Association between a healthy lifestyle and general obesity and abdominal obesity in an elderly population at high cardiovascular risk ☆

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ABSTRACT

Background: Diet, smoking and physical activity are important modifiable lifestyle factors that can influence body weight and fat accumulation. We assessed the relationship between lifestyle and obesity risk in a baseline analysis of the PREDIMED study, a randomized dietary primary prevention trial conducted in Spain.
Methods: 7000 subjects at high cardiovascular risk were assessed cross-sectionally. A healthy lifestyle pattern (HLP) was determined using a score including: adherence to the Mediterranean diet, moderate alcohol consumption, expending ≥ 200 kcal/day in leisure-time physical activity, and non-smoking.
Results: Inverse linear trends were observed between the HLP-score and body-mass-index (BMI) or waist circumference ($p < 0.001$). The BMI and waist circumference of participants with a HLP-score = 4 were, respectively, 1.3 kg/m^2 (95% CI: 0.9 to 1.7) and 4.3 cm (3.1 to 5.4) lower than those of subjects with an HLP ≤ 1. The odds ratios of general obesity and abdominal obesity for an HLP score of 4 compared to an HPL score ≤ 1 were 0.50 (0.42 to 0.60) and 0.51 (0.41 to 0.62), respectively
Conclusion: A combination of four healthy lifestyle behaviors was associated with a lower prevalence of general obesity and abdominal obesity in Mediterranean elderly subjects at high cardiovascular risk.

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Introduction

Obesity has reached epidemic proportions globally, with a deep negative impact on public health (World Health Organization, 2006). Several epidemiological studies have associated obesity with the incidence of multiple co-morbidities such as type-2 diabetes, hypertension, cardiovascular disease and cancer (Guh et al., 2009), and also with increased cardiovascular mortality (Flegal et al., 2007)

and all-cause mortality (Adams et al., 2006). Fat distribution, not only total body fat, has a significant impact on the development of obesity comorbidities and it is considered as a better predictor of disease than body mass index (BMI) (Canoy et al., 2007; Heber, 2010; Lee et al., 2008). Nevertheless, presently it is accepted that both general and abdominal adiposity, measured by the BMI and waist circumference (WC), respectively, are associated with the risk of various chronic diseases and total mortality (Pischon et al., 2008).

Changes in dietary patterns and other lifestyle factors have been held responsible for the obesogenic environment of modern industrialized societies (Heber, 2010). Epidemiological studies have established an association between BMI or body fat distribution and modifiable lifestyle factors, such as dietary habits, alcohol consumption, physical activity and smoking (Atlantis et al., 2008; Koh-Banerjee et al., 2003; Lahti-Koski et al., 2002; Leite and Nicolosi, 2006; Ong et al., 2009; Romaguera et al., 2010; Travier et al., 2009; Wilsgaard et al., 2005). However, in these studies all lifestyle factors were individually associated with obesity and/or abdominal obesity, while their potential combined effects were not assessed. We hypothesized that evaluating the combined effect of these healthier lifestyle factors could provide useful information to better understand the interplay of diet and lifestyle factors. It has previously been reported that the combination of various lifestyle factors is associated with lower rates of mortality (Khaw et al., 2008; Knoops et al., 2004; Kvaavik et al., 2010), stroke (Myint et al., 2009) and colorectal cancer (Kirkegaard et al., 2010), but the role of the combined impact of favorable lifestyle factors on obesity and body fat distribution is less well-documented. To our knowledge, only one cross-sectional study conducted in the Framingham cohort evaluated the effect of the combination of healthy lifestyle factors on adiposity (Molenaar et al., 2009), but its authors did not include the diet item in the lifestyle pattern that they defined.

The purpose of the present study was to assess the relationship between compliance with a healthy lifestyle pattern (HLP) and the odds of prevalent general obesity or abdominal obesity in a cross-sectional analysis of an elderly population at high cardiovascular risk living in a Mediterranean country. We also assessed how each of these lifestyle factors that made up the HLP-score was associated with obesity prevalence.

Subjects and methods

Subjects

The present study was conducted within the frame of the PREDIMED Study, a large, parallel-group, multicenter, randomized, controlled clinical trial aiming to assess the effects of two traditional Mediterranean Diets (MedD) enriched with nuts or virgin olive oil compared to a low-fat (control) diet on the primary prevention of cardiovascular disease. The design and methods of the PREDIMED trial have been reported elsewhere (Estruch et al., 2006; Martínez-González et al., 2010). Briefly, participants were men (55–80 years) and women (60–80 years), without cardiovascular disease and fulfilling at least one of the two following criteria: type 2 diabetes mellitus, or three or more cardiovascular risk factors [current smoking, hypertension, elevated low-density lipoprotein cholesterol level, low levels of high-density lipoprotein cholesterol, BMI ≥ 25 kg/m^2, or family history of premature cardiovascular disease]. The study protocol was approved by the institutional review boards of all the centers involved and all participants provided written informed consent.

Measurements

Variables assessed were food consumption, physical activity, smoking status, anthropometrical measures, educational level, occupation status, and medication use.

Adherence to the traditional MedD was assessed using a validated 14-item questionnaire (Table 1 in Supplemental File) designed for this purpose (Martinez-Gonzalez et al., 2004; Schröder et al., 2011). Subjects who scored ≥ 9 points were considered to comply with the MedD according to the median value as used in analyses of the PREDIMED group (Sánchez-Taínta et al., 2008). Energy intake and alcohol consumption were determined using a previously validated semi-quantitative questionnaire (Fernandez-Ballart et al., 2010) and Spanish food composition tables (Mataix Verdú, 2003). A moderate alcohol intake was defined as consumption of 1–30 g/day for men and 1–15 g/day for women (Gunzerath et al., 2004). Physical activity was assessed using the validated Spanish version of the Minnesota Leisure-Time Physical Activity (LTPA) Questionnaire (Elosua et al., 1994; Elosua et al., 2000).

The HLP was constructed using a four-point score based on 1) whether subjects complied with the MedD; 2) consumed a moderate amount of alcohol (versus either low or high alcohol intake), 3) expended ≥ 200 kcal/day in LTPA, and 4) were never smokers (versus current or former smokers). Each participant could therefore have a total HLP-score between 0 and 4.

Body weight and height were measured in light clothing and without shoes, and BMI was calculated. WC was measured midway between the lowest rib and the iliac crest. Obesity was defined as a BMI ≥ 30 kg/m^2 (Salas-Salvado et al., 2007). Abdominal obesity was defined by a WC ≥ 102 cm in men and ≥ 88 cm in women (National Institutes of Health, 1998).

Statistical analysis

The general characteristics of the participants according to the number of health behaviors were compared using ANOVA for continuous variables and chi-square tests for categorical variables. The means of baseline BMI and WC for each item included in the HLP-score were assessed by analysis of covariance (ANCOVA) using general linear models with confounding factors included as covariates. We first built a model adjusted for sex, age, energy intake, educational level (primary education or illiterate, secondary education, higher education), and occupational status (homemaker, blue-collar worker, clerical worker, white-collar worker) (model 1), and then a second model additionally adjusted for antidiabetic treatment with insulin, sulfonylureas, glitazones and/or biguanides (model 2). Values are expressed as means (95% confidence intervals, CIs).

Multiple logistic regression analyses were fitted to calculate the prevalence odds ratio (OR) of general obesity and abdominal obesity according to categories of the HLP-score at baseline. The adjusting variables were the same as those used in model 2 described above. HLP-scores of 0 and 1 were merged into a single stratum used as reference category. A multiple logistic regression analyses was fitted to evaluate which of the lifestyle factors considered in the HLP-score were most strongly associated with general obesity or abdominal obesity forcing the inclusion of previously described non-lifestyle factors (model 1), and additionally adjusted for antidiabetic treatment (model 2).

Both in linear and logistic regression analysis we explored for potential interactions between sex and each of the components of the HLP score. Because there were significant interactions between some score components and sex, we stratified by sex to examine the relationship between individual health behaviors and the odds of general obesity or abdominal obesity. Statistical significance was established at a two-tailed p < 0.05 level. Analyses were performed using SPSS 17.0 software.

Results

Of the 7447 PREDIMED participants, 31 were excluded from the present study because of incomplete data. 216 subjects were also

excluded because their age or BMI was out of predefined ranges for inclusion in the study. Thus the total sample considered for the cross-sectional general obesity analysis was 7200 subjects. Because baseline WC measurements were missing in 200 subjects, only 7000 subjects entered the abdominal obesity cross-sectional analyses.

Table 1 shows baseline characteristics of participants by number of health behaviors. Men reported significantly more health behaviors than women. BMI and WC decreased with an increasing number of health behaviors. Educational level, occupational status and energy intake were significantly higher with higher HLP-scores.

The specific proportion of participants complying with each of the 14 items of the MedD score is reported in Table 1 of the Supplemental Files. Subjects with high adherence to the MedD (≥ 9 points) had a lower BMI [-0.4 kg/m^2 (95% CI: -0.6 to -0.3)] and a lower WC [-1.9 cm (95% CI: -2.4 to -1.5)] than those with low adherence, after adjusting for potential confounders ($p < 0.001$) (Table 2). There were no significant differences in BMI or WC associated with alcohol intake after adjusting for confounding variables. Subjects who expended at least 200 kcal/day on LTPA had a lower BMI and WC [-1.1 kg/m^2 (95% CI: -1.2 to -0.9), and -2.9 cm (95% CI: -3.4 to -2.5), respectively; $p < 0.001$]. However, former smokers and never smokers showed higher BMI and WC than current smokers ($p < 0.05$). The subjects who complied with all the health behaviors considered in the HLP had a lower BMI and WC [-1.3 kg/m^2 (95% CI: -1.7 to -0.9) and -4.3 cm (95% CI: -5.4 to -3.1), respectively; $p < 0.001$] than those who had an unhealthy lifestyle (HLP ≤ 1).

The presence of general obesity or abdominal obesity was inversely associated with the HLP-score even after adjusting for potential confounders. Thus, the highest HLP-score was associated with the lowest risk for general obesity [OR (95%CI): 0.50 (0.42 to 0.60)] and abdominal obesity [OR (95%CI): 0.51 (0.41 to 0.62)] using a HLP-score ≤ 1 as reference (Table 3).

Table 4 shows which of the items used to define the HLP score were most closely associated with general obesity or abdominal obesity. Adherence to the MedD and a total energy expenditure on LTPA higher than 200 kcal/day were inversely associated with general obesity and abdominal obesity, whereas the non-smoking status was associated with higher odds for general obesity in both sexes. This last association was more pronounced in women (p for sex interaction 0.005). Additionally, alcohol intake and smoking status were also significantly related to abdominal obesity only among women (p for sex x alcohol and sex x smoking interaction <0.01 for both).

The statistical analyses were also performed separately according to intervention group (low fat versus the two MedD groups merged together). No relevant changes were observed in comparison to those obtained in the whole population (Tables 2–7 in Supplemental Files). Additional analyses were conducted excluding alcohol intake in the calculation of the MedD score (potential range: 0 to 13 instead of 0 to 14) and the results were essentially similar (Table 8 in Supplemental Files).

Discussion

The results of this cross-sectional study of an elderly Mediterranean population at high cardiovascular risk show that a healthy lifestyle (defined as a MedD pattern, moderate alcohol consumption, daily physical activity and nonsmoking) is inversely and linearly associated with a lower prevalence of general obesity and abdominal obesity. These results concur with those recently reported from the Framingham cohort using the Recommended Dietary Guidelines for Americans as an index of a healthy diet (Molenaar et al., 2009).

Healthier dietary and lifestyle factors have been associated with an improvement in blood pressure (Sugiyama et al., 2007), a reduced risk of coronary heart disease (Stampfer et al., 2000), and a better quality of life in cancer survivors (Mosher et al., 2009). However, in those studies

Table 1
Baseline characteristics of the study participants according to the number of health behaviors.

	Health behaviors				p for trend*
	≤ 1 (n = 1454)	2 (n = 2590)	3 (n = 2234)	4 (n = 922)	
Men, % (n)	32.8 (477)	36.2 (938)	48.3 (1079)	64.5 (595)	<0.001
Age, years	67.0 ± 6.3	67.3 ± 6.1	66.8 ± 6.0	67.2 ± 6.0	0.022
BMI, kg/m2	30.5 ± 3.7	30.0 ± 3.8	29.7 ± 3.5	28.8 ± 3.3	<0.001
Waist circumference, cm	101.5 ± 10.3	100.3 ± 10.6	100.1 ± 10.4	99.0 ± 9.9	<0.001
Educational level, % (n)					
Primary education	79.2 (1151)	80.3 (2081)	76.4 (1707)	70.7 (652)	<0.001
Secondary education	13.8 (201)	14.1 (365)	15.2 (340)	19.0 (175)	
Higher education	7.0 (102)	5.6 (144)	8.4 (187)	10.3 (95)	
Occupational status, % (n)					
Homemaker	41.3 (588)	40.9 (1043)	31.2 (683)	21.2 (190)	<0.001
Blue-collar worker	27.6 (393)	28.7 (732)	33.3 (728)	38.9 (349)	
Clerical worker	27.2 (388)	26.2 (668)	30.1 (658)	32.9 (295)	
White-collar worker	3.9 (56)	4.1 (105)	5.4 (118)	7.0 (63)	
Diagnosis of type 2 diabetes, % (n)	48.3 (703)	49.3 (1278)	47.0 (1051)	48.6 (448)	0.463
Treatment with insulin, % (n)	6.5 (92)	6.5 (164)	3.8 (84)	5.4 (49)	<0.001
Treatment with sulfonylureas, % (n)	15.1 (213)	16.5 (417)	14.7 (324)	14.0 (127)	0.185
Treatment with biguanides, % (n)	22.4 (316)	21.4 (539)	19.8 (435)	17.8 (162)	0.031
Diagnosis of hyperlipidemia, % (n)	71.7 (1042)	72.3 (1873)	73.3 (1638)	71.4 (658)	0.606
Diagnosis of hypertension, % (n)	83.1 (1209)	83.1 (2153)	82.7 (1847)	80.7 (744)	0.373
Total energy intake, kcal/day	2187.1 ± 645.3	2241.2 ± 612.5	2327.8 ± 592.4	2379.8 ± 532.9	<0.001
Alcohol consumption, g/day	7.7 ± 17.8	6.9 ± 14.0	9.8 ± 13.6	11.2 ± 8.5	<0.001
14-point Mediterranean diet score	7.2 ± 1.4	8.4 ± 1.9	9.3 ± 1.7	10.2 ± 1.1	<0.001
EEPA, kcal/day	103.0 ± 127.5	191.9 ± 200.5	306.9 ± 255.6	429.6 ± 260.0	<0.001
Smoking status, % (n)					<0.001
Current	31.8 (462)	15.2 (394)	6.8 (152)	0.0 (0)	
Former	9.8 (143)	18.8 (486)	33.8 (756)	43.6 (402)	
Never	58.4 (849)	66.0 (1710)	59.4 (1326)	56.4 (520)	

Participants were recruited for the PREDIMED-Spain study between October 2003 and June 2009.
BMI, body mass index; EEPA, energy expenditure in leisure-time physical activity.
Values are means ± SD or percentage (number) of participants.
* Trend test across the number of health behaviors practiced obtained from a one-way ANOVA or chi-square test.

Table 2
Baseline means (95% CIs) of BMI and waist circumference according to individual and combined health behaviors.

		Unadjusted model		Model 1†		Model 2‡	
		Mean (95% CIs)	p*	Mean (95% CIs)	p*	Mean (95% CIs)	p*
BMI (kg/m2)							
Adherence to MedD							
<9 points	(n=3303)	30.2 (30.0 to 30.3)	<0.001	30.1 (30.0 to 30.3)	<0.001	30.1 (30.0 to 30.3)	<0.001
≥9 points	(n=3897)	29.6 (29.5 to 29.7)		29.6 (29.5 to 29.8)		29.7 (29.6 to 29.8)	
Alcohol intake							
Light/high	(n=3831)	30.1 (30.0 to 30.2)	<0.001	29.9 (29.8 to 30.1)	0.118	30.0 (29.8 to 30.1)	0.086
Moderate	(n=3369)	29.6 (29.5 to 29.8)		29.8 (29.7 to 29.9)		29.8 (29.7 to 29.9)	
EEPA							
<200 kcal/day	(n=3771)	30.5 (30.3 to 30.6)	<0.001	30.4 (30.3 to 30.5)	<0.001	30.4 (30.3 to 30.5)	<0.001
≥200 kcal/day	(n=3429)	29.2 (29.1 to 29.3)		29.3 (29.2 to 29.4)		29.3 (29.2 to 29.5)	
Smoking status							
Current	(n=1008)	29.1 (28.9 to 29.3)	<0.001	29.4 (29.1 to 29.6)	<0.001	29.4 (29.1 to 29.6)	<0.001
Never/former	(n=6192)	30.0 (29.9 to 30.1)		30.0 (29.9 to 30.1)		30.0 (29.9 to 30.1)	
Health behaviors							
≤1	(n=1454)	30.5 (30.3 to 30.7)	<0.001	30.4 (30.2 to 30.6)	<0.001	30.4 (30.2 to 30.6)	<0.001
2	(n=2590)	30.0 (29.9 to 30.2)		30.0 (29.8 to 30.1)		30.0 (29.9 to 30.2)	
3	(n=2234)	29.7 (29.5 to 29.8)		29.7 (29.6 to 29.9)		29.8 (29.6 to 29.9)	
4	(n=922)	28.8 (28.6 to 29.1)		29.0 (28.8 to 29.3)		29.1 (28.8 to 29.3)	
Waist circumference (cm)							
Adherence to MedD							
<9 points	(n=3216)	101.4 (101.0 to 101.7)	<0.001	101.4 (101.0 to 101.8)	<0.001	101.3 (101.0 to 101.7)	<0.001
≥9 points	(n=3784)	99.4 (99.1 to 99.8)		99.4 (99.0 to 99.7)		99.4 (99.1 to 99.7)	
Alcohol intake							
Light/high	(n=3729)	99.7 (99.4 to 100.0)	<0.001	100.4 (100.0 to 100.7)	0.591	100.3 (100.0 to 100.7)	0.790
Moderate	(n=3271)	101.0 (100.7 to 101.4)		100.2 (99.9 to 100.6)		100.2 (99.9 to 100.6)	
EEPA							
<200 kcal/day	(n=3641)	101.1 (100.8 to 101.5)	<0.001	101.8 (101.4 to 102.1)	<0.001	101.7 (101.4 to 102.0)	<0.001
≥200 kcal/day	(n=3359)	99.4 (99.1 to 99.8)		98.7 (98.4 to 99.1)		98.8 (98.4 to 99.1)	
Smoking status							
Current	(n=977)	101.1 (100.5 to 101.8)	0.008	99.4 (98.7 to 100.1)	0.005	99.5 (98.8 to 100.2)	0.017
Never/former	(n=6023)	100.2 (99.9 to 100.5)		100.4 (100.2 to 100.7)		100.4 (100.1 to 100.7)	
Health behaviors							
≤1	(n=1410)	101.5 (101.0 to 102.1)	<0.001	102.1 (101.6 to 102.6)	<0.001	102.0 (101.4 to 102.5)	<0.001
2	(n=2515)	100.3 (99.9 to 100.7)		100.7 (100.3 to 101.1)		100.6 (100.2 to 101.0)	
3	(n=2172)	100.1 (99.6 to 100.5)		99.8 (99.3 to 100.2)		99.9 (99.4 to 100.3)	
4	(n=903)	99.0 (98.3 to 99.7)		97.8 (97.1 to 98.4)		97.7 (97.0 to 98.4)	

Participants were recruited for the PREDIMED-Spain study between October 2003 and June 2009.
Abbreviations: BMI, body mass index; EEPA, energy expenditure in leisure-time physical activity; MedD, Mediterranean diet.
*p value obtained from ANCOVA. Values are means (95% CIs).
† Adjusted for sex, age, total energy intake, educational level and occupational status.
‡ Additionally adjusted for treatment with insulin, sulfonylureas, glitazones and/or metformin.

evaluating the relationship between lifestyle factors and obesity, factors were individually analyzed and their potential combined effects were not assessed (Atlantis et al., 2008; Besson et al., 2009; Koh-Banerjee et al., 2003; Lahti-Koski et al., 2002; Leite and Nicolosi, 2006; Ong et al., 2009; Romaguera et al., 2010; Travier et al., 2009; Wilsgaard et al., 2005). In contrast to these studies, and in a way similar to the Framingham cohort (Molenaar et al., 2009), we have considered the sum of multiple modifiable lifestyle behaviors and assessed their

Table 3
Odds ratio (95% CIs) for general obesity and abdominal obesity according to the number of health behaviors (cross-sectional analysis).

	Number of health behaviors				p for linear trend*
	≤1	2	3	4	
General obesity					
Participants (n)	(1454)	(2590)	(2234)	(922)	
Obese subjects, n (%)	791 (54.4)	1256 (48.5)	994 (44.5)	317 (34.3)	
Unadjusted model	1	0.79 (0.69 to 0.90)	0.67 (0.59 to 0.77)	0.44 (0.37 to 0.52)	<0.001
Model 1†	1	0.80 (0.70 to 0.91)	0.71 (0.62 to 0.81)	0.49 (0.41 to 0.58)	<0.001
Model 2‡	1	0.83 (0.72 to 0.95)	0.73 (0.63 to 0.84)	0.50 (0.42 to 0.60)	<0.001
Abdominal obesity					
Participants (n)	(1410)	(2515)	(2172)	(903)	
Abdominal obese subjects, n (%)	1143 (81.0)	1914 (76.1)	1511 (69.5)	539 (59.7)	
Unadjusted model	1	0.74 (0.63 to 0.87)	0.53 (0.45 to 0.63)	0.35 (0.29 to 0.42)	<0.001
Model 1†	1	0.77 (0.65 to 0.91)	0.64 (0.54 to 0.76)	0.50 (0.41 to 0.62)	<0.001
Model 2‡	1	0.77 (0.65 to 0.92)	0.65 (0.55 to 0.78)	0.51 (0.41 to 0.62)	<0.001

Participants were recruited for the PREDIMED-Spain study between October 2003 and June 2009.
* Linear trend test across the number of health behaviors was obtained from logistic regression analyses with polynomial contrast.
† Adjusted for sex, age, total energy intake, educational level and occupational status.
‡ Additionally adjusted for treatment with insulin, sulfonylureas, glitazones and/or metformin.

Table 4
Odds ratios (95% CIs) for general obesity and abdominal obesity by individual health behaviors, stratified by sex (cross-sectional analysis).

		Male (n = 3089)	Female (n = 4111)	p for sex interaction
General obesity				
Unadjusted model	Adherence to Mediterranean diet	0.77 (0.67 to 0.89)	0.76 (0.67 to 0.86)	0.692
	Moderate alcohol intake	0.96 (0.83 to 1.12)	0.89 (0.78 to 1.01)	0.301
	Expenditure of ≥ 200 kcal/day on physical activity	0.64 (0.55 to 0.74)	0.63 (0.55 to 0.71)	0.760
	Current non-smoking	1.23 (1.04 to 1.45)	1.99 (1.50 to 2.64)	<0.001
Model 1†	Adherence to Mediterranean diet	0.78 (0.67 to 0.90)	0.75 (0.66 to 0.86)	0.480
	Moderate alcohol intake	0.96 (0.82 to 1.12)	0.91 (0.80 to 1.04)	0.305
	Expenditure of ≥ 200 kcal/day on physical activity	0.63 (0.54 to 0.73)	0.62 (0.54 to 0.70)	0.705
	Current non-smoking	1.25 (1.05 to 1.49)	1.87 (1.40 to 2.50)	0.003
Model 2‡	Adherence to Mediterranean diet	0.77 (0.66 to 0.90)	0.77 (0.68 to 0.88)	0.629
	Moderate alcohol intake	0.96 (0.82 to 1.12)	0.90 (0.78 to 1.03)	0.227
	Expenditure of ≥ 200 kcal/day on physical activity	0.63 (0.54 to 0.74)	0.63 (0.55 to 0.72)	0.783
	Current non-smoking	1.26 (1.05 to 1.50)	1.91 (1.42 to 2.56)	0.005
Abdominal obesity§				
Unadjusted model	Adherence to Mediterranean diet	0.70 (0.61 to 0.82)	0.73 (0.61 to 0.87)	0.100
	Moderate alcohol intake	0.95 (0.82 to 1.11)	1.09 (0.90 to 1.31)	0.012
	Expenditure of ≥ 200 kcal/day on physical activity	0.62 (0.54 to 0.73)	0.58 (0.48 to 0.69)	0.563
	Current non-smoking	1.12 (0.95 to 1.32)	1.76 (1.25 to 2.48)	<0.001
Model 1†	Adherence to Mediterranean diet	0.11 (0.03 to 0.53)	0.73 (0.61 to 0.88)	0.166
	Moderate alcohol intake	0.93 (0.79 to 1.08)	0.07 (0.01 to 0.74)	0.008
	Expenditure of ≥ 200 kcal/day on physical activity	0.63 (0.54 to 0.73)	0.58 (0.48 to 0.69)	0.671
	Current non-smoking	1.09 (0.92 to 1.29)	1.52 (1.07 to 2.16)	<0.001
Model 2‡	Adherence to Mediterranean diet	0.09 (0.02 to 0.44)	0.74 (0.61 to 0.89)	0.202
	Moderate alcohol intake	0.92 (0.79 to 1.08)	0.04 (0.00 to 0.48)	0.006
	Expenditure of ≥ 200 kcal/day on physical activity	0.63 (0.53 to 0.73)	0.58 (0.48 to 0.70)	0.573
	Current non-smoking	1.10 (0.92 to 1.31)	1.51 (1.06 to 2.14)	<0.001

Participants were recruited for the PREDIMED-Spain study between October 2003 and June 2009.
p value obtained from logistic regression analyses.
† Adjusted for age, total energy intake, educational level and occupational status.
‡ Additionally adjusted for treatment with insulin, sulfonylurea, glitazones and metformin. Model 1 and model 2 were additionally adjusted for interaction variables (age*MedD item for men; and age*alcohol item for women).

combined effect on obesity. Data from the present analysis shows that subjects with healthier behaviors have a lesser prevalence of general obesity and abdominal obesity than those with fewer healthy habits. Of these healthy habits, adherence to the MedD and energy expenditure in LTPA ≥ 200 Kcal/day was inversely associated with the prevalence of general obesity and abdominal obesity, whereas alcohol intake was significantly related to abdominal obesity in women. Our results are in consonance with epidemiological evidence showing suggesting that the MedD plays a role in the prevention of obesity (Beunza et al., 2010; Schröder, 2007), although the possible mechanisms involved are still controversial.

We observed that smoking was inversely associated with general obesity prevalence in both sexes and with abdominal obesity prevalence in women. The association between smoking and body weight is not well understood and is still controversial. It was believed that BMI was lower in current smokers than nonsmokers, but more recent data cast doubt on this relationship (Chiolero et al., 2008; Basterra-Gortari et al., 2010). In current smokers, nicotine helps increase energy expenditure by exerting anorectic effects, which could explain why smokers tend to have lower body weight (Chiolero et al., 2008). However, it has been reported that heavy smokers have greater BMI than light-smokers or non-smokers, probably because the former are more prone to obesogenic behaviors, such as an unhealthy diet and sedentariness (Chiolero et al., 2006; Chiolero et al., 2007; Basterra-Gortari et al., 2010). At odds with previous epidemiological observations of a direct association between alcohol consumption and obesity (Schroder, 2007; Yeomans, 2010) in our study moderate alcohol intake was negatively associated with abdominal adiposity, especially in women. The exact relationship between alcohol intake and obesity remains to be elucidated, but it has recently been suggested that the type of drink (which could be influenced by sex), the drinking frequency, and the drinking pattern are important factors to take into account when assessing the association between alcohol consumption and obesity risk

(Sayon-Orea et al., 2011; Yeomans, 2010). It should be born in mind that red wine was the main source of alcohol in our Mediterranean cohort (data not shown). It should be underlined that red wine is the main source of alcohol in Mediterranean cultures. Our results may be partly due to the fact that red wine has more antioxidant and anti-inflammatory properties than other sources of alcohol (Estruch et al., 2004; Estruch et al., 2011), thus favoring thermogenesis (Raben et al., 2003) and fat oxidation (Blade et al., 2010).

This study has strengths and limitations. One strength is that associations between lifestyle and adiposity were analyzed in a large sample of free-living volunteers. Moreover, all the health behaviors included in our score are simple and easily measurable, thus its use at the individual and the population level could help implement preventive strategies and shape public health policy. A limitation of the present study is that results cannot be generalized because our aged participants at high cardiovascular risk are not representative of the general population. Because of the cross-sectional design, we cannot prove causal relationships, and the possibility exists of reverse causation bias, as obesity status could be a reason for individuals to change their lifestyle.

Conclusion

In summary, the present study shows that a Mediterranean-type diet, moderate alcohol consumption, daily physical activity and nonsmoking, all of which are easily modifiable lifestyle habits, are associated with a lower prevalence of general obesity and abdominal obesity. Although longitudinal analysis regarding the benefits of a healthier lifestyle on incidence of general obesity and abdominal obesity should be conducted in the future, our findings are relevant to the design of public health strategies aimed at reducing the burden of overweight and obesity through simple behavioral changes.

Appendix A. Supplementary data

Supplementary data to this article can be found online at doi:10.1016/j.ypmed.2011.06.008.

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