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Dietary indexes, food patterns and incidence of metabolic syndrome in a Mediterranean cohort: The SUN project

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SUMMARY

Background & aims—We prospectively assessed the association between adherence to several *a priori* defined healthy food patterns and risk of metabolic syndrome (MetS).

Methods—We assessed 6851 participants of a Spanish dynamic prospective cohort of university graduates, initially free of any MetS-specific definition criteria, and followed-up for a median of 8.3 years. We calculated the adherence to thirteen different *a priori* defined food patterns or dietary indexes. MetS was classified according to the updated harmonizing criteria. We estimated multivariable-adjusted Incidence Rate Ratios (IRR) of metabolic syndrome and their 95% Confidence Intervals (95% CI), using Poisson regression models.

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Statement of authorship

AMP and RL-I participated in the study design, statistical analyses, data interpretation and manuscript drafting. ET participated in the study design, statistical analyses and data interpretation. MCR-D, AG, NS and JRH participated in the study design and data interpretation. MAM-G participated in the study design, statistical analyses, data interpretation, funding, and manuscript drafting. All authors have revised the manuscript for important intellectual content and read and approved the final version of the manuscript.

Conflict of interest

The authors declare that they have no competing interests.

Appendix A. Supplementary data

Supplementary data related to this article can be found online at <http://dx.doi.org/10.1016/j.clnu.2014.06.002>.

Results—The cumulative incidence of MetS was 5.0%. Moderate adherence to the Pro-Vegetarian Diet (PVEG) was significantly associated with a lower risk for developing MetS (IRR = 0.75, 95% CI = 0.59–0.97). Among women, an inverse association with the PVEG was significant not only for a moderate adherence (IRR = 0.54, 95% CI = 0.36–0.82), but also for higher adherence (IRR = 0.63, 95% CI = 0.43–0.93). A higher adherence to the Dietary Approaches to Stop Hypertension (DASH) diet showed an inverse association with the MetS among participants, but only if they had low alcohol intake (RR = 0.41, 95% CI = 0.20–0.85).

Conclusions—Our findings support the adoption of a PVEG dietary pattern for the reduction of MetS risk. The same statement can be applied in relation to the DASH diet, insofar a limited consumption of alcoholic beverages is also maintained.

Keywords

Diet; vegetarian; Sodium restricted; Alcohol drinking; Metabolic syndrome X; Cohort studies; Spain

1. Introduction

According to most recent report of World Health Organization, cardiovascular diseases (CVD) and diabetes are the main public health concerns in all regions around the world, accounting for more than one-third of all deaths in people aged 30–70 years [1]. Thus, identifying the risk factors for these conditions has become an important goal of scientific research in order to establish appropriate evidence-based approaches for the prevention and control of these conditions. From this perspective, metabolic syndrome (MetS) is recognized as a major modifiable determinant of both CVD and diabetes, and its prevalence is >20% in adult populations worldwide [2].

Regarding healthy dietary habits, some *a priori* defined (hypothesis-based) indexes or food patterns have proven to be effective in preventing or reversing MetS, such as the Dietary Approaches to Stop Hypertension (DASH) diet and the Mediterranean Diet [3,4]. Despite the effectiveness of these dietary patterns to prevent MetS, based on clinical trials, some of them were short-term trials [3]. It may be that the subjects with MetS at baseline simply were not on the diets for a sufficiently long time to have prevented the condition, were not strongly committed enough to reverse symptoms, or may have provided biased self-reports. Thus, longitudinal observational studies including subjects initially free of MetS at baseline are needed to test the ability of these food patterns to prevent MetS.

To the best of our knowledge, there has been no published, longitudinal long-term study evaluating the association between adherence to the DASH diet and incidence of MetS. Moreover, several studies have concluded that subjects with higher adherence to the Mediterranean diet had a lower incidence of MetS, but the diagnosis of MetS was done according to different definitions [5,6].

Another dietary pattern extensively studied in recent years is a vegetarian diet. The results of two investigations on its effect in preventing MetS are contradictory; with one of them

showing an association of a vegetarian diet with a lower risk of MetS [7], and the other not supporting any relationship [8].

In summary, the effects of dietary indexes and food patterns on MetS present sparse epidemiological consistence and we could consider this topic as elusive. Therefore, the aim of the present study was to provide longitudinal evidence to clarify which of the most frequently proposed healthy dietary indexes and food patterns are effective for preventing long-term incidence of MetS in a prospective cohort of Spanish university graduates.

2. Material and methods

2.1. Design

The “*Seguimiento Universidad de Navarra*” [University of Navarra Follow-up] (SUN) Project is a dynamic prospective cohort study, conducted in Spain with university graduates since December 1999. Additional details on its objectives, design and methods have been published previously [9].

Information is gathered by mailed or electronic mailed questionnaires collected biennially. After baseline assessment (Q_0), participants received every other year follow-up questionnaires (Q_2, Q_4, Q_6, Q_8, ..., Q_n) with important questions to evaluate changes in lifestyle and health related behavior, anthropometric measures, incident diseases, and medical conditions.

2.2. Subjects

The present study was conducted in June 2013. To allow for a minimum follow-up of 6 years, all participants who had answered their first questionnaire before October 2006 and were free of any MetS-specific definition criteria or diabetes at baseline were considered eligible ($n = 11,950$). Out of these, we excluded 1092 subjects reporting total energy intake values out of predefined limits (less than 800 kcal/day in men and 500 kcal/day in women or more than 4000 kcal/day in men and 3500 kcal/day in women) [10]; subjects who had not answered any of the follow-up questionnaires ($n = 544$); and those who failed to reply to both 6-year (Q_6) and 8-year (Q_8) follow-up questionnaires ($n = 1291$), as the MetS features were ascertained in these questionnaires. Additionally, we also excluded participants who had missing information on MetS components in the baseline questionnaire ($n = 1039$), and those with more than 9 missing items in the food-frequency questionnaire (FFQ) ($n = 1133$). Thus, a total of 6851 participants were included in the final analyses.

The study was conducted according to the Declaration of Helsinki, and all procedures involving human subjects were approved by the institutional review board of the University of Navarra. Voluntary completion of baseline questionnaire was considered to imply informed consent.

2.3. Exposure assessment – diet indexes and food patterns

Habitual diet was assessed at baseline with a semi-quantitative 136-item food-frequency questionnaire (FFQ) previously validated in Spain [11]. Each item in the questionnaire included a typical portion size. Daily food consumption was estimated by multiplying the

portion size by the consumption frequency for each food item. Nutrient composition of the food items was derived from Spanish food composition tables [12].

We tested 13 previously published dietary indexes and food patterns which are briefly explained in the next paragraphs. Further information on the composition and how to calculate these dietary indexes and food patterns can be found in the Appendix and the cited references.

The Pro-Vegetarian Diet (PVEG) has been previously defined as *a priori* dietary index that tries to capture a preference for foods of plant origin instead of foods from animal origin, and it has been reported to be associated with lower total mortality [13]. In order to build the PVEG, we adjusted the consumption (g/d) of 7 food groups from plant origin and 5 food groups from animal origin for total energy intake using the residual method, separately for men and women. The energy-adjusted estimates (residuals) were ranked according to their sex-specific quintiles. To evaluate adherence, quintile values of plant foods and reverse quintile values of animal foods were summed up. Thus, the final scores may range from 12 (lowest adherence) to 60 (highest adherence). Finally, we divided the adherence to the PVEG in tertiles.

The DASH score rewarded points for certain foods according to their quintile rankings. In relation to adequate food consumption, participants in the lowest quintile were assigned 1 point and those in the highest quintile 5 points. On the other hand, with regard to inadequate foods, participants in the lowest quintile received a score of 5, and those in the highest, a score of 1. As we have considered eight groups of food items, the total possible score range was 8–40. Finally, we divided adherence of the DASH diet into quintiles [14].

We also looked at other previously published food patterns dealing with the Mediterranean diet: the Mediterranean Diet Score, defined according to the 9 points score proposed by Trichopoulou et al., divided into low (0–2), intermediate (3–5), and high (6–9) adherence [15]; the Modified Mediterranean Diet Score, calculated from the Mediterranean Diet Score with some corrections [16]; the Mediterranean Adequacy Index [17]; the Mediterranean Diet Quality Index [18]; the Mediterranean Food Pattern, proposed by Sanchez-Villegas et al. [19] and the Mediterranean Score, proposed by Panagiotakos et al. [20].

Finally, we computed the Diet Quality Index-International [21]; the Healthy Eating Index [22]; the Alternate Healthy Eating Index [23]; the Dietary Guidelines for Americans Adherence Index [24]; and the Dietary Inflammatory Index [25].

Except for the PVEG, Mediterranean Diet Score, and the Modified Mediterranean Diet Score, adherence to the other dietary indexes and food patterns was divided into quintiles.

2.4. Outcome assessment – metabolic syndrome and its components

MetS was defined according to the International Diabetes Federation and American Heart Association/National Heart, Lung, and Blood Institute harmonizing definition [26], which requires the diagnosis of three or more of the following five criteria: a) elevated waist circumference (≥ 94 cm for men and ≥ 80 cm for women, cutoff points for European populations); b) elevated triglycerides (≥ 150 mg/dl or presence of pharmacologic treatment

for hyper-triglyceridemia); c) reduced HDL-cholesterol (<40 mg/dl for men and <50 mg/dl for women or presence of pharmacologic treatment for reduced HDL-cholesterol); d) elevated blood pressure (systolic $\geq$ 130 mmHg and/or diastolic $\geq$ 85 mmHg or presence of pharmacologic treatment for hypertension in patients with a history of this disease); e) elevated fasting glucose ($\geq$ 100 mg/dl or pharmacologic treatment for hyperglycemia).

In Q_6 and Q_8 follow-up questionnaires, self-reported information on these MetS criteria was collected. Waist circumference was measured in a horizontal plane, midway between the inferior margin of the ribs and the superior border of the iliac crest. All participants were sent a tape measure with Q_6 and Q_8 follow-up questionnaires, and an explanation on how to measure their waist.

The validation of the self-reported MetS components was assessed in a specific study within a subsample of 287 participants. Significant intra-class correlation coefficients ($p < 0.001$) ranged from 0.5 to 0.9 between self-reported MetS components and their direct assessments by an experienced physician [27].

An incident case of MetS was defined when the participant, free of this condition at baseline, met three or more of its components in either Q_6 or Q_8 follow-up questionnaires.

2.5. Potential confounding factors

We considered a wide array of characteristics inquired at baseline questionnaire as potential confounding factors and adjusted our analysis for them: age, sex, lifestyle and health related behavior [smoking status (never, current, former), alcohol consumption (g/day), physical activity (quartiles of activity metabolic equivalent – MET h/week), time spent viewing television (h/day)]; dietary habits [total energy intake (kcal/day), use of special diets, snacking between main meals]; and anthropometric data [changes in weight over the last 5 years prior to the study (no change, lost, gained), baseline Body Mass Index (BMI)].

2.6. Statistical analyses

We conducted the statistical analyses in three steps: 1) In the first step, some baseline characteristics of participants according to development of MetS and stratified by sex were described, using relative frequencies, means and standard deviations. The differences were estimated with t-Student or Pearson's chi-square tests; 2) In the second step, crude and multivariable Poisson regression models were fitted to assess the relationship between some baseline characteristics of participants and the incidence of MetS according to sex; 3) In the last step, Poisson regression models were also fitted to assess the relationship between adherence to each 13 dietary indexes and food patterns with the development of MetS. Incidence Rate Ratios (IRR) and their 95% Confidence Intervals (95% CI) were estimated using those participants who had the minimum level of adherence to the food patterns (or dietary indexes) as the reference category. It is important to highlight that, for the Dietary Inflammatory Index, we used the higher scores as reference category because it indicates greater inflammatory potential of this diet.

A first model included only age and sex as covariates (model 1). Then, we fitted another model additionally adjusting for all previously described potential confounding factors (model 2).

Alcohol consumption was considered as a potential confounding factor only in those food patterns and dietary indexes that had no alcoholic component in their scoring system. Similar procedure was done with total energy intake, because we included this variable only in the models which the food pattern and dietary indexes were calculated without the use of residual method for adjust energy intake.

Tests for linear trend were conducted assigning medians within each category of food pattern adherence, and this new variable was introduced as a continuous variable in the Poisson regression models.

Additionally, to PVEG and DASH diets, we repeated the third step, stratifying the statistical analyses, respectively, by sex and alcohol consumption.

All analyses were performed with STATA[®] version 12.1 (Stata-Corp, College Station, Texas) and the statistical significance was set at 5% (p values <0.05 , based on 2-tailed tests).

3. Results

Three hundred forty six participants (221 men and 125 women), initially free of MetS, were newly classified as incident cases during a median follow-up of 8.3 years. Thus, the overall cumulative incidence of MetS in this population was 5.0% (9.5% for men and 2.8% for women) and the overall incidence density was 3.1/1000 persons-year (6.0/1000 persons-year for men and 1.5/1000 persons-year for women).

Baseline characteristics of the study participants are presented in Table 1. When men and women were considered together, participants with MetS were more likely to be older, former smokers, and consume more alcohol. They also had lower intake of total fat and saturated fatty acids (SFA), more frequency of weight gain in the last 5 years prior to the study, and higher average BMI at baseline ($p < 0.05$). Men with MetS had a similar profile, except for the total fat intake and weight gain in the last 5 years prior the study, whose differences were not statistically significant in comparison to men without MetS. Women with MetS also were more likely to be older, former smokers, and consume more alcohol. They also had more frequency of weight gain in the last 5 years prior the study, and higher average BMI at baseline. Additionally, they had more protein intake, and a higher ratio of monounsaturated (MUFA):polyunsaturated fatty acids (PUFA) ($p < 0.05$).

Baseline characteristics of participants associated with MetS are presented in Table 2. Among the total sample and also in men, age, alcohol intake, snacking between main meals, and BMI were independently related to MetS. Only age and BMI were associated with MetS in the female sex.

Among the 13 dietary indexes and food patterns evaluated, only the PVEG diet showed an independent association with MetS. We also observed a reduction in the incidence of MetS

in participants with the lower adherence to the Dietary Inflammatory Index, and with higher adherence to other food patterns or dietary indexes, except the Healthy Eating Index and Mediterranean Adequacy Index, although the associations were only borderline significant (data not shown). Thus, from this point forward, we are going to present only the results of PVEG diet and the DASH diet.

Incidence Rate Ratios (IRR) and their 95% CI for the incidence of MetS according to the adherence of PVEG diet are shown in Table 3. Higher adherence to the PVEG diet was associated with a lower risk for developing MetS after adjusting for age and sex (p for trend = 0.006). However, these findings remained statistically significant only for moderate versus low adherence (IRR = 0.75, 95% CI = 0.59–0.97) to this food pattern after additional multivariate adjustment (p for trend = 0.083).

We considered appropriate to stratify this analysis by sex because of the different prevalence of MetS among men and women. Thus, subsequently to this procedure, the moderate (IRR = 0.54, 95% CI = 0.36–0.82) and higher (IRR = 0.63, 95% CI = 0.43–0.93) categories of adherence to PVEG diet exhibited a reduced risk of MetS incidence compared to the lowest category after multivariate analysis in female participants (p for trend = 0.014) (Table 3). In contrast, a non-significant association was observed among men (moderate versus lower: IRR = 0.93, 95% CI = 0.68–1.27; higher versus lower: IRR = 0.95, 95% CI = 0.71–1.28; p for trend = 0.752), despite the protective effect (Table 3).

Although the adherence of DASH diet was not associated with MetS, we decided to stratify this analysis by tertiles of alcohol consumption, because, the founding authors recommended a moderate consumption of alcoholic beverages when the subject has this habit. Thus, a higher adherence to the DASH diet showed and inverse association with the MetS after multivariate adjustment, but it was only apparent among participants in the first tertile of alcohol intake (IRR = 0.41, 95% CI = 0.20–0.85, p for trend = 0.008) (Table 4).

4. Discussion

The data from the SUN cohort study showed that moderate adherence to a PVEG diet was associated with a reduction in the risk of MetS. But, this protective effect was more evident among women, because both moderate and higher adherences to this food pattern were independently related to a lower incidence of MetS. We also observed that the higher adherence to the DASH diet in participants with low alcohol consumption was associated with a reduced risk of MetS development. No significant association was seen between the other food patterns or dietary indexes and MetS, despite suggestions of protective effects.

The lack of significant associations in our cohort can be attributed to the characteristics of its participants. As compared with most US cohort, the participants in the SUN cohort were considerably healthier. Additionally, there was only small between-subject variability in most of the key variables, especially because we restricted our analyses to participants initially free of all criteria for the MetS. This is a good characteristic of a cohort study because it minimizes confounding through the use of restriction as it is recommended by epidemiologic methodology [28]. However, a likely explanation for the lack of statistically

significant associations may be that there was simply not enough variability in unhealthy behaviors, including poor dietary patterns in our assessed cohort. This certainly would be consistent with our observed dose–response trend for many patterns that appear to be plateauing at the second quintile or the middle tertile.

Our findings should be also interpreted in the context of food patterns and dietary indexes that were derived from a self-reported 136-item FFQ. Also self-reported data were used to assess the MetS components. In any case, the validation studies that we have published support the appropriateness of this methodology [11,27]. On the other hand, strengths of this study include its prospective design, the inclusion of a large number of participants, the control for a wide array of potential confounding factors, and a long-term follow-up, enabling us to assume a sufficiently large induction period and minimize reverse causation bias.

In looking at the vegetarian diet, the results of a previous study are seemingly contradictory. A retrospective Taiwanese cohort study with 93,209 participants showed that a vegan diet did not decrease the risk of developing MetS [7]. However, in a cross-sectional analysis of 773 subjects from the Adventist Health Study II, the vegetarian diet was related to a 56% decrease in the risk of MetS. In the first study, the exposure variable was veganism, a food pattern that does not include meat, fish, dairy products or eggs in the individuals' diet [8]. Therefore, these findings are difficult to compare with our data, because we tested a pro-vegetarian diet, a food pattern that includes smaller amounts (but not suppression) of animal products. In the second study, participants were classified as vegetarian when they reported consuming meat, poultry or fish <1 time/month, an exposure variable more similar than the one we evaluated, although the authors have not considered the consumption of dairy products or eggs [7]. In addition, those results should be interpreted with caution for the cross-sectional design does not guarantee causality.

It is important to highlight that, in the present study, the independent inverse association between the PVEG and MetS was confirmed only for participants with moderate adherence, suggesting the possibility of an L-shaped dose–response pattern. After stratifying the analysis by sex, this situation was different among women, because both moderate and higher adherence were inversely associated with the MetS (p for trend = 0.031). On the other hand, no significant results were observed among men. The difference between sexes may be due to two potential explanations: a) a poorer dietary assessment among men might have led to a higher measurement error. In fact, in the validation study of our FFQ [11], the correlation coefficients for all evaluated items were worse among men; b) stratification might reduce statistical power especially among males, because they represented only 34% of the sample.

There is biological plausibility to support the potential beneficial effects of the PVEG diet on MetS, because this food pattern is based on a rich intake and diversity of biologically active phytochemicals with ability to decrease chronic disease risks. Moreover, the different constituents of the component foods of a PVEG diet are likely to interact synergistically in health promotion [29].

With respect to the DASH-type diets, a short-term clinical trial has shown potential to reduce its prevalence [3]. Nevertheless, this was the first observational study that examined the association of a DASH diet on the long-term risk of MetS. Thus, we found that the higher adherence to a DASH diet was associated with a reduction in the incidence of MetS only among participants with lower alcohol intake (lowest tertile). The consumption of alcohol was demonstrated as an important determinant of MetS in the SUN study [30] and in another longitudinal investigation [31], despite its favorable influence on HDL-cholesterol among individuals who consume moderate doses [30]. Although alcohol intake is not a component of the DASH diet, its authors recommend moderate consumption of alcoholic beverages, when the subject has this habit, as an additional lifestyle change for health promotion.

In the Insulin Resistance Atherosclerosis Study, higher adherence to the DASH diet was associated with a lower risk of type 2 diabetes, only among white individuals; however this relationship was not adjusted for alcohol intake [32].

The DASH diet emphasizes the consumption of healthy food groups. Hence, its components also are likely to act in synergy to prevent MetS, promoting reduction in body weight, blood pressure, blood lipids and glucose, raising antioxidant capacity, and reducing oxidative stress [32].

The benefits of a Mediterranean diet on MetS have been demonstrated in longitudinal studies [5,6]. However, the lack of association observed in the present study could be due to differences in MetS assessment, because, in the previous investigation [5], the outcome was not identified with the most recent harmonizing definition, and it is well known that the predictors of MetS may vary depending on the diagnostic criteria.

After the establishment of a harmonizing definition of MetS, to the best of our knowledge, only one large prospective study was carried out. This study was conducted in France involving 3232 adult participants with a 6-year follow-up [6]. Using a specific Mediterranean diet score proposed by the researchers group of Framingham Offspring Cohort, the adherence to this food pattern was not significantly associated with a lower risk of MetS.

Nevertheless, both the traditional Mediterranean diet score, proposed by Trichopoulou et al. [15], and the updated Mediterranean score, adapted by this French group, proved to be effective as a protective factor against MetS in that study [6]. We reinforce the difference between the mean age of the participants (50 years) of this French study compared to those in our cohort (30 years) as a possible explanation for the lack of association between the Mediterranean diet and MetS found in our study. Lastly, it is possible that the effect of the Mediterranean diet would be observed more readily in older individuals.

In summary, our findings suggest that a pro-vegetarian diet pattern may be effective for reducing the risk of MetS. The same statement can be applied in relation to the DASH diet, observing the importance of limiting consumption of alcoholic beverages.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations

MetS	metabolic syndrome
IRR	Incidence Rate Ratio
95% CI	95% Confidence Interval
PVEG	Pro-Vegetarian Diet
DASH	Dietary Approach to Stop Hypertension
CVD	cardiovascular disease
IDF	International Diabetes Federation
NCEP-ATP III	National Cholesterol Education Program Adult Treatment Panel III
MET	activity metabolic equivalent
SUN	<i>Seguimiento Universidad de Navarra</i>

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Baseline characteristics of SUN study population according to development of metabolic syndrome, stratified by sex. The SUN Project (*Seguimiento Universidad de Navarra*, University of Navarra Follow-up), Navarra, Spain, 1999–2011.

Table 1

Baseline characteristics	Sex		Total			
	Male		Female		Total	
	Developed MetS	Did not develop MetS	Developed MetS	Did not develop MetS	Developed MetS	Did not develop MetS
<i>n</i>	221	2114	125	4391	346	6505
Age (years) [mean (SD)] ^a	45 (10)	37.1 (10.1)	42.6 (9.5)	33.3 (8.9)	44.1 (9.9)	34.5 (9.4)
Smoking (%) ^b						
Non-smokers	34.8	52.8	40	51.5	36.7	51.9
Current smokers	21.7	21.5	24.8	24.8	22.8	23.7
Ex-smokers	43.7	25.7	35.2	23.7	40.5	24.3
Alcohol consumption (g/d) [mean (SD)] ^a	13.5 (13.9)	9.1 (10.4)	5.0 (7.6)	4.0 (5.7)	10.5 (12.7)	5.6 (7.9)
Snacking between main meals (%)	29.9	27	40	38.4	33.5	34.7
Use of special diets (%)						
Total energy intake (kcal/d) [mean (SD)]	2430 (646)	2535 (628)	2403 (582)	2340 (547)	2459 (624)	2403 (582)
Carbohydrate intake (% of energy intake) [mean (SD)]	43 (6.4)	43.7 (6.8)	43.0 (7.3)	43.6 (6.9)	43 (6.8)	43.6 (6.9)
Protein intake (% of energy intake) [mean (SD)] ^c	17.6 (2.8)	17.4 (2.7)	18.8 (3.4)	18.1 (3)	18 (3.1)	17.9 (2.9)
Total fat intake (% of energy intake) [mean (SD)] ^d	35.5 (5.6)	36.3 (5.9)	36.7 (6.7)	37.1 (6.3)	35.9 (6)	36.8 (6.2)
MUFA (% of energy intake) [mean (SD)]	15.1 (3.1)	15.3 (3.1)	16 (3.7)	16 (3.7)	15.4 (3.4)	15.8 (3.5)
SFA (% of energy intake) [mean (SD)] ^e	12.3 (2.7)	12.8 (3)	12.6 (3)	12.1 (3)	12.3 (2.8)	12.7 (3)
PUFA (% of energy intake) [mean (SD)]	5.1 (1.3)	5.3 (1.5)	5 (1.7)	5.2 (1.6)	5.1 (1.4)	5.2 (1.5)
MUFA:SFA ratio [mean (SD)] ^c	1.3 (0.3)	1.2 (0.3)	1.4 (0.3)	1.3 (0.3)	1.3 (0.3)	1.3 (0.3)
Television watching (h/d) [mean (SD)]	1.6 (1.1)	1.5 (1.1)	1.8 (1.4)	1.7 (1.4)	1.7 (1.2)	1.6 (1.3)
Leisure-time physical activity (MET-h/week) [mean (SD)]	23.6 (25.1)	27.3 (28.5)	16.1 (15.7)	18.2 (18.7)	20.9 (22.4)	21.2 (22.8)
Weight gain in the 5 years before (%) ^f	57	55.3	66.4	47.6	60.4	50.1
BMI (kg/m ²) [mean (SD)] ^a	25.9 (2.2)	24.3 (2.3)	24.4 (2.5)	21.6 (2.4)	25.3 (2.4)	22.5 (2.7)

MetS, metabolic syndrome; SD, standard deviation; kcal/d, kilocalories per day; MUFA, monounsaturated fatty acids; SFA, saturated fatty acids; PUFA, polyunsaturated; MET, metabolic equivalent of task; kg/m², kilograms per square meters.

- ^a *P*-Value of *t*-Student test <0.05 (total, male, female).
- ^b *P*-Value of chi-square test <0.05 (total, male, female).
- ^c *P*-Value of *t*-Student test >0.05 (female).
- ^d *P*-Value of *t*-Student test >0.05 (total).
- ^e *P*-Value of *t*-Student test >0.05 (total, male).
- ^f *P*-Value of chi-square test <0.05 (total, male).

Table 2

Baseline characteristics of SUN study population associated with the development of metabolic syndrome according to sex. The SUN Project (*Seguimiento Universidad de Navarra*, University of Navarra Follow-up), Navarra, Spain, 1999–2011.

Baseline characteristics	Sex		Total			
	Male	Female				
	Crude IRR (95% CI)	Multivariable-adjusted IRR (95% CI) ^a	Crude IRR (95% CI)	Multivariable-adjusted IRR (95% CI) ^a	Crude IRR (95% CI)	Multivariable-adjusted IRR (95% CI) ^{a,b}
Age (years) [per 1 years]	1.05 (1.04–1.06)	1.04 (1.02–1.05)	1.07 (1.05–1.09)	1.05 (1.03–1.07)	1.06 (1.05–1.07)	1.04 (1.03–1.05)
Smoking						
Non-smokers	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Current smokers	1.42 (1.01–2.01)	1.15 (0.81–1.64)	1.44 (0.97–2.16)	1.43 (0.94–2.16)	1.38 (1.05–1.79)	1.25 (0.96–1.64)
Ex-smokers	1.97 (1.50–2.59)	1.19 (0.89–1.60)	1.71 (1.18–2.48)	1.16 (0.79–1.69)	1.94 (1.56–2.42)	1.17 (0.93–1.47)
Alcohol consumption [per 10 g/day]	1.22 (1.13–1.32)	1.11 (1.02–1.21)	1.19 (0.95–1.50)	1.12 (0.89–1.42)	1.37 (1.29–1.47)	1.10 (1.02–1.19)
Snacking between main meals						
No	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Yes	1.17 (0.91–1.52)	1.38 (1.05–1.81)	1.22 (0.89–1.67)	1.13 (0.81–1.56)	1.03 (0.85–1.26)	1.28 (1.04–1.57)
Use of special diets (%)						
No	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Yes	0.94 (0.51–1.75)	0.86 (0.46–1.62)	1.48 (0.85–2.56)	1.04 (0.59–1.82)	1.07 (0.72–1.59)	0.97 (0.64–1.46)
Television watching [per 1 h/day]	0.98 (0.93–1.05)	0.99 (0.93–1.07)	1.00 (0.92–1.08)	1.01 (0.93–1.10)	0.98 (0.93–1.03)	1.00 (0.95–1.06)
Leisure-time physical activity [MET-h/week]						
1st quartile	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
2nd quartile	0.88 (0.62–1.24)	0.92 (0.64–1.29)	1.15 (0.76–1.74)	0.96 (0.64–1.45)	1.10 (0.85–1.43)	0.95 (0.73–1.24)
3rd quartile	0.83 (0.58–1.17)	0.82 (0.58–1.17)	0.96 (0.62–1.48)	0.88 (0.56–1.37)	1.03 (0.79–1.34)	0.85 (0.65–1.12)
4th quartile	0.63 (0.44–0.90)	0.82 (0.58–1.17)	0.80 (0.48–1.35)	0.84 (0.49–1.44)	0.93 (0.69–1.24)	0.79 (0.59–1.07)
Changes in weight over the last 5 years prior (kg)						
No	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)	1.00 (reference)
Lost	1.29 (0.87–1.90)	1.14 (0.77–1.69)	0.90 (0.52–1.56)	0.97 (0.55–1.69)	0.94 (0.69–1.29)	1.05 (0.77–1.43)
Gained	1.29 (0.96–1.74)	1.01 (0.74–1.39)	1.96 (1.25–3.08)	1.08 (0.68–1.74)	1.52 (1.19–1.94)	1.06 (0.82–1.36)

Baseline characteristics	Total					
	Sex		Male		Female	
BMI (kg/m ²) [per 1 kg/m ²]	Crude IRR (95% CI)	1.32 (1.25–1.39)	Multivariable-adjusted IRR (95% CI) ^a	1.26 (1.19–1.34)	Crude IRR (95% CI)	1.40 (1.32–1.47)
					Multivariable-adjusted IRR (95% CI) ^a	1.26 (1.19–1.34)
					Crude IRR (95% CI)	1.39 (1.34–1.44)
					Multivariable-adjusted IRR (95% CI) ^{a,b}	1.30 (1.25–1.36)

kcal, kilocalories; MET, metabolic equivalent of task; kg/m², kilograms per square meters.

^aAdjusted for age, smoking, alcohol consumption, snacking between main meals, use of special diets, television watching, physical activity, changes in weight over the last 5 years prior, and BMI at baseline.

^bAdditional adjusting for sex.

Table 3

Incidence Rate Ratios (IRR) and 95% Confidence Intervals (95% CI) of metabolic syndrome according to pro-vegetarian diet adherence, stratifying by sex. The SUN Project (*Seguimiento Universidad de Navarra*, University of Navarra Follow-up), Navarra, Spain, 1999–2011.

Sex	Pro-vegetarian diet adherence (scores)			<i>p</i> for trend
	18–33 ^a	34–38	39–54	
Male				
<i>n</i>	926	640	769	
Crude incidence/Person-years	5.8	5.1	6.9	0.269
Age-adjusted	1.00 (ref.)	0.89 (0.65–1.22)	0.84 (0.63–1.13)	0.261
Multivariable IRR (95% CI) ^b	1.00 (ref.)	0.93 (0.68–1.27)	0.95 (0.71–1.28)	0.752
Female				
<i>n</i>	1753	1406	1357	
Crude incidence/Person-years	1.9	0.9	1.6	0.122
Age-adjusted	1.00 (ref.)	0.54 (0.36–0.82)	0.58 (0.40–0.85)	0.004
Multivariable IRR (95% CI) ^b	1.00 (ref.)	0.54 (0.36–0.82)	0.63 (0.43–0.93)	0.014
Total				
<i>n</i>	2697	2046	2126	
Crude incidence/Person-years	3.4/1000	2.3/1000	3.4/1000	0.974
Age- and sex-adjusted	1.00 (ref.)	0.73 (0.57–0.93)	0.72 (0.57–0.91)	0.006
Multivariable IRR (95% CI) ^{b,c}	1.00 (ref.)	0.75 (0.59–0.97)	0.82 (0.64–1.03)	0.083

^aReference category.

^bAdjusted for age, smoking, alcohol consumption, snacking between main meals, use of special diets, television watching, physical activity, changes in weight over the last 5 years prior, and BMI at baseline.

^cAdditional adjusting for sex.

Table 4

Incidence Rate Ratios (IRR) and 95% Confidence Intervals (95% CI) of metabolic syndrome according to Dietary Approach to Stop Hypertension diet adherence, stratifying by alcohol consumption. The SUN Project (*Seguimiento Universidad de Navarra*, University of Navarra Follow-up), Navarra, Spain, 1999–2011.

Alcohol consumption	Dietary approach to stop hypertension adherence (scores)				p for trend
	9–18 ^a	19–21	22–24	25–28	29–40
1st tertile					
<i>n</i>	440	430	488	499	448
Crude incidence/Person-years	2.3/1000	1.2/1000	3.5/1000	2.3/1000	1.2/1000
Age- and sex-adjusted	1.00 (ref.)	0.85 (0.44–1.65)	0.88 (0.48–1.60)	0.62 (0.33–1.16)	0.49 (0.25–0.97)
Multivariable IRR (95% CI) ^b	1.00 (ref.)	0.74 (0.38–1.45)	0.81 (0.44–1.48)	0.52 (0.27–1.00)	0.41 (0.20–0.85)
2nd tertile					
<i>n</i>	431	433	475	494	414
Crude incidence/Person-years	3.3/1000	3.0/1000	1.6/1000	1.2/1000	1.8/1000
Age- and sex-adjusted	1.00 (ref.)	1.10 (0.61–2.00)	1.17 (0.64–2.16)	0.99 (0.54–1.81)	0.59 (0.29–1.22)
Multivariable IRR (95% CI) ^b	1.00 (ref.)	1.07 (0.58–1.97)	1.13 (0.60–2.13)	1.01 (0.54–1.89)	0.68 (0.32–1.44)
3rd tertile					
<i>n</i>	559	449	462	481	348
Crude incidence/Person-years	4.0/1000	4.9/1000	4.2/1000	4.8/1000	8.1/1000
Age- and sex-adjusted	1.00 (ref.)	1.39 (0.91–2.11)	1.07 (0.70–1.65)	1.34 (0.87–2.05)	1.07 (0.65–1.75)
Multivariable IRR (95% CI) ^b	1.00 (ref.)	1.42 (0.93–2.19)	1.12 (0.72–1.74)	1.41 (0.90–2.22)	1.22 (0.73–2.03)
Total					
<i>n</i>	1430	1312	1425	1474	1210
Crude incidence/Person-years	3.3/1000	3.0/1000	3.1/1000	2.7/1000	3.3/1000
Age- and sex-adjusted	1.00 (ref.)	1.16 (0.86–1.58)	1.06 (0.79–1.42)	1.03 (0.76–1.39)	0.74 (0.52–1.05)
Multivariable IRR (95% CI) ^b	1.00 (ref.)	1.12 (0.82–1.53)	1.05 (0.78–1.41)	1.01 (0.74–1.39)	0.80 (0.55–1.15)

^aReference category.

^bAdjusted for age, sex, smoking, alcohol consumption, snacking between main meals, use of special diets, total energy intake, television watching, physical activity, changes in weight over the last 5 years prior, and BMI at baseline.