 | 11.7 | 13.6 | <0.001 | 8.5 | 10.0 | 11.2 | 13.5 | <0.001 |
| Energy,[3] *MJ/d* | 9.5 | 11.0 | 12.3 | 14.1 | <0.001 | 8.6 | 10.2 | 11.3 | 13.7 | <0.001 |
| Energy density, *kJ/g* | 5.56 | 5.43 | 5.08 | 4.77 | <0.001 | 4.62 | 4.49 | 4.29 | 4.79 | <0.001 |
| Water,[4] *g/4.18 MJ* | 616.2 | 624.4 | 664.0 | 709.0 | <0.001 | 772.9 | 797.8 | 817.8 | 824.7 | <0.001 |
| Carbohydrate,[5] % | 39.1 | 40.7 | 40.7 | 42.1 | <0.001 | 38.9 | 39.7 | 41.4 | 42.3 | <0.001 |
| Protein,[5] % | 17.7 | 17.1 | 17.2 | 16.9 | 0.001 | 18.3 | 17.6 | 17.2 | 16.8 | <0.001 |
| Fat,[5] % | 43.2 | 42.1 | 42.1 | 40.9 | <0.001 | 42.8 | 42.7 | 41.4 | 40.9 | <0.001 |
| Saturated fat,[5] % | 13.0 | 12.0 | 11.5 | 10.9 | <0.001 | 12.0 | 11.3 | 10.9 | 10.4 | <0.001 |
| Monounsaturated fat,[5] % | 19.0 | 19.3 | 19.7 | 19.3 | 0.214 | 19.9 | 20.4 | 20.1 | 20.0 | 0.926 |
| Polyunsaturated fat,[5] % | 6.0 | 5.9 | 6.1 | 6.0 | 0.905 | 6.1 | 6.1 | 5.9 | 6.0 | 0.067 |
| Dietary fiber, *g/4.18 MJ* | 8.4 | 9.9 | 10.8 | 12.4 | <0.001 | 10.5 | 12.1 | 13.0 | 14.0 | <0.001 |
| Unsaturated:saturated fat | 2.00 | 2.16 | 2.31 | 2.40 | <0.001 | 2.29 | 2.41 | 2.47 | 2.60 | <0.001 |

[1] Food groups included in the Mediterranean diet score.
[2] Food groups not included in the Mediterranean diet score.
[3] Including alcohol consumption.
[4] Water content of foods.
[5] Percentage of total energy consumption.



**TABLE 3**

*Age and age-adjusted lifestyle and anthropometric variables according to adherence to the Mediterranean diet*

| | Mediterranean diet score | | | | |
|---|---|---|---|---|---|
| Quartile | Lowest | Second | Third | Top | *P* for linear trend |
| Men, *n* | 344 | 304 | 340 | 409 | |
| Age, *y* | 47.9 | 50.9 | 51.6 | 51.2 | 0.001 |
| LTPA, *(MET · min)/d* | 338.5 | 345.4 | 369.2 | 425.6 | 0.002 |
| Low LTPA,[1] % | 34.5 | 30.2 | 26.6 | 20.1 | <0.001 |
| Smokers, % | 36.4 | 35.8 | 26.5 | 22.4 | <0.001 |
| Alcohol drinkers, % | 78.9 | 85.5 | 86.3 | 91.8 | <0.001 |
| Alcohol intake among alcohol drinkers, *g/d* | 22.2 | 21.8 | 22.1 | 18.8 | 0.063 |
| Women, *n* | 409 | 358 | 313 | 386 | |
| Age, *y* | 48.8 | 51.3 | 50.5 | 50.0 | 0.495 |
| LTPA, *(MET · min)/d* | 293.0 | 313.0 | 333.5 | 347.0 | 0.013 |
| Low LTPA,[1] % | 36.2 | 29.8 | 26.0 | 20.0 | <0.001 |
| Smokers, % | 22.4 | 16.8 | 12.6 | 17.6 | 0.022 |
| Alcohol drinkers, % | 46.6 | 59.2 | 62.6 | 75.7 | <0.001 |
| Alcohol intake among alcohol drinkers, *g/d* | 8.8 | 8.2 | 8.1 | 9.4 | 0.653 |

[1] LTPA < 1000 (MET · min)/wk.

**TABLE 4**

*Regression coefficients and OR of obesity according to the Mediterranean diet score (MDS)*

| | Age adjusted model[1] | | | Full adjusted model[2] | | |
|---|---|---|---|---|---|---|
| | Frequency (*n*) | Regression coefficient (SD) | Odds ratio (95% CI) | Frequency (*n*) | Regression coefficient (SD) | Odds ratio (95% CI) |
| Men | 1391 | | | 1329 | | |
| MDS first quartile | 343 | 1 [Reference] | 1 [Reference] | 322 | 1 [Reference] | 1 [Reference] |
| MDS second quartile | 303 | 0.016 (0.182) | 1.02 (0.71–1.45) | 296 | −0.082 (0.191) | 0.92 (0.63–1.33) |
| MDS third quartile | 339 | −0.164 (0.181) | 0.85 (0.60–1.21) | 327 | −0.305 (0.197) | 0.73 (0.49–1.07) |
| MDS top quartile | 406 | −0.254 (0.175) | 0.78 (0.55–1.09) | 384 | −0.489 (0.210) | 0.61 (0.40–0.92) |
| Age, *y* | 1391 | 0.036 (0.005) | 1.04 (1.03–1.05) | 1329 | 0.032 (0.006) | 1.03 (1.02–1.04) |
| Energy intake, *MJ/d* | — | | — | 1329 | 0.007 (0.021) | 1.01 (0.97–1.05) |
| LTPA,[3] *100 (MET · min)/d* | — | | — | 1329 | −0.022 (0.018) | 0.98 (0.9–1.02) |
| Smoking[4] | — | | — | 390 | −0.430 (0.163) | 0.65 (0.47–0.90) |
| Alcohol drinking[4] | — | | — | 1139 | 0.537 (0.200) | 1.71 (1.16–2.53) |
| Educational level | | | | | | |
| University | — | | — | 147 | 1 [Reference] | 1 [Reference] |
| Secondary school | — | | — | 276 | 0.084 (0.272) | 1.09 (0.69–1.85) |
| Primary school | — | | — | 849 | 0.322 (0.237) | 1.38 (0.87–2.20) |
| Less than primary school | — | | — | 57 | 0.649 (0.537) | 1.91 (0.92–3.98) |
| Linear *P* for trend (MDS) | | | 0.180 | | | 0.012 |
| Women | 1456 | | | 1397 | | |
| MDS first quartile | 406 | 1 [Reference] | 1 [Reference] | 395 | 1 [Reference] | 1 [Reference] |
| MDS second quartile | 355 | −0.097 (0.168) | 0.91 (0.65–1.26) | 340 | −0.166 (0.177) | 0.85 (0.60–1.20) |
| MDS third quartile | 312 | −0.335 (0.179) | 0.72 (0.50–1.02) | 300 | −0.384 (0.197) | 0.68 (0.46–1.00) |
| MDS top quartile | 383 | −0.546 (0.175) | 0.58 (0.41–0.82) | 362 | −0.492 (0.214) | 0.61 (0.40–0.93) |
| Age, *y* | 1456 | 0.052 (0.005) | 1.05 (1.04–1.06) | 1397 | 0.036 (0.006) | 1.04 (1.02–1.05) |
| Energy intake, *MJ/d* | — | | — | 1397 | 0.017 (0.021) | 1.02 (0.98–1.06) |
| LTPA,[3] *100 (MET · min)/d* | — | | — | 1397 | −0.021 (0.023) | 0.98 (0.94–1.02) |
| Smoking[4] | — | | — | 245 | −0.349 (0.213) | 0.71 (0.47–1.07) |
| Alcohol drinking[4] | — | | — | 843 | −0.263 (0.134) | 0.77 (0.59–1.00) |
| Educational level | | | | | | |
| University | — | | — | 179 | 1 [Reference] | 1 [Reference] |
| Secondary school | — | | — | 325 | 0.084 (0.329) | 2.32 (1.22–4.42) |
| Primary school | — | | — | 821 | 1.220 (0.309) | 3.39 (1.85–6.21) |
| Less than primary school | — | | — | 72 | 1.665 (0.397) | 5.29 (2.43–11.51) |
| Linear *P* for trend (MDS) | | | 0.001 | | | 0.011 |

1 −2log(likelihood) improvement of the model: men = 59.2, $P < 0.001$; women = 132.5, $P < 0.001$.
2 −2log(likelihood) improvement of the model: men = 76.3, $P < 0.001$; women = 160.3, $P < 0.001$.
3 Leisure-time physical activity.
4 Binary (0 = no, 1 = yes).



highest quartile of the Mediterranean diet score with those in the lowest quartile.

## DISCUSSION

The main finding of this study is that high adherence to the traditional Mediterranean dietary pattern, characterized by high intakes of vegetables, fruits, legumes, fish, cereals, and nuts and low and moderate consumption of meat and wine, respectively, is associated with a lower prevalence of obesity in men and women in this Mediterranean population. This association held even after controlling for age, LTPA, educational level, smoking, and alcohol consumption.

High BMI or obesity is an important independent risk factor for various chronic diseases, including heart disease, cancer, and diabetes (2–4). Obesity has increased dramatically during the last decade not only in the United States but also in Europe, and particularly in Spain (7,29,30). The prevalence of obesity among 25- to 60-y-old Spaniards is 14.5% (8). These observations emphasize that obesity and its deleterious effects on health are creating a serious pandemic in the industrialized world.

The present study population inhabits the wealthiest region of Spain, with a prevalence of obesity significantly higher than that of the general Spanish population (8). In view of the deleterious health effects of obesity and its associated increased mortality risk, effective treatment and prevention policies should be urgently sought.

The traditional Mediterranean diet refers to a food pattern first described by Ancel Keys in the 1960s (31). This healthy dietary pattern is associated with a significant reduction in cardiovascular and cancer mortality (21). The main characteristics of this dietary pattern consist of a high consumption of plant-based foods and low and high intakes of meat and fish, respectively. Furthermore, high intakes of both low (e.g., vegetables and fruits) and high (e.g., olive oil and nuts) energy-dense food characterize the traditional Mediterranean diet. Interestingly, in the present study, fast food, sweets, and pastries, which are atypical of the traditional Mediterranean diet, were consumed less often by those in the higher quartiles of the Mediterranean diet score. Indeed, this might be of importance for preventing weight gain because these 2 energy-dense food groups are frequently linked to the obesity epidemic (32,33).

Dietary patterns, including typical foods of the traditional Mediterranean diet such as vegetables, fruits, or olive oil, were associated with providing protective effects against cardiovascular disease (34–36), cancer (37), and obesity (38).

In the present study, adherence to the traditional Mediterranean dietary pattern was inversely correlated with BMI and was associated with a reduced risk of obesity in both genders. Long-term success in weight loss was reported for a Mediterranean-style diet in a randomized prospective 18-mo trial (39,40). Previous epidemiologic studies that analyzed the association of dietary patterns and excessive weight observed protective effects of dietary patterns that included some typical components of the traditional Mediterranean diet (14,41). Using a cluster analysis, Newby and collaborators (17) reported that a dietary pattern rich in vegetables and fruits was associated with smaller 3-y gain in BMI among adults compared with other dietary patterns. However, results concerning the association of BMI and obesity with a dietary pattern are inconsistent when exploring the data using predefined combinations of foods in a diet index (15). The fact that not all "healthy" dietary patterns were significantly associated with a lower BMI or risk of obesity might be a true observation, a consequence of insufficient control for confounders, or a result of differences in dietary assessment methods among studies. In the present study, we used a FFQ that was validated, including biomarkers, in a Spanish population (19). Several lifestyle factors might confound the association of obesity and diet. Socioeconomic status (SES), physical activity, and smoking strongly affect diet and weight gain (29,42–44). In the present study, the prevalence of a sedentary lifestyle and smoking decreased with higher adherence to the traditional Mediterranean dietary pattern. Interestingly, the association of obesity with the traditional Mediterranean dietary pattern was only slightly attenuated after controlling for these confounders. SES is commonly measured through education, occupation, and income in epidemiologic surveys (45). Education was reported to be the strongest and most consistent indicator in assessing differences in SES (45–47). However, each of these indicators is conceptually distinct; hence, the control for SES as a confounder is limited when using educational level as the only indicator of SES in statistical models. Education is directly associated with income and occupation in Spain (48)

Nevertheless, causality between obesity and the traditional Mediterranean dietary pattern cannot be drawn because of the cross-sectional design of the present study. A shortcoming of cross-sectional surveys is the possibility that the dietary pattern may represent a post-hoc event, i.e., that obese individuals have adopted a particular diet composition as a consequence of their obesity. Moreover, obese people tend to underreport their energy consumption and to overestimate the dietary intake of particular foods such as fruits and vegetables. In the present study, there was more energy underreporting among obese individuals. Furthermore, they reported higher intakes of "healthy" and low energy-dense foods such as fruits and vegetables (data not shown). These findings suggest an underestimation of the observed association between obesity and the Mediterranean diet score in the present study.

A limitation of the dietary pattern approach is the inability to isolate food or nutrient-specific effects on obesity. However, one of the causes of the development of obesity is an increase in energy intake. The energy density of foods is considered to be the key determinant of energy intake (49,50). Energy intake strongly increased with an increase in the energy density of foods. An excessive energy intake is unlikely when consuming a low energy-dense diet (51) and this, in turn, protects against weight gain. Interestingly, in the present study, the higher the adherence to the traditional Mediterranean diet, the lower the energy density. In addition, the intake of dietary fiber was directly associated with the Mediterranean diet score. Previous studies showed that a higher intake of dietary fiber protects against weight gain through its physical and chemical properties (52). The low energy density and high fiber content associated with a high adherence to the Mediterranean diet might have partially accounted for the observed associations between the latter and obesity in the present study.

In conclusion, a higher BMI was associated with a lower adherence to a traditional Mediterranean diet in men and women. Most importantly, the risk of being obese decreased significantly with a higher adherence to the traditional Mediterranean diet in both genders. These associations held after adjusting the statistical models for total energy intake, LTPA, educational status, alcohol consumption, and smoking status. These findings might be of interest in the effort to develop dietary patterns for weight control strategies.

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