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A brief assessment of eating habits and weight gain in a Mediterranean cohort

ABSTRACT

Assessment of eating habits (EH) through closed questions could be an alternative tool to assess diet as a predictor of weight change in epidemiological studies. The aim was to assess the association between baseline EH and risk of weight gain or becoming overweight/obese in a Spanish dynamic prospective cohort (the SUN Project) of 10,509 participants. The baseline questionnaire included 10 short questions with two possible answers: Yes or No. We calculated a baseline EH score, categorized in quartiles, positively weighting answers on more fruit, vegetable, fish and fiber and less meat, sweets and pastries, fat, butter, fatty meats and added sugar to drinks. Reducing the consumption of meat or fat and removing fat from meat were significantly associated with lower weight gain. Partial correlation coefficient between EH score and weight change was -0·033 (p=0·001). We observed 1063 cases of incident overweight/obesity among 7217 participants without overweight/obesity at baseline. Trying to eat more fruit, fish, or fiber and less meat were inversely significantly associated with incident overweight/obesity. Those participants in the upper quartile of the score were at 38% (adjusted OR: 0·62; 95% CI: 0·48-0·81) lower risk of developing overweigh/obesity during follow-up compared to those in the lower quartile. However, the ROC curves for the model with and without the EH score were materially identical. Despite the apparent significant inverse association, this score had a low predictive value for future weight gain and for incident overweight/obesity in a Mediterranean population, although some EH were independently and positively associated with weight gain.

INTRODUCTION

Obesity constitutes the most common metabolic disease in developed countries and it is associated with numerous adverse health problems, including, but not limited to, cardiovascular disease, hypertension, diabetes and cancer (1, 2).

The rising prevalence of obesity in both developed and developing countries in the last two decades suggests that current efforts to control weight have been inadequate (2, 3). In this regard, excess body fat has reached epidemic proportions and should be recognized as an important health crisis, and not simply a matter of cosmetics or lifestyle choice (4).

Determinants of weight gain are clearly multifactorial and involve genetic components, but the most important modifiable factors are the diet and a sedentary lifestyle (1). Thus, although previous studies have shown that weight changes depend on energy balance and on the composition of the diet (5, 6), others have suggested that several characteristics of diet-related habits or attitudes (for example fewer healthy food choices, a lower fiber density, a higher percentage of energy from fat), may also be responsible for the considerable increase in the prevalence of obesity (6-9). Besides, a better understanding of these factors is essential to design more appropriate health policies.

On the other hand, in the past 20 years, most of the epidemiologists who have investigated relationships between diet and chronic disease have used long FFQ to evaluate dietary patterns in large studies (10). However, the validity of dietary information obtained from this and other methods has been questioned, being also sometimes too complicated and time-consuming for using it in the field of intervention studies, routine clinical or community health education (11-13). One of the main challenges of nutritional epidemiology has always been to assess correctly the diet of individuals, taking into account the possible inherent presence of information bias. One of the alternatives proposed is the possible assessment of dietary habits through closed questions and not only to assess the nutrient intake. In addition, this procedure allows giving simple and clear messages as fast feedback to participants in intervention studies (14).

Furthermore, a better understanding of eating behaviours could be essential to innovate more appropriate health policies to combat the growing obesity epidemic (15, 16). However, although previous studies based on FFQ have consistently shown an association between some food patterns or specific dietary habits and the risk of obesity (17-19), to the best of our knowledge, no previous studies have focused on the effect of dietary habits on weight gain among a large cohort in a Mediterranean region. Thus, the purpose of this study was to examine the association between

several baseline eating behaviours and the risk of weight gain (or becoming overweight/obese) in a large prospective cohort of university graduates in Spain.

SUBJECTS AND METHODS

Study population

The "Seguimiento Universidad de Navarra" (SUN) Project is a multipurpose, dynamic cohort designed to establish the association between diet and several chronic diseases and health conditions like overweight, obesity and weight change along time (20). The SUN cohort was designed in collaboration with the Harvard School of Public Health and uses a similar methodology as large American cohorts such as the Nurses' Health Study and the Health Professionals Follow-up Study.

Briefly, the recruitment of participants started in December 1999 and it is permanently open. Information is collected using self-administered questionnaires sent by postal mail every 2 years. Details on the cohort design, recruitment strategy and follow-up methods are available elsewhere (21).

For this analysis, we included participants who had already been followed up for at least 2 years. Participants who completed a baseline assessment (Q_0) before February 2006 were eligible for longitudinal analyses (n=15982). Among them, 1885 had not answered any of the follow-up questionnaires, and after five more mailings separated by 2 months each, they were considered lost to follow-up. We therefore retained 14097 participants (88 %). Data from 10509 participants remained available for the analysis, because we excluded those participants who were following a special diet at baseline (n=922), subjects who reported extremely low or high values for total energy intake (<800 or > 4200 kcal/d for men and <500 or > 3500 kcal/d for women) (n=1380), pregnant women at baseline and during follow-up (n=1272), and participants with missing values in the variables of interest (n=14), but not in dietary habits, were excluded from the analysis. Finally, those participants with missing data in dietary behaviours were considered as negative respondents for the healthy dietary habits.

The project protocol was approved by the Institutional Review Board at the University of Navarra. Voluntary completion of the first self-administered questionnaire was considered to imply informed consent.

Assessment of dietary exposure

Dietary exposures were assessed through a baseline semi quantitative food-frequency questionnaire (136 items), previously validated in Spain (22) inquiring about food consumption during the previous year.

This questionnaire was based on typical portion sizes and had nine categories for frequency of consumption that ranged from "never or almost never" to "≥6 times/day". Energy and nutrient intake were derived by trained dietitians using a computer program based on latest available information in Spanish food composition tables (23, 24).

Food and nutrient intakes were adjusted for total energy intake using the residuals method (25).

Additionally, the baseline FFQ questionnaire included information about changes in the general dietary habits through the following questions: 'Do you try to eat more fiber?', 'Do you try to eat more fruit?', 'Do you try to eat more vegetables?', 'Do you try to eat more fish?', 'Do you try to eat less fat?', 'Do you try to eat less meat?', 'Do you try to eat less sweets and pastries?', 'Do you avoid the consumption of butter?', 'Do you try to eat less fat from meat?', and 'Do you try to add sugar to drinks?' all of them with two possible answers: Yes or No. We calculated a baseline score of dietary behaviours assigning 1 point if the behaviour was healthy, defined as healthy if the participant tried to eat more fiber, more fruit, more vegetables, more fish, less meat, less sweets and pastries, if he/she tried to avoid the intake of fat, the consumption of butter, removed fat from meat and if he/she did not add sugar to drinks. We summed up the 10 values for each participant obtaining a score ranging from 0 to 10. A negative answer was considered when a participant had a missing value in those questions (range for missing values 1·1% - 6·8 %). Finally, this score was categorized roughly into quartiles.

Assessment of other variables

The baseline questionnaire included questions about a wide array of characteristics: sociodemographic (sex, age, marital status, college degree or employment), anthropometric (weight, height, body image or weight change), lifestyle and health-related habits (smoking status, physical activity or consumption of alcoholic beverages, time spent sitting down and TV viewing), family history of several diseases, obstetric history for women (pregnancy) and medical history variables (prevalence of chronic diseases, medication use, and lipids or blood pressure levels).

Physical activity was collected at baseline through a questionnaire which included information about 17 activities. To quantify the volume of activity during leisure time, an activity metabolic equivalent (MET) index was computed by assigning a multiple of resting metabolic rate (MET score) to each activity (26). The time spent in each of the activities was multiplied by the MET

score specific to each activity, and then summed for the overall activities, obtaining a value of overall weekly MET hours. The validity of data on self- reported leisure –time physical activity in the SUN cohort has been previously reported (27).

Assessment of the outcome

Information on weight was collected at baseline and at each follow-up questionnaire. BMI was calculated as weight in kilograms divided by height in meters squared. The validity of self-reported weight was assessed in a subsample of the cohort. The mean relative error in self-reported weight was 1·45%. The correlation coefficient between measured and self-reported weight was 0·99 (95% CI 0·98-0·99) (28).

The outcomes after follow-up were: 1) change per year in body weight during follow-up as a continuous variable calculated as the difference between the last answered questionnaire and the baseline questionnaire divided by the years of follow-up and 2) incident overweight/obesity (participants with a BMI < 24·9 kg/m^2 at baseline and with a BMI ≥25 kg/m^2 at follow-up). We repeated the analyses after excluding those participants who had missing values in dietary habits and also after excluding those who had prevalent cardiovascular disease, diabetes or cancer at baseline.

Statistical analysis

Linear regression models were used to assess the association between each dietary habit and change per year in body weight during the follow-up period and also between the baseline eating behaviours score and weight change.

Non-conditional logistic regression models were fit to assess the relationship between each eating behaviour or the overall baseline score (categorized in quartiles) and the risk of becoming overweight/obese (BMI ≥ 25 kg/m^2).

The area under the receiver-operating characteristic (ROC) curve was used to assess the ability of the eating habits score to predict future weight changes.

For each exposure, we fitted four types of models: a) a crude (univariate) model, b) an age- and gender- adjusted model, c) a multivariate- adjusted model controlling for age, gender and lifestyle and d) a multivariate- adjusted model, adjusting also for total energy intake (kcal/day), in addition to all the variables presented above.

The lifestyle variables that we adjusted for were: baseline BMI (Kg/m^2, continuous), smoking status (never smoker, ex-smoker and current smoker), physical activity during leisure time (MET-

hours/week, continuous), time spent sitting (h/week, continuous), TV viewing (h/week, continuous) and weight gain $\geq$ 3 kg in the past 5 years (yes/no).

We considered the lowest quartile of the overall baseline score or the negative answers to each dietary habit change as the reference category.

The association between the baseline eating habits score and weight gain was analysed using a partial correlation coefficient, and controlling for age, sex and TV viewing. Finally, we used the Hosmer-Lemeshow test cross-classification in deciles to assess the proportion of participants correctly classified by the logistic model as future cases of overweight/obesity or not. In one model we introduced only the baseline BMI as predictor and in the other we added the baseline eating habits score.

Analyses were performed with SPSS version 15.0 (SPSS Inc., Chicago, Illinois, USA). All P values are two-tailed; P <0˙05 was considered statistically significant.

RESULTS

The median follow-up of participants was 4˙5 years. Baseline characteristics of the study population according to the categories of the quartiles of the overall score of eating behaviours are shown in Table 1. Women were more likely than men to be in the upper quartile. Participants with better dietary habits were also older, more active during leisure time and less likely to be current smokers or ex-smokers. Energy, total fat, PUFA and alcohol intakes were inversely associated with the baseline score. However, carbohydrate, protein and fiber intakes increased in parallel with the 10-unit dietary habits score. Moreover, participants belonging to the highest quartile were more likely to exhibit healthier dietary habits in almost every evaluated aspect.

Table 2 shows the results of the linear regression models fitted to evaluate the association between baseline eating behaviours and weight gain during follow-up. We found that although, on average, participants increased their weight at follow-up, subjects with the worst dietary habits (quartile 1 of the score) showed a weight gain = + 0.33 kg/year, whereas subjects with the better eating behaviours (quartile 4) experienced a significantly lower weight gain = + 0.16 kg/year. These results remained also statistically significant in all multivariable models. Moreover, an increase in two points in the baseline eating score was significantly associated with less weight gain (ß = -0.03, 95 % CI:-0.05 to -0.01) in the multivariate model (Table 2). The partial correlation coefficient after controlling for age, sex and TV viewing showed a significant inverse association between the eating habits score and weight change (p = 0˙001), however, the absolute magnitude of the coefficient was small (partial r= -0˙033).

When we specifically assessed the association with weight change for each of the 10 components of the eating behaviours score (Table 3), we found an inverse association with a positive answer to the question 'Do you try to eat less meat?' (ß coefficients = -0.07, 95 % CI:-0.11 to -0.02), 'Do you try to remove fat from meat?' (ß = -0.06, 95 % CI: -0.11, to -0.01) and with 'Do you try to eat less fat?' (ß = -0.06, 95 % CI: -0.11 to -0.02) after adjusting for age, gender, lifestyle and total energy intake (Table 3).

Moreover, a positive answer to 'Do you try to eat more fruit?', '¿Do you try to eat more vegetables?', 'Do you try to eat more fish?', 'Do you try to avoid the consumption of butter?' and 'Do you try to eat less sweets and pastries?', were not statistically significant after multivariate adjustment, although the point estimates suggested a beneficial effect.

We did not observe any significant interaction between eating behaviours score and sex, age and physical activity.

We included 7217 subjects without prevalent overweight or obesity at baseline to assess the association between baseline dietary habits and the risk of incidence overweight/obesity (Table 4). During follow-up, we observed 1063 incident cases of overweight/obesity.

When we assessed the association between quartiles of the overall score and the risk of becoming overweight/obese, we observed that participants in the 2 upper quartiles of dietary habits score exhibited a significantly lower risk during follow-up than did participants in the quartile with the worst practices (OR: 0.77; 95% CI: 0.62 to 0.97, and 0.62; 95% CI: 0.48 to 0.81, for the quartiles 3 and 4, respectively) (Table 4). In addition, an increase in two points in the score reduced the risk of becoming overweight/obese by 12% (OR=0.88; 95% CI: 0.81 to 0.94) after adjusting for age, gender and other potential confounding variables.

Moreover, the most consistent predictors of a lower risk for the development of overweight/obesity were more fruit, more fish, less meat and more fiber intake. No significant association was observed for any of the other 6 eating behaviours (Table 5).

On the other hand, the proportions of correctly classified cases by the models with or without the eating habits score were very similar (99.29 % and 99.37 %, respectively).

When we repeated the analyses after excluding subjects with missing values in variables of eating behaviours in the baseline questionnaire (n=1244) as a sensitivity analysis, the results were almost the same (data not shown). Finally, when we excluded from the analysis those with a diagnosis of diabetes, hypertension, cancer or cardiovascular disease during the follow-up period (n=1835) from the analysis, the results in the multivariate models were very similar and they were in the same

direction with respect to the following items: 'Try to eat less fat' (ß = -0·09, 95 % CI:-0·14 to -0·04), 'less butter' (ß = -0·06, 95 % CI: -0·10 to -0·01, and 'less meat' (ß = -0·09, 95 % CI: -0·13 to -0·04), in the multivariate models.

The areas under the ROC curves were also estimated for the models with and without the eating habits score. They were very similar, showing areas under the curve of 0·8810 and 0·8798, respectively.

DISCUSSION

To our knowledge, this is the first prospective cohort that has investigated the association between several eating habits and weight change in a Mediterranean population.

The use of a few simple, short closed-ended questions has a low value to predict future weight gain or the risk of overweight/obesity in a cohort of Spanish university graduates.

In the present population, overall nutrient intake profile was more favourable among participants with better baseline dietary habits (quartile 4 of the score) compared with those who had the worst dietary practices (quartile 1).

As expected, although participants increased their average weight during follow-up (0.22 kg/year), crude increments were lower among those with the best dietary practices according to the score.

Although the scientific literature about this topic is not abundant, previous studies have suggested that eating habits may be associated with body weight and weight changes. However, an important concern to compare our findings with other studies is that the majority of the available evidence comes from studies using a long FFQ, instead of a short questionnaire food habits and practices.

Results from our study suggest that specific dietary habits such as 'trying to eat less meat', 'removing fat from meat' and 'eating less fat' are associated with less weight gain after controlling for age, gender, lifestyle and total energy intake. The role of dietary intake, particularly dietary fat, and some dietary patterns (Low-Carbohydrate, Mediterranean or Low-Fat diet) in weight gain remains highly controversial (18, 29). Thus, a recent randomized trial suggests that low-fat diets may contribute to weight maintenance, while high fat diets may promote weight gain due to the fact that dietary fat is more energy-dense per gram than protein or carbohydrate (30). On the other hand, the saturated fat and trans fat are the two subtypes of dietary fat that have the strongest association with the risk of weight gain (31). Besides, foods that are high in fat are usually more palatable. Therefore, people may consume them in larger quantities, and thus increase their energy intake

(32). However, evidence from long-term randomized trials and epidemiological studies linking dietary fat intake to weight gain or obesity is weak and not consistent (30-32).

It is important to note that the Mediterranean dietary pattern is characterized by high intake of monounsaturated fat, obtained from olive oil. However, in some Mediterranean countries, traditional food choices are changing and the adherence rate to the Mediterranean diet has decreased (33). Thus, in Spain, unfortunately, the consumption of fast-food, rich in saturated fat, has increased in the last years. A previous study or our cohort reported this change, but especially in younger men after 28 months of follow-up (17).

We might speculate that the dietary pattern of participants belonging to the upper quartile of the practices score resembles a Prudent diet, characterized by high intakes of fruits, vegetables, whole grains, fish, but less meat, sweets and fat (35). Relatively few studies have examined associations between overall dietary patterns and prospective weight change. However, results from the Nurses' Health Study II suggest that a prudent dietary pattern may facilitate weight maintenance, whereas a Western pattern characterized by high intakes of red and processed meats, refined grains, sweets, desserts, and potatoes was associated with larger weight gain in women (18). Moreover, in the European Prospective Investigation into Cancer and Nutrition-Potsdam (EPIC) cohort, Shulz *et al* identified a food pattern characterized by high fiber and low-fat food choices. The main result was that subjects scoring high for this pattern maintained their weight or gained significantly less weight over time compared to subjects with an opposite pattern (36). In this context, in our study participants who had a higher score ($\geq$ 9) in the eating behaviours were 38 % less likely to become overweight or obese in comparison with those who had a lower score ($\leq$4). We considered the possibility that this inverse association may be simply a marker of an overall healthier lifestyle. However, when we simultaneously adjusted for age, gender, a wide array of lifestyle variables and total energy intake, the results were similar to the unadjusted estimates.

We also observed that 'To eat less meat' was associated with lower gains in body weight over time. This finding is consistent with previous studies (37-41) and with a previous assessment from the SUN cohort (17). It should be highlighted that this healthy behaviour presented a consistent inverse association with weight gain and with the risk of presenting overweight/obesity. Higher intakes of meat were also predictive of weight gain over a 2-year follow-up period among men and women in the EPIC study (37). In addition, in the EPIC- Spain cohort, meat consumption in women was significantly associated with the incidence of obesity (38). Moreover, a larger weight gain was significantly predicted by meat consumption in a study of 79000 men and women recruited in 1982, for the Cancer Prevention Study (39). Another study suggested that consumption of more red meat may be a factor contributing to body weight gain in China (40). Finally, a recent research has

suggested that meat consumption was specially associated with weight change and that a decrease in meat consumption was able to improve weight management (41).

On the other hand, in our cohort, participants who 'tried to eat more fiber' had an 18% lower risk of developing overweight/obesity than those who did not try to consume more fiber. This finding was broadly in agreement with those observed in other studies (6, 42-44) and in a previous cross-sectional assessment in the SUN project (45). Thus, whole grain consumption has been associated with reduced risk of both weight gain and the development of obesity in large cohorts of both middle-aged women (42) and men (43). Our group also found that food items with low fiber content [34] which are not typical of the Mediterranean diet (17) were associated with larger weight gains. Moreover, intervention studies have also reported smaller weight change with an increase in fiber intake in the context of ad libitum diets (46,47). Dietary fiber has been shown to increase insulin sensitivity, decrease hunger and subsequently decrease total energy intake and increase the sensation of satiety (17, 45).

Another dietary behaviour that was inversely associated with the development of overweight/obesity was 'Try to eat more fish'. Unfortunately, there is a scarcity of research on the relationship between fish consumption and the risk of obesity. This finding can be partially confirmed by results from the Nurses' Health Study (48), but not by the data from the Potsdam-EPIC cohort or the EPIC-Spain cohort although some estimates were also below the null value (37,38) and there were methodological differences between our study and these other cohorts.

On the contrary, 'Trying to eat less fat' was not associated with a lower risk of overweight/ obesity. Perhaps, the lack of association might be due to the fact that this question does not specify what type of fat the participants try to reduce. For example, in our context of a Mediterranean dietary pattern, it is possible that participants try to decrease dietary fat intake from meats, pastries or dairy food, but not of healthy fat, such as olive oil.

Finally, our results indicate that adding sugar to beverages was not associated with a higher risk of developing overweight/obesity or with higher weight gain. A possible explanation is that our question was likely to be interpreted by participants as referring to the practice of adding sugar (for example, one or two teaspoons) to beverages with low energy density (i.e. coffee or tea), but it was not perceived as the consumption of sugar-sweetened beverages per se. In addition, a prospective study of more than 58000 women and men demonstrated that increases in caffeine intake may lead to a small reduction in long- term weight gain (49).

Strengths of our study include the prospective design, which avoids the possible effect of reverse causality in the reported associations, the relatively large sample size, the long follow-up period, the

control for an important number of potential confounders and the previous validation of the methods used for the assessment of our outcomes. This may clarify the complex and dynamic relationship between eating behaviours and weight change.

Our study has several methodological limitations. First, the questions on eating behaviours have not been specifically validated. However, the questions used are simple enough to expect not many problems with classification, because people should easily remember their food habits. Besides, the high level of education in our cohort (all participants were university graduates, with 48% health professionals) increased the internal validity of the study and probably the quality of these self-reported data. When we supported the validity of our instrument with more data on food and nutrient intake from the validated food frequency questionnaire, we observed that although the short tool capture only specific foods or nutrients of interest, it could captures a larger pattern of dietary behavior or nutrient intake. However, we have shown that each question assesses more specifically participants' food consumption or nutrient intake directly related to it (data not shown). Nevertheless, we have to take into account the inherent methodological flaws of self-reported food frequency questionnaires.

Second, a potential limitation of the present study is related to the use of self-reported weight gain. Thus, weight change might have been under-reported in our participants. However, the validity of a self-reported medical diagnosis of overweight/obesity among highly educated participants in our cohort and in other similar cohorts has been sufficiently demonstrated elsewhere (28, 50).

Third, residual confounding may have affected the observed associations. However, we attempted to adjust for the known weight gain risk factors in our multivariate analyses. We did not control for confounding due to socioeconomic status or educational level because the relatively homogenous study population (all of them university graduates) with respect to these characteristics reduced the possibility that our findings were seriously biased because of confounding by socioeconomic status.

It could be speculated that both the answers to the 10 short questions on habits/practices toward a healthy diet and the self-reporting of weight might be affected by social desirability bias. Thus, subjects more prone to this bias, wanting to be perceived as healthier from their responses to the questionnaire, might be classified both with a higher score and less likely to gain weight. Had this bias occurred, it would provide an alternative, non-causal explanation of our findings. We were concerned about this potential bias and analysed in the weight validation study whether those with a higher score were more or less likely to underreport their weight. We found that those with a higher score were significantly less likely to underreport their actual weight (mean average error= 2.4 %

among those scoring <=5 versus mean average error=0˙6 % among those scoring >=6, p =0˙005). Therefore this alternative non-causal explanation does not seem very likely for our results.

In conclusion, the present study is important because it is the first in suggesting that a score built after a brief assessment of key eating habits is independently associated with weight gain and with the incidence of overweight/obesity in a free-living Mediterranean adult population. But, as all our participants were university graduates, and many of them (48%) were health professionals, our results may lack external validity for less educated subjects. However, in highly educated population, this abbreviated-form tool has the advantage of providing short, easily understandable messages to the population to avoid overweight and obesity. This simplified method could be useful as an additional tool to evaluate dietary habits. Nevertheless, our results suggest that its value to predict, discriminate or classify future weight change is low.

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Table 1. Main characteristics of the 10509 participants of the SUN cohort based on scores evaluating baseline eating habits (Means and standard deviations or percentages).

	Quartiles of baseline eating habits (Score)							
	Q1		Q2		Q3		Q4	
	(<= 4points)		(5-6 points)		(7-8 points)		(>=9 points)	
Sample size (*n*) …	2113		2661		3402		2333	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age (years)	35·3	10·4	37·4	11·6	40·0	12·2	42·5	12·7
Baseline BMI (kg/m^2)	23·7	3·5	23·6	3·5	23·8	3·4	23·6	3·3
Baseline BMI > 24,9 (%)	33·5		31·9		33·2		31·6	
Baseline weight (kg)	70·5	14·1	68·2	13·6	67.8	13.3	66.3	12.6
Physical activity during leisure time (MET-h/week)	22·7	20·7	23·4	20·5	24.0	21.3	27.2	24.4
Gender (%)								
Men	62·3		48·0		42·9		35·9	
Smoking status (%)								
Ex-smoker	22·1		26·2		32·4		35·5	
Current-smoker	30·0		23·7		21·4		16·8	
Non-smokers	44·5		46·9		43·6		45·0	
Fruit consumption (g/day)	208·1	179·6	276·8	224·1	355.9	291.5	470.3	342.9
Vegetable consumption (g/day)	374·2	281·0	455·0	278·9	528·4	309·2	615·5	362·0
Fish consumption (g/day)	75·6	47·6	87·4	50·1	100·8	61·6	120·8	68·8
Meat consumption (g/day)	199·5	81·4	187·2	74·4	170·3	74·0	150·1	70·9
Nuts (g/day)	5·8	8·3	6·6	9·6	6·9	11·2	8·8	14·9
Legumes (g/day)	22·3	20·0	22·4	15·2	23·0	17·0	23·6	17·3

Table 1 (continued). Main characteristics of the 10509 participants of the SUN cohort based on scores evaluating baseline eating habits (Means and standard deviations or percentages).

	Quartiles of baseline eating habits (Score)							
	Q1		Q2		Q3		Q4	
	(<= 4points)		(5-6 points)		(7-8 points)		(>=9 points)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Dairy products (g/day)	281·0	228·0	241·2	213·3	196·6	194·8	157·0	174·0
Cereals (g/day)	109·8	79·8	105·2	75·3	104·4	75·9	100·3	71·2
Mediterranean Diet Score (Trichopoulou et al)	3·2	1·6	3·9	1·7	4·5	1·7	5·2	1·7
Energy intake (kcal/day)	2489	652	2441	611	2335	607	2295	601
CHO intake (% E)	44·5	17·5	45·1	15·8	48·5	17·4	50·6	17·3
Protein intake (% E)	17·1	3·1	17·5	2·9	18·2	3·2	18·7	3·5
Fat intake (% E)	40·3	15·2	39·5	13·8	39·8	14·9	36·7	15·3
PUFA intake (% E)	5·9	2·6	5·7	2·4	5·7	2·5	5·7	2·6
MUFA/SFA ratio	1·2	0·3	1·2	0·3	1·5	8·0	1·4	1·3
Fiber intake (g/day)	20·6	7·9	24·1	8·5	28·3	9·3	33·1	11·2
Alcohol intake (g/day)	7·9	11·7	7·4	11·1	7·1	10·8	6·6	9·7
Do you try to eat more fruit? (% Yes)	26·7		57·9		77·1		95·9	
Do you try to eat more vegetable? (% Yes)	38·2		73·2		91·6		99·2	
Do you try to eat more fish? (% Yes)	20·5		44·9		68·0		92·9	
Do you avoid the consumption of butter? (% Yes)	28·0		61·0		82·9		96·2	
Do you try to eat less meat? (% Yes)	4·9		15·7		35·6		76·9	
Do you try to remove fat from meat? (% Yes)	56·9		75·7		87·1		97·4	

Table 1 (continued). Main characteristics of the 10509 participants of the SUN cohort based on scores evaluating baseline eating habits (Means and standard deviations or percentages).

	Quartiles of baseline eating habits (Score)			
	Q1	Q2	Q3	Q4
	(<= 4points)	(5-6 points)	(7-8 points)	(>=9 points)
Do you try to eat less sweets and pastries? (% Yes)	21·2	49·6	71·0	93·4
Do you try to eat more fiber? (% Yes)	13·9	39·6	68·7	93·7
Do you try to eat less fat? (% Yes)	28·7	72·2	93·3	99·7
Do you add sugar to some beverages? (% Yes)	44·4	34·4	25·1	10·5

Table 2. Mean weight change (kg)/ based on quartiles of scores evaluating baseline eating habits and based on an increase of 2 points in the score. Linear regression coefficients (b) and 95 % CI.

	Weight change (kg/year)	Crude		Adjusted for age and gender		Adjusted for age, gender and lifestyle[1]		Adjusted for age, gender, lifestyle and total energy intake	
	Mean	b	95 % CI	b	95 % CI	b	95 % CI	b	95 % CI
Quartiles of 10-unit eating habits score									
Q1 (<= 4points)	+0·33	0 (ref)		0 (ref)		0 (ref)		0 (ref)	
Q2 (5-6 points)	+0·23	-0·10	-0·16, -0·04**	-0·08	-0·14, -0·02**	-0·07	-0·13, -0·10*	-0·07	-0·13,-0·01*
Q3 (7-8 points)	+0·18	-0·15	-0·21, -0·10**	-0·11	-0·17, -0·05**	-0·10	-0·15, -0·04**	-0·10	-0·16, -0·04**
Q4 (>=9 points)	+0·16	-0·16	-0·23, -0·10**	-0·11	-0·17, -0·04**	-0·09	-0·15, -0·03**	-0·10	-0·16, -0·03**
Eating habits score (for an increase of 2 points in the score)	+0·22	-0·05	-0·07, -0·03**	-0·03	-0·05, -0·01**	-0·03	-0·04, -0·01**	-0·03	-0·05, -0·01**

[1] Lifestyle variables: baseline BMI, smoking status (never smoker, ex-smoker, or former smoker), leisure-time physical activity (metabolic equivalent-h/wk), sitting (h/week), TV viewing (h/week) and weight gain $\geq$ 3 kg in the past 5 years (yes or no). * $p < 0.05$, ** $p < 0.001$

Table 3. Factors associated with the weight change(kg)/ year in the SUN cohort (n=10509). Linear regression coefficients (b) and 95 % CI. The answer "No" is given as the reference (zero values)

	Weight change (kg/year)	Crude		Adjusted for age and gender		Adjusted for age, gender and lifestyle[1]		Adjusted for age, gender, lifestyle and total energy intake	
	Mean	b	95 % CI	b	95 % CI	b	95 % CI	b	95 % CI
Do you try to eat more fruit?									
Yes (n=6964)	+0·19	-0·06	-0·11, -0·02**	-0·03	-0·07, 0·01	-0·03	-0·07, 0·02	-0·03	-0·07, 0·02
Do you try to eat more vegetable?									
Yes (n=8187)	+0·21	-0·05	-0·10, -0·001*	-0·02	-0·07, 0·03	-0·03	-0·08, 0·02	-0·03	-0·08, 0·02
Do you try to eat more fish?									
Yes (n=6107)	+0·20	-0·05	-0·09, -0·01*	-0·03	-0·07, 0·01	-0·02	-0·06, 0·02	-0·02	-0·06, 0·02
Do you avoid the consumption of butter?									
Yes (n=7279)	+0.19	-0.10	-0.14, -0.06 **	-0.06**	-0.12, -0.02	-0.04	-0.08,0.01	-0.04	-0.08,0.01

Table 3 (continued). Factors associated with the weight change(kg)/ year in the SUN cohort (n=10509). Linear regression coefficients (b) and 95 % CI. The answer "No" is given as the reference (zero values)

	Weight change (kg/year)	Crude		Adjusted for age and gender		Adjusted for age, gender and lifestyle[1]		Adjusted for age, gender, lifestyle and total energy intake	
	Mean	b	95 % CI	b	95 % CI	b	95 % CI	b	95 % CI
Do you try to eat less meat?									
Yes (n=3528)	+0·15	-0·09	-0·13, -0·05**	-0·06**	-0·10, -0·01**	-0·06	-0·11, -0·02**	-0·07	-0·11, -0·02**
Do you try to remove fat from meat?									
Yes (n=8455)	+0·21	-0·05	-0·01, -0·10*	-0·04	-0·10, 0·01	-0·06	-0·11, -0·01*	-0·06	-0·11, -0·01*
Do you try to eat less sweets and pastries?									
Yes (n=6364)	+0·19	-0·06	-0·10, -0·02**	-0·04	-0·08, -0·001*	-0·02	-0·06, 0·02	-0·02	-0·06, 0·02
Do you try to eat more fiber?									
Yes (n=5870)	+0·20	-0·03	-0·07, 0·01	-0·01	-0·05, 0·03	-0·01	-0·05, -0·04	-0·01	-0·05, 0·04

Table 3 (continued). Factors associated with the weight change(kg)/ year in the SUN cohort (n=10509). Linear regression coefficients (b) and 95 % CI. The answer "No" is given as the reference (zero values)

	Weight change (kg/year)	Crude		Adjusted for age and gender		Adjusted for age, gender and lifestyle[1]		Adjusted for age, gender, lifestyle and total energy intake	
	Mean	b	95 % CI	b	95 % CI	b	95 % CI	b	95 % CI
Do you try to eat less fat?									
Yes (n=8027)	+0·20	-0·10	-0·15, -0·06**	-0·07	-0·12, -0·02**	-0·06	-0·11, -0·01*	-0·06	-0·11,-0·02*
Do you add sugar to some beverages?									
Yes (n=2955)	+0·24	0·03	-0·02, 0·07	0·01	-0·03, 0·06	0·002	-0·04, 0·04	0·001	-0·04, 0·05

[1] Lifestyle variables: baseline BMI, smoking status (never smoker, ex-smoker, or former smoker), leisure-time physical activity (metabolic equivalent-h/wk), sitting (h/week), TV viewing (h/week) and weight gain ≥ 3 kg in the past 5 years (yes or no).* $p < 0.05$, ** $p < 0.001$

Table 4. Incident Overweight/Obesity in participants without overweight/obese at baseline based on quartiles of scores evaluating baseline eating habits and based on an increase of 2 points in the score. Odds Ratios (ORs) and 95 % confidence intervals (CI).

	Subjects	Incident cases of overweight/obesity	OR Crude		OR adjusted for age and gender		OR Adjusted for age, gender and lifestyle[1]		OR Adjusted for age, gender, lifestyle and total energy intake	
	n	n	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Quartiles of 10-unit eating habits score										
Q1 (<= 4points)	1430	250	1 (ref)		1 (ref)		1 (ref)		1 (ref)	
Q2 (5-6 points)	1841	285	0·87	0·72, 1·04	1·02	0·84, 1·23	0·89	0·71, 1·11	0·89	0·71, 1·12
Q3 (7-8 points)	2330	336	0·80	0·67, 0·96*	0·99	0·81, 1·19	0·77	0·62, 0·96*	0·77	0·62, 0·97*
Q4 (>=9 points)	1626	192	0·63	0·52, 0·77**	0·81	0·65, 1·00	0·62	0·48, 0·81**	0·62	0·48, 0·81**

Table 4 (continued). Incident Overweight/Obesity in participants without overweight/obese at baseline based on quartiles of scores evaluating baseline eating habits and based on an increase of 2 points in the score. Odds Ratios (ORs) and 95 % confidence intervals (CI).

	Subjects	Incident cases of overweight/obesity	OR Crude		OR adjusted for age and gender		OR Adjusted for age, gender and lifestyle[1]		OR Adjusted for age, gender, lifestyle and total energy intake	
	n	n	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Eating habits score (for an increase of 2 points in the score)	7217	1063	0·89	0·84, 0·94**	0·96	0·90, 1·02	0·87	0·81, 0·94**	0·88	0·81, 0·94**

[1] Lifestyle variables: baseline BMI, smoking status (never smoker, ex-smoker, or former smoker), leisure-time physical activity (metabolic equivalent-h/wk), sitting (h/week), TV viewing (h/week) and weight gain $\geq$ 3 kg in the past 5 years (yes or no). * $p < 0.05$, ** $p < 0.001$

Table 5 Odds Ratios (ORs) for incident Overweight/Obesity according to eating habits in the SUN cohort (n=7217) after excluding 3292 overweight/obese participants at baseline.

	Incident cases of overweight/ obesity	OR Crude		OR adjusted for age and gender		OR Adjusted for age, gender and lifestyle[1]		OR Adjusted for age, gender, lifestyle and total energy intake	
	(n)	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Do you try to eat more fruit?									
No (n=2398)	388	1 (ref)		1 (ref)		1 (ref)		1 (ref)	
Yes (n=4819)	675	0·84	0·74, 0·97*	0·84	0·73, 0·97*	0·74	0·62, 0·87**	0·73	0·62, 0·87**
Do you try to eat more vegetable?									
No (n=1509)	265	1 (ref)		1 (ref)		1 (ref)		1 (ref)	
Yes (n=5708)	798	0·76	0·66, 0·89**	0·87	0·74, 1·02	0·84	0·70, 1·01	0·84	0·69, 1·01

Table 5 (continued). Odds Ratios (ORs) for incident Overweight/Obesity according to eating habits in the SUN cohort (n=7217) after excluding 3292 overweight/obese participants at baseline.

	Incident cases of overweight/ obesity	OR Crude		OR adjusted for age and gender		OR Adjusted for age, gender and lifestyle[1]		OR Adjusted for age, gender, lifestyle and total energy intake	
	(n)	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Do you try to eat more fish?									
No (n=3083)	488	1 (ref)		1 (ref)		1 (ref)		1 (ref)	
Yes (n=4134)	575	0·86	0·75, 0·98*	0·86	0·75, 0·99*	0·83	0·71, 0·97*	0·83	0·71, 0·97*
Do you avoid the consumption of butter?									
No (n=2384)	347	1 (ref)		1 (ref)		1 (ref)		1 (ref)	
Yes (n=4833)	716	1·02	0·89, 1·17	1·11	0·96, 1·29	0·88	0·74, 1·04	0·88	0·74, 1·05

Table 5 (continued). Odds Ratios (ORs) for incident Overweight/Obesity according to eating habits in the SUN cohort (n=7217) after excluding 3292 overweight/obese participants at baseline.

	Incident cases of overweight/ obesity	OR Crude		OR adjusted for age and gender		OR Adjusted for age, gender and lifestyle[1]		OR Adjusted for age, gender, lifestyle and total energy intake	
	(n)	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Do you try to eat less meat?									
No (n=4719)	741	1 (ref)		1 (ref)		1 (ref)		1 (ref)	
Yes (n=2498)	322	0·79	0·69, 0·92*	0·84	0·72, 0·97*	0·76	0·64, 0·90**	0·76	0·64, 0·90**
Do you try to remove fat from meat?									
No (n=1217)	258	1 (ref)		1 (ref)		1 (ref)		1 (ref)	
Yes (n=6000)	805	0·58	0·49, 0·67**	0·73	0·62, 0·87**	0·84	0·69, 1·01	0·84	0·69, 1·01

Table 5 (continued). Odds Ratios (ORs) for incident Overweight/Obesity according to eating habits in the SUN cohort (n=7217) after excluding 3292 overweight/obese participants at baseline.

	Incident cases of overweight/ obesity	OR Crude		OR adjusted for age and gender		OR Adjusted for age, gender and lifestyle[1]		OR Adjusted for age, gender, lifestyle and total energy intake	
	(n)	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Do you try to eat less sweets and pastries?									
No (n=2959)	414	1 (ref)		1 (ref)		1 (ref)		1 (ref)	
Yes (n=4258)	649	1·11	0·97, 1·26	1·34	1·17, 1·54**	1·02	0·87, 1·21	1·03	0·88, 1·22
Do you try to eat more fiber?									
No (n=3099)	516	1 (ref)		1 (ref)		1 (ref)		1 (ref)	
Yes (n=4118)	547	0·77	0·67, 0·87**	0·85	0·74, 0·98*	0·81	0·69, 0·95**	0·81	0·69, 0·95**

Table 5 (continued). Odds Ratios (ORs) for incident Overweight/Obesity according to eating habits in the SUN cohort (n=7217) after excluding 3292 overweight/obese participants at baseline.

	Incident cases of overweight/ obesity	OR Crude		OR adjusted for age and gender		OR Adjusted for age, gender and lifestyle[1]		OR Adjusted for age, gender, lifestyle and total energy intake	
	(n)	OR	95 % CI	OR	95 % CI	OR	95 % CI	OR	95 % CI
Do you try to eat less fat?									
No (n=1692)	259	1 (ref)		1 (ref)		1 (ref)		1 (ref)	
Yes (n=5525)	804	0·94	0·81, 1·10	1·16	0·99, 1·36	0·99	0·82, 1·19	0·99	0·82, 1·20
Do you add sugar to some beverages?									
No (n=5157)	747	1 (ref)		1 (ref)		1 (ref)		1 (ref)	
Yes (n=2060)	316	1·07	0·93, 1·23	0·96	0·83, 1·11	1·02	0·86, 1·20	1·01	0·85, 1·20

[1] Lifestyle variables: baseline BMI, smoking status (never smoker, ex-smoker, or former smoker), leisure-time physical activity (metabolic equivalent-h/wk), sitting (h/week), TV viewing (h/week) and weight gain ≥ 3 kg in the past 5 years (yes or no). * $p < 0.05$, ** $p < 0.001$