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Original Research

Dietary patterns and lifestyle characteristics in adults: results from the Hellenic National Nutrition and Health Survey (HNNHS)



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ABSTRACT

Objectives: The objective of this study was to identify and describe different dietary patterns in a nationally representative sample of Greek adults and to assess potential associations with lifestyle characteristics.

Study design: This was a cross-sectional study.

Methods: Dietary patterns were derived by principal component analysis using individual dietary data (24-h recall) of 3552 participants of the Hellenic National Nutrition and Health Survey (HNNHS). Analysis of variance and chi-squared test were used to determine the lifestyle characteristics of the participants following each pattern.

Results: Three dietary patterns were identified explaining 16.5% of variance; a traditional pattern, loading positively on olive oil, non-starchy vegetables, and cheese; a Western pattern, loading positively on refined grains, processed meats, and animal fats; and a prudent pattern, loading positively on fruits, whole grains, and yoghurt and negatively on fast food. A fourth, snack-type pattern, loading positively on sweets, salty snacks, and nuts, was identified in women. Primary crude results revealed an association between dietary patterns and socio-economic status. In multivariate analysis, highest adherence to the prudent pattern was associated with higher protein and unsaturated fat intake and lower energy and saturated fat intake (all $P \leq 0.05$); the Western and traditional patterns were associated with higher energy and total and saturated fat intake. The traditional

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pattern was additionally associated with higher monounsaturated fatty acids intake, whereas the Western pattern, with higher alcohol intake (all $P \leq 0.001$).

Conclusions: These findings are valuable for understanding the dietary behaviors of adults in Greece and enabling more focused public health policies for the promotion of healthier food behaviors in the future.

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Introduction

The relationship between diet and health has been strongly established.^{1–3} The consumption of foods, such as fruits, vegetables, fish, whole grains, and red meat, and of nutrients, such as saturated fat (SFA) and sodium, has been positively or negatively associated with the risk of various chronic non-communicable diseases, including cardiovascular risk factors and disease,^{4–6} obesity,⁷ cancer,^{8,9} and depression.¹ The usual approach for exploring these relationships has been to focus on specific foods or nutrients.¹⁰

Multidimensional approaches, however, such as identification of dietary patterns, have gained considerable interest in nutritional epidemiology in an attempt to account for food-nutrient interactions.¹¹ The assessment of the cumulative effect of multiple nutrients included in an overall dietary pattern is likely to provide a better explanation of diet-health associations.^{11–13} The scientific literature of the past decades has consistently shown the effects of certain diet patterns on health, such as the negative effects of a ‘Western type’ and the benefits of the Mediterranean diet on cardiovascular disease (CVD), cancer, longevity, and neurodegenerative diseases.^{14–20} From the public health perspective, the description of dietary patterns, which reflect the foods commonly consumed together, can be used to define practical public health policies to promote healthier food behaviors and improve the diet and health of the population.¹³ Further understanding of the associations of dietary habits with demographic, lifestyle, and health characteristics is essential for identifying population groups at risk and developing effective public policy strategies.

A standard approach applied for studying national dietary patterns is principal component analysis (PCA), a powerful method for summarizing nutrient and food intake to depict the entire diet.¹¹ To our knowledge, few studies, in general, and none in Greece have explored the association of dietary patterns and lifestyle characteristics in a nationally representative sample of adults.^{21–23} Such analysis is of great value, especially for countries in recession, because economic crises are times of high risk to the physical and mental well-being of the population;²⁴ people who experience unemployment and impoverishment smoke more, have decreased physical activity, and are at greater risk of alcohol use disorders than their unaffected counterparts.^{24,25}

The aims of this study were (a) to identify the main dietary patterns in the Greek adult population using individual dietary intake data of the Hellenic National Nutrition and Health Survey (HNNHS), the first nationally representative survey in Greece, (b) to determine the main demographic, lifestyle,

sleep, and mental health characteristics of the individuals adhering to the identified patterns, and (c) to assess the nutrient profile of these patterns.

Methods

The survey

The HNNHS is the first nutrition and health study in Greece that included a nationally representative sample, irrespective of age and sex.²⁶ Infants aged <6 months, pregnant/lactating women, and people residing outside the country or a private household (e.g. military service, hospitals, institutions) were excluded. The selection of the participants was performed with a random stratified design based on the 2011 census data. Stratification was made according to geographical density criteria by area, age group, and gender distribution. The data collection – realized between September 2013 and May 2015 – included an in-person interview at the participant’s residence, using the computer-assisted personal interview (CAPI) method, and a health examination appointment in the HNNHS mobile examination units (~one-third of the participants). Fieldwork was carried out by trained interviewers, and health examination was performed by physicians and trained dietitians. All participants (or legal guardian) gave their written informed consent before entering the survey. The study was approved by the Ethics Committee of the Department of Food Science and Human Nutrition of the Agricultural University of Athens and by the Hellenic Data Protection Authority.

Participants

We used only the adult (≥ 20 years) HNNHS participants ($N = 3703$). Of these, 151 (~4%) participants were excluded from the analysis; 45 had missing 24-h recall (24 hR) data; 102 reported extreme energy intake (<600 or >6000 kcal/d); and 4 were bed bound, and hence, their diet and lifestyle were expected to deviate from the general population. The final study sample consisted of 3552 participants (41.2% men). Body mass index (BMI) could not be estimated for 124 participants because of missing weight and/or height data; values were not imputed as the number of missings was small compared with the overall sample size, and we did not want to add random misclassification error. Underreporters (women: 31.9%; men: 32.8%) and overreporters (3.6%; 3.0%) of energy intake were identified by the modified Goldberg equation,^{27,28} which is based on the energy intake to basal metabolic rate ratio and appropriate by age group cutoff values. Misreporters were

included in the main analysis, as recommended by the European Food Safety Authority (EFSA),²⁹ and excluded in sensitivity analyses.

Dietary assessment

Diet intake was assessed by interviewer-administered 24 hR. The HNNHS 24 hR was developed based on the US Department of Agriculture (USDA) Automated Multiple-Pass Method (AMPM),³⁰ a method with validated accuracy in estimating energy and nutrient intake. Two 24 hR were collected for each participant (15.5% without a second 24 hR) on non-consecutive days: one during the interview and one by telephone. Appropriate-by-age food atlases were the primary tool for portion size estimation, while photographs of standardized household measures (e.g. cups, plates, grids) were also available; during the in-person interview, participants were given copies of these tools to use in the second 24 hR. EFSA's FoodEx2 food classification and description system was used for the standardized classification and description of the food items entered in the 24 hR.³¹ The nutrient content of reported foods was primarily derived from the Nutrition Data System for Research (NDSR; Nutrition Coordinating Center, University of Minnesota), a food composition database containing more than 18,000 foods. Greek food composition tables were additionally used for traditional recipes.

Food items were categorized into 30 food groups based on nutrient composition and culinary use. Mixed dishes (e.g. sandwiches) and recipes (e.g. moussakas) were disaggregated into their ingredients, which were then assigned to the appropriate food group in proportion to their contribution to the recipe. Mixed dishes such as pizza, hot dog, burger, and souvlaki were not disaggregated; they were overall assigned to the fast food group because of their high fat and sodium content and their low nutrient quality.

Demographic, lifestyle, sleep, and depression data

Information on demographics (e.g. sex, age, education, living area), lifestyle, and presence of depression was collected during the interview. Lifestyle indicators included dietary habits (weekly breakfast consumption, meals outside home), physical and sedentary activities, smoking status, alcohol consumption, and sleep quality (e.g. night sleep duration and adequacy, afternoon sleep, sleeping disorders). Presence of depression was evaluated with the Patient Health Questionnaire (PHQ-9),³² a self-administered questionnaire for screening, diagnosing, monitoring, and measuring the severity of depression; the PHQ-9 is validated for the Greek population.³³ Participants completed the PHQ-9 alone; based on their PHQ-9 score (0–27 points), they were classified into five predefined categories of depression symptoms severity (none/minimal, mild, moderate, moderately severe, and severe).

Statistical analysis

Descriptive statistics were calculated for all study variables. Owing to the large sample size, all continuous variables were assumed to follow a normal distribution, according to the central limit theorem. To determine reason for stratified

analysis, gender mean differences were evaluated using student t-test and chi-squared test.

PCA was performed to derive dietary patterns for the overall population and by sex, using intake data (in g/d) for 30 food groups.³⁴ The Kaiser-Meyer-Olkin (KMO) measure of sample adequacy and the Bartlett test of sphericity were used to assess data adequacy for PCA. The components were evaluated based on how much variance they explained, using eigenvalues (>1.3) and scree plots. Extracted components were rotated with varimax rotation creating orthogonal, uncorrelated components, to be more interpretable. For each food group, component loadings (i.e. correlation between the food group and the underlying component) were calculated. For each of the retained components, each survey participant was assigned a score; the score was based on the sum of the component loadings of each food group multiplied with the reported intakes of the specific food group. Dietary patterns were 'named' based on the interpretation of the component loadings (i.e. in this analysis, values > 0.2 were considered as having an impact in the construction of the component), nutritional knowledge, and traditional Greek cuisine. Analysis of variance (ANOVA) and chi-squared test were performed to evaluate mean differences by dietary pattern quintile for continuous and categorical variables, respectively. Distribution of energy and macronutrients (expressed as percent of energy, %E) were tested for trend across quintiles using multiple regression analysis, adjusted for age, sex, living area, education, employment status, BMI, and smoking status. Correlations between diet pattern score and energy intakes were tested with Pearson's correlation. All analyses were performed in STATA statistical software (STATA 14.0, StataCorp LP, Texas, USA) with significance level set to 0.05.

Results

Study sample

The mean age of the overall sample was 43.7 (standard deviation [SD]: 18.1) years (age range: 20–102 years) (Table 1); no difference was observed between women (44.0 years; SD: 18.2) and men (43.2 years; 18.0). Living area and household size did not differ by sex, whereas the opposite was observed for education and employment status ($P < 0.001$). In particular, the percentage of women vs men with high education was higher (54.5%, 50.6%) but lower regarding employment status (44.9%, 57.6%). Significant gender differences were also found for smoking status, mean BMI, and weight status ($P < 0.001$, for all); women vs men had lower current and former smoker percentage, mean BMI (24.9 kg/m², 26.4 kg/m²), and overweight/obesity prevalence (40.1%, 58.4%).

Dietary habits, alcohol consumption, physical activity, sleep quality, and presence of depression also differed by sex ($P < 0.001$, for all). Compared with men, women had breakfast more frequently (5.6 vs 5.2 d/week), less meals prepared outside home (2.3 vs 3.4 meals/week), less alcoholic drinks (0.3 vs 0.6 drinks/d), and increased moderately intense/intense physical activity (75.6 vs. 68.2 min/d), yet they had more frequently inadequate night sleep (8.1 vs 7.0 d/month) and higher depression prevalence (16.0 vs 10.7%).

Table 1 – Characteristics of the adult participants of the Hellenic National Nutrition and Health Survey in 2013–2015.

Characteristic	Overall	Women	Men	P value ^a
Sex, n (%)		2090 (58.8)	1462 (41.2)	
Age, years	43.7 (18.1)	44.0 (18.2)	43.2 (18.0)	0.184
Age range, years	20–102	20–102	20–92	
Living area, %				
Attica	48.5	48.7	48.3	0.807
Education, % ^b				
Low (≤6 years)	12.0	13.6	9.7	<0.001
Medium (6–12 years)	35.1	31.9	39.6	
High (>12 years)	52.9	54.5	50.6	
Employment status, %				
Employed	50.2	44.9	57.6	<0.001
Unemployed	11.3	12.4	9.8	
Retired	10.5	19.1	22.1	
Student	20.4	10.7	10.1	
Housekeeping	7.6	12.8	0.1	
Marital status, %				
Married	44.6	43.3	46.3	0.075
Household size, n	2.5 (1.3)	2.5 (1.3)	2.5 (1.3)	0.684
Smoking status, %				
Smoker	49.4	31.5	38.3	<0.001
Former smoker	34.3	12.9	21.0	
Never smoked	16.3	55.6	40.6	
BMI				
Mean (SD) ^c	25.5 (4.8)	24.9 (5.2)	26.4 (4.0)	<0.001
Underweight, %	2.7	4.2	0.5	<0.001
Normal, %	49.5	55.6	41.1	
Overweight, %	32.3	25.5	41.6	
Obese, %	15.6	14.6	16.8	
Dietary habits				
Eating breakfast, d/week	5.5 (2.5)	5.6 (2.3)	5.2 (2.6)	<0.001
Food outside home, meals/week	2.7 (3.1)	2.3 (2.6)	3.4 (3.5)	<0.001
Physical activity ^d				
Moderately intense/intense, min/d	72.6 (103.3)	75.6 (101.1)	68.2 (106.3)	0.040
Watching TV, h/d	2.0 (1.8)	2.0 (1.8)	2.0 (1.8)	0.433
Using PC/smartphone, h/d ^d	1.9 (2.6)	1.6 (2.4)	2.2 (3.0)	<0.001
Alcohol consumption, drinks/d ^e	0.4 (0.7)	0.3 (0.5)	0.6 (0.8)	<0.001
Sleep quality				
Night sleep duration-weekdays, h/d	7.4 (1.3)	7.5 (1.3)	7.3 (1.3)	<0.001
Night sleep duration-weekend, h/d	7.9 (1.4)	7.9 (1.4)	7.7 (1.4)	<0.001
Sleep during the afternoon, %	43.6	40.2	48.5	<0.001
Inadequate sleep, d/month ^e	7.6 (8.9)	8.1 (9.1)	7.0 (8.5)	<0.001
Depressive disorder (PHQ-9), %	13.8	16.0	10.7	<0.001

BMI, body mass index; PHQ-9, Patient Health Questionnaire-9; PC, personal computer; TV, television; SD, standard deviation.

Data are presented as mean (SD) for continuous variables and as percentages for categorical variables.

^a P-values for continuous variables refer to independent samples t-test and those for categorical variables refer to chi-squared test (χ^2).

^b Education was categorized as high if a university/college degree had been completed, as medium if secondary education had been completed, and as low if education for any level below that.

^c Body mass index (BMI) was calculated by dividing self-reported body weight in kilograms (kg) by the squared self-reported height in meters (kg/m^2).

^d The duration of physical and sedentary activities was based on data referring to the 7 days before the interview.

^e Values were based on data referring to the 30 days before the interview.

Identification of dietary patterns

Three major dietary patterns were derived for the overall sample, explaining 16.5% of the total variance in the consumption of the 30 food groups (Table 2); in gender-stratified analysis, a fourth dietary pattern was revealed only in women. The pattern explaining the highest variance overall (6.1%) and by sex (men: 6.4%; women: 6.1%) was named 'traditional'; it was characterized by significantly positive loadings of traditional Greek foods, such as olive oil, non-

starchy vegetables, and cheese. The second pattern was overall characterized by positive loadings for processed meats, animal fats, cheese, and refined grains. This 'Western dietary pattern' additionally loaded positively for milk and red meat in men, while negative loadings for legumes and seafood were observed for both men and women. The 'prudent' pattern was similar overall and by sex; it loaded positively for fruits, whole grains, yoghurt, and white meat and negatively for fast food. In women, this pattern additionally loaded negatively for sugar-sweetened beverages (SSBs), and, in men,

Table 2 – Component loadings for the four major dietary patterns in the Hellenic National Nutrition and Health Survey.

Food group ^a	Overall			Women				Men		
	Traditional	Western	Prudent	Traditional	Western	Prudent	Snack-type	Traditional	Western	Prudent
Fruits	0.14	−0.10	0.32 ^b	0.15	−0.10	0.33 ^{b,c}	−0.06	0.17	−0.15	0.26 ^b
Fruit juices 100%	0.01	0.14	0.12	0.01	0.10	<0.01	−0.06	<0.01	0.15	0.17
Non-starchy vegetables	0.56^b	−0.05	0.03	0.58^b	−0.04	0.04	<0.01	0.53^b	−0.04	0.02
Starchy vegetables	−0.06	0.04	0.12	−0.04	−0.08	−0.001	−0.03	−0.11	0.05	0.20 ^b
Whole grains	−0.03	0.10	0.46^b	0.02	−0.02	0.40^b	0.14	−0.03	0.05	0.46^b
Refined grains	0.16	0.25 ^b	−0.13	0.08	0.31 ^b	−0.21 ^b	−0.11	0.17	0.26 ^b	−0.02
Legumes	0.18	−0.14	−0.05	0.14	−0.23 ^b	−0.07	0.14	0.24 ^b	−0.13	−0.03
Nuts	0.03	0.12	0.17	0.16	−0.13	0.07	0.35 ^{b,c}	0.04	0.15	0.15
Milk	−0.06	0.11	0.22 ^b	−0.03	0.03	0.12	−0.08	−0.09	0.19	0.28 ^b
Yoghurt	−0.03	−0.08	0.41^b	−0.04	−0.04	0.40^b	−0.16	0.02	−0.07	0.36^b
Cheese	0.33 ^b	0.30 ^b	0.04	0.30 ^b	0.38 ^b	0.04	−0.03	0.33 ^b	0.24 ^b	<0.01
Eggs	0.19	0.19	0.03	0.14	0.18	−0.03	−0.07	0.20 ^b	0.20 ^b	0.06
Seafood	0.06	−0.11	0.05	0.11	−0.20 ^b	0.11	0.13	0.03	−0.11	0.02
Red meat	0.09	0.18	−0.11	0.08	0.22 ^b	−0.14	−0.14	0.01	0.16	−0.04
White meat	−0.15	0.16	0.24 ^b	−0.13	0.06	0.22 ^b	0.07	−0.19	0.15	0.29 ^b
Processed meats	−0.05	0.38^b	−0.02	−0.07	0.41^b	<0.01	<0.01	−0.03	0.35^b	−0.06
Olive oil	0.60^b	0.02	−0.03	0.62^b	0.03	−0.03	0.01	0.55^b	0.02	−0.04
Other vegetable oils	0.07	0.14	−0.01	0.13	−0.07	−0.10	0.30 ^b	0.15	0.18	−0.01
Animal fats	0.00	0.38^b	0.04	−0.03	0.41^b	0.01	0.07	0.05	0.40^b	0.05
Alcohol	0.00	0.16	−0.22 ^b	−0.12	0.11	−0.07	0.20 ^b	0.02	0.10	−0.28 ^b
SSBs	−0.08	0.18	−0.19	0.01	0.04	−0.28 ^b	0.21 ^b	−0.13	0.25 ^b	−0.06
Beverages with sweeteners	−0.14	0.19	0.00	−0.05	0.06	0.04	0.44^b	−0.09	0.09	−0.10
Salty snacks	−0.08	0.13	−0.02	−0.03	−0.002	−0.03	0.28^b	−0.07	0.18	−0.04
Sweets	−0.07	0.23 ^b	−0.09	0.04	<0.01	−0.25	0.34 ^b	−0.04	0.32^b	−0.03
Spices/herbs	−0.04	0.18	0.09	−0.01	0.13	0.08	0.11	−0.01	0.24^b	0.01
Water	0.03	0.27 ^b	0.21 ^b	0.01	0.29 ^b	0.38 ^b	0.12	−0.01	0.15	0.13
Coffee	−0.04	0.19	−0.17	−0.07	0.26 ^b	0.06	0.21 ^b	−0.003	0.14	−0.33 ^{b,c}
Tea	−0.04	0.04	0.20 ^b	−0.01	−0.06	0.13	0.16	0.04	0.04	0.19
Sweeteners	−0.06	0.10	0.09	−0.07	0.07	0.19	0.30 ^b	0.02	0.06	0.03
Fast food	−0.11	0.07	−0.30 ^{b,c}	−0.09	−0.02	−0.26 ^b	0.07	−0.18	0.10	−0.27 ^b
Variability explained, %	6.1	5.9	4.5	6.1	5.7	4.6	4.3	6.4	5.9	4.8

The unique characteristics of each component (dietary pattern) are presented in bold.

^a The definitions of food groups are as follows: *fruits*, total fresh, dried, and canned fruits (g/d); *fruit juices 100%*, total 100% fruit juices (g/d); *non-starchy vegetables*, total fresh and canned vegetables (g/d), excluding starchy vegetables; *starchy vegetables*, total starchy vegetables (e.g. potatoes, corn) (g/d); *whole grains*, total grain foods with ≥1.0 g of fiber per 10 g of carbohydrate (g/d); *refined grains*, total refined grain foods, including rice and oat milk (g/d); *legumes*, total beans, legumes, and soy products (g/d); *nuts*, total nuts and seeds, including peanut butter and almond milk (g/d); *milk*, total non-, low-, and full-fat milk (g/d), excluding plant-derived alternatives; *yoghurt*, total non-, low-, and full-fat yoghurt (g/d); *cheese*, total non-, low-, and full-fat cheese (g/d); *eggs*, total eggs (g/d); *seafood*, total fresh, frozen, and processed seafood (g/d); *red meat*, total red unprocessed meats, including offal (g/d); *white meat*, total white unprocessed meats (g/d); *processed meats*, total processed meat intake (g/d); *olive oil*, total olive oil (g/d); *other vegetable oils*, total vegetable oils other than olive oil (e.g. margarine, sunflower oil) (g/d); *animal fats*, total animal fats (e.g. butter, lard) (g/d); *alcohol*, total alcohol (g/d); *SSBs (sugar-sweetened beverages)*, total SSBs with added sugar; *beverages with sweeteners*, total beverages with added sweeteners (e.g. aspartame); *salty snacks*, total salty snacks (e.g. chips, crackers) (g/d); *sweets*, total sweets and confectionary (e.g. chocolate, desserts, cake, croissant, cookies) (g/d); *spices/herbs*, total spices and herbs, including mustard and vinegar (g/d); *water*, total water (g/d); *coffee*, total coffee (g/d); *tea*, total tea (g/d); *sweeteners*, total sweeteners (g/d); *fast food*, total fast food, including pizza, burger, hot dog, french fries, souvlaki, and pastries (g/d).

^b Loadings ≥0.20 and ≤−0.20.

^c Marginally unique dietary characteristic for each component.

for alcohol. A fourth dietary pattern identified in women was named ‘snack-type’ because it loaded positively mainly for ready-to-eat foods that require minimum preparation, such as beverages with sweeteners, nuts, sweets, and salty snacks.

In sensitivity analyses, excluding misreporters of energy, intake did not appreciably change the patterns observed for the first three patterns in women; the snack-type pattern yielded smaller positive loadings for salty snacks and nuts (<0.10) and greater positive loadings for water and sweeteners (>0.40) (data not shown). In men, none of the patterns notably changed, with the exception of greater negative loadings for

fast food in the traditional pattern (−0.27) and greater positive loadings for animal fats in the Western pattern (0.56) and milk in the prudent pattern (0.41).

Demographic, lifestyle, and mental health characteristics and dietary patterns

Participants with highest (Q5) vs lowest (Q1) adherence to the traditional pattern were more likely to be married and live outside Attica and less likely to have high education and be employed (Table 3). Interestingly, the traditional pattern was

Table 3 – Demographic and lifestyle characteristics per quintile of dietary pattern scores overall and by sex.

Characteristic	N	Traditional			Western			Prudent			Snack-type		
		Q1	Q5	P value	Q1	Q5	P value	Q1	Q5	P value	Q1	Q5	P value
Overall													
Age, years	3552	39.3 (17.3)	45.3 (17.6)	0.094	55.1 (19.1)	34.6 (12.5)	<0.001	36.6 (13.6)	46.5 (19.1)	<0.001			
Living in Attica	3544	54.7	39.9	<0.001	43.3	52.9	0.006	51.1	51.0	0.169			
Education, %	3543												
Low		8.5	11.6	0.009	27.5	2.1	<0.001	4.8	11.6	<0.001			
High		56.1	49.4	0.030	41.0	59.8	<0.001	57.8	55.3	0.003			
Employment status, %	3541												
Employed		53.7	48.9	<0.001	32.8	64.8	<0.001	61.2	46.4	<0.001			
Unemployed ^a		32.2	41.7	0.001	61.2	20.3	<0.001	25.7	44.7	<0.001			
Marital status, %	3548												
Married		37.0	52.3	<0.001	57.3	31.7	<0.001	36.9	44.3	<0.001			
BMI, kg/m	3428	25.0 (4.5)	26.2 (4.7)	<0.001	26.1 (5.1)	25.1 (4.6)	<0.001	24.9 (4.6)	25.5 (4.6)	<0.001			
Overweight, %		30.9	34.2	0.026	35.1	30.5	0.249	30.6	34.4	0.553			
Obese, %		11.9	19.2	<0.001	18.7	13.7	0.062	12.3	13.9	0.006			
Dietary habits													
Eating breakfast, d/week	3539	5.0 (2.7)	5.6 (2.4)	<0.001	5.6 (2.4)	5.1 (2.6)	<0.001	4.4 (2.8)	6.2 (1.9)	<0.001			
Food outside home, meals/week	3518	3.4 (3.7)	2.4 (2.7)	<0.001	1.5 (2.1)	4.0 (3.6)	<0.001	4.1 (3.6)	2.1 (2.6)	<0.001			
Physical activity^b													
Moderately intense/Intense, min/d	3452	66.7 (94.5)	73.6 (104.8)	0.025	75.4 (101.3)	71.0 (107.8)	0.877	64.9 (100.6)	69.5 (92.5)	0.026			
Watching TV, h/d	3513	2.0 (1.9)	2.1 (1.9)	0.228	2.3 (1.9)	1.7 (1.8)	<0.001	1.9 (1.7)	2.0 (1.9)	0.376			
Using PC/smartphone, h/d ^c	2948	2.6 (3.0)	2.0 (2.7)	<0.001	1.6 (2.4)	2.7 (3.1)	<0.001	2.6 (3.1)	2.1 (2.7)	<0.001			
Smoking status, %													
Smoker	3539	38.2	32.9	0.014	23.2	44.7	<0.001	51.7	23.5	<0.001			
Former smoker		13.5	21.3	<0.001	15.4	15.0	0.641	13.0	20.3	<0.001			
Never smoked		48.3	45.8	0.092	61.5	40.3	<0.001	35.4	56.2	<0.001			
Alcohol consumption, drinks/d ^d	3517	0.4 (0.7)	0.5 (0.7)	0.031	0.2 (0.5)	0.6 (0.8)	<0.001	0.7 (1.0)	0.3 (0.5)	<0.001			
Sleep quality													
Night sleep duration Sun-Thu, h/d	3440	7.5 (1.4)	7.4 (1.3)	0.348	7.5 (1.3)	7.3 (1.4)	0.198	7.3 (1.5)	7.5 (1.3)	0.116			
Night sleep duration Fri-Sat, h/d	3434	8.0 (1.5)	7.8 (1.3)	0.009	7.8 (1.3)	7.9 (1.4)	0.029	7.9 (1.4)	7.9 (1.4)	0.818			
Sleep during the afternoon, %	3527	38.2	48.5	<0.001	47.9	40.1	0.002	39.9	46.0	0.174			
Inadequate sleep, d/month ^d	3419	8.8 (9.6)	7.1 (8.4)	0.001	6.1 (8.5)	9.2 (9.2)	<0.001	8.8 (9.4)	7.5 (8.9)	<0.001			
Depressive disorder (PHQ-9), %	3529	17.5	11.6	0.006	11.1	15.7	0.111	14.1	13.7	0.708			
Women													
Age, years	2090	40.3 (18.1)	45.9 (17.3)	<0.001	51.9 (19.1)	36.4 (14.0)	<0.001	36.7 (15.5)	47.3 (18.4)	<0.001	53.9 (20.0)	36.9 (13.7)	<0.001
Living in Attica	2084	52.0	41.2	0.012	46.6	53.1	0.322	46.2	50.2	0.477	43.3	50.0	0.004
Education, %	2085												
Low		10.8	13.0	0.302	24.4	4.8	<0.001	7.9	13.2	0.003	31.7	3.4	<0.001
High		54.8	55.4	0.846	45.0	61.4	<0.001	58.3	56.8	0.219	40.5	66.0	<0.001
Employment status, %	2084												
Employed		48.9	45.0	0.370	33.3	56.4	<0.001	51.1	41.5	0.030	35.1	56.4	<0.001
Unemployed ^a		36.7	46.4	0.008	60.3	29.3	<0.001	34.3	49.4	<0.001	59.6	30.7	<0.001
Marital status, %	2087												
Married		34.6	51.4	<0.001	50.7	34.1	<0.001	35.9	44.6	0.008	49.6	36.4	<0.001

(continued on next page)

Table 3 – (continued)

Characteristic	N	Traditional			Western			Prudent			Snack-type		
		Q1	Q5	P value	Q1	Q5	P value	Q1	Q5	P value	Q1	Q5	P value
BMI, kg/m	1994	24.4 (4.8)	25.5 (5.5)	<0.001	25.6 (5.3)	24.4 (5.5)	0.012	24.0 (5.6)	25.6 (5.3)	<0.001	25.5 (4.8)	24.1 (5.5)	<0.001
Overweight, %		23.7	25.2	0.188	32.8	20.3	0.002	20.4	29.0	0.131	32.7	22.3	0.005
Obese, %		12.1	19.2	0.015	15.7	14.6	0.553	10.4	16.9	0.113	16.8	10.9	0.003
Dietary habits													
Eating breakfast, d/week	2081	5.1 (2.6)	5.9 (2.1)	<0.001	5.9 (2.2)	5.5 (2.4)	0.107	5.0 (2.6)	6.4 (1.6)	<0.001	6.1 (2.0)	5.4 (2.4)	<0.001
Food outside home, meals/week	2068	2.8 (1.9)	1.9 (2.3)	<0.001	1.3 (1.8)	3.0 (2.9)	<0.001	3.1 (2.9)	1.7 (2.2)	<0.001	1.4 (1.9)	3.0 (2.8)	<0.001
Physical activity ^b													
Moderately intense/intense, min/d	2030	65.8 (95.0)	76.1 (97.6)	0.112	89.1 (105.9)	70.0 (107.1)	0.046	63.6 (92.5)	71.7 (90.1)	0.033	75.7 (95.8)	70.2 (97.6)	0.662
Watching TV, h/d	2063	1.9 (1.9)	2.1 (1.9)	0.140	2.2 (1.8)	1.7 (1.7)	<0.001	2.0 (1.9)	2.1 (1.8)	0.783	2.2 (1.7)	1.7 (1.6)	<0.001
Using PC/smartphone, h/d ^c	1732	2.2 (2.9)	1.8 (2.5)	0.112	1.4 (2.0)	2.4 (2.8)	<0.001	2.1 (2.5)	1.9 (2.5)	0.077	1.5 (2.3)	2.3 (2.8)	<0.001
Smoking status, %													
Smoker	2080	38.4	29.0	0.012	21.2	42.8	<0.001	39.1	25.2	0.001	16.6	43.0	<0.001
Former smoker		11.4	17.5	0.018	13.5	12.7	0.338	11.3	16.6	0.086	10.6	16.4	0.195
Never smoked		50.2	53.5	0.107	65.3	44.2	<0.001	49.6	58.2	0.056	72.8	40.6	<0.001
Alcohol consumption, drinks/d ^d	2067	0.4 (0.6)	0.3 (0.4)	<0.001	0.2 (0.3)	0.4 (0.5)	<0.001	0.4 (0.7)	0.3 (0.4)	<0.001	0.1 (0.4)	0.5 (0.6)	<0.001
Sleep quality													
Night sleep duration Sun-Thu, h/d	2019	7.6 (1.5)	7.4 (1.2)	0.074	7.6 (1.3)	7.5 (1.3)	0.628	7.6 (1.4)	7.5 (1.3)	0.213	7.7 (1.3)	7.4 (1.3)	0.153
Night sleep duration Fri-Sat, h/d	2018	8.0 (1.6)	7.8 (1.3)	0.249	8.0 (1.3)	8.0 (1.4)	0.374	8.1 (1.3)	7.9 (1.4)	0.165	7.9 (1.3)	8.0 (1.4)	0.231
Sleep during the afternoon, %	2074	37.3	42.9	0.141	43.7	37.6	0.041	41.4	42.6	0.372	45.5	35.8	0.007
Inadequate sleep, d/month ^d	2020	9.0 (9.4)	7.9 (8.8)	0.155	6.6 (8.9)	8.8 (8.9)	0.005	9.0 (9.3)	8.6 (9.6)	0.009	6.4 (8.0)	9.9 (9.7)	<0.001
Depressive disorder (PHQ-9), %	2074	19.1	12.7	0.081	14.3	16.5	0.466	16.3	15.5	0.803	9.4	20.5	<0.001
Men													
Age, years	1462	36.4 (15.9)	44.6 (17.6)	<0.001	55.3 (19.4)	33.7 (11.6)	<0.001	37.3 (12.4)	46.4 (20.0)	<0.001			
Living in Attica	1460	58.4	39.9	<0.001	41.6	49.8	0.095	53.2	51.6	0.103			
Education, %													
Low	1458	4.8	9.3	0.008	22.6	1.4	<0.001	4.5	7.9	<0.001			
High		52.6	48.6	0.876	42.5	56.2	0.004	55.0	51.0	0.012			
Employment status, %													
Employed	1457	61.0	58.6	0.282	41.8	71.8	<0.001	69.2	51.6	<0.001			
Unemployed ^a		21.9	33.5	<0.001	53.8	13.1	<0.001	19.2	39.5	<0.001			
Marital status, %													
Married	1461	32.4	51.6	<0.001	64.2	28.2	<0.001	37.7	44.5	<0.001			
BMI, kg/m	1434	25.9 (4.0)	26.6 (4.0)	0.116	26.7 (4.1)	25.9 (4.0)	0.025	25.9 (3.8)	26.0 (3.5)	0.004			
Overweight, %		40.5	42.7	0.866	44.5	39.9	0.565	41.2	42.1	0.251			
Obese, %		12.1	18.2	0.114	18.0	13.5	0.305	15.1	12.8	0.084			
Dietary habits													
Eating breakfast, d/week	1458	4.8 (2.8)	5.6 (2.4)	0.002	5.3 (2.7)	5.0 (2.7)	0.118	4.0 (2.9)	6.0 (2.2)	<0.001			
Food outside home, meals/week	1450	4.6 (4.3)	2.7 (2.7)	<0.001	2.0 (2.4)	4.5 (3.7)	<0.001	4.8 (3.9)	2.7 (2.9)	<0.001			
Physical activity ^b													
Moderately intense/intense, min/d	1422	65.4 (95.1)	72.4 (113.7)	0.068	62.8 (98.1)	79.0 (118.7)	0.082	78.5 (119.8)	69.7 (106.0)	0.256			
Watching TV, h/d	1450	2.1 (1.9)	2.0 (1.8)	0.946	2.4 (2.0)	1.7 (1.7)	<0.001	1.8 (1.7)	1.9 (1.8)	0.010			
Using PC/smartphone, h/d ^c	1212	3.2 (3.2)	2.1 (2.6)	<0.001	2.1 (2.9)	3.0 (3.3)	0.009	2.9 (3.3)	2.6 (3.2)	0.242			
Smoking status, %													
Smoker	1459	41.6	37.7	0.193	36.1	42.8	0.057	61.3	25.1	<0.001			

Former smoker	17.8	24.0	0.242	24.4	16.1	0.076	13.4	25.4	<0.001
Never smoked	40.6	38.4	0.366	39.5	41.1	0.787	25.3	49.5	<0.001
Alcohol consumption, drinks/d ^d	1450	0.6 (0.8)	0.204	0.5 (0.9)	0.7 (1.0)	0.006	1.0 (1.2)	0.5 (0.7)	<0.001
Sleep quality									
Night sleep duration Sun-Thu, h/d	1421	7.3 (1.4)	0.949	7.3 (1.4)	7.3 (1.4)	0.868	7.1 (1.4)	7.4 (1.3)	0.025
Night sleep duration Fri-Sat, h/d	1416	8.0 (1.4)	0.032	7.6 (1.4)	7.9 (1.4)	0.079	7.7 (1.4)	7.8 (1.3)	0.447
Sleep during the afternoon, %	1453	36.8	<0.001	59.0	41.2	<0.001	39.3	48.8	0.005
Inadequate sleep, d/month ^d	1399	7.7 (9.1)	0.071	5.6 (8.1)	9.3 (9.2)	<0.001	8.8 (9.6)	6.7 (8.4)	<0.001
Depressive disorder (PHQ-9), %	1455	14.4	0.216	8.0	14.8	0.003	11.4	9.3	0.909

BMI, body mass index; PHQ-9, Patient Health Questionnaire-9; Q1, quintile 1, including individuals with the lowest dietary pattern score; Q5, quintile 5, including individuals with the highest dietary pattern score; SD, standard deviation; PC, personal computer; TV, television.

Data are presented as mean (SD) for continuous variables and as percentages for categorical variables. P-values for continuous variables refer to an analysis of variance (ANOVA) and those for categorical variables refer to chi-squared test (χ^2).

^a Including students and individuals who reported housekeeping as their occupation.

^b The duration of physical and sedentary activities was based on data referring to the 7 days before the interview.

^c This question was only made in adults aged 18–65 years; the missing values are 19 in women and 9 in men.

^d The number of days was based on data referring to the 30 days before the interview.

associated with higher prevalence of overweight ($P = 0.026$) and obesity ($P < 0.001$) but lower prevalence of smoking ($P = 0.014$). These results did not substantially change by sex. In contrast, individuals with highest vs lowest Western pattern score were more likely to be of younger age, have higher education, and be employed (all $P < 0.001$); women with highest vs lowest adherence were additionally less physically active ($P = 0.046$) and more likely to be smokers ($P < 0.001$). Both women and men with highest vs lowest Western pattern adherence were associated with higher consumption of meals prepared outside home, lower weekly frequency of having breakfast, and higher alcohol consumption. Findings for the prudent pattern were similar to the traditional pattern in terms of most participant characteristics, yet overweight and obesity prevalence did not differ across quintiles in women or men. Highest vs lowest adherence to the snack-type pattern yielded similar findings with those in the Western dietary pattern. Remarkably, the snack-type pattern was associated with lower sleep quality, indicated by higher frequency of inadequate night sleep, as well as with the presence of depression (both $P < 0.001$).

Energy intake and contribution of macronutrients

Total energy was positively correlated with the Western dietary pattern (women: $r = 0.36$, men: $r = 0.50$) and snack-type pattern (0.43); all other correlations were generally low (<0.20) (data not shown). In energy contribution by macronutrients, moderate correlations were observed only between the traditional pattern and %E from total fat and mono-unsaturated fatty acids (MUFAs) in both women (0.42 and 0.51, respectively) and men (0.33 and 0.39, respectively) and between the prudent pattern and %E from total fat and MUFAs in the overall population (0.31 and 0.40, respectively). Adjusted regression analysis showed that high adherence to all dietary patterns was associated with higher energy intake, with the exception of the prudent pattern that was associated with lower energy intake ($P \leq 0.001$) (Table 4). Overall and by sex, high agreement with the prudent pattern was associated with better diet quality, including higher percentage of energy intake from protein, MUFAs, and polyunsaturated fatty acids (PUFAs) and lower percentage of energy from SFA and alcohol (all $P \leq 0.05$). Conversely, high adherence to the Western dietary pattern was associated with higher %E from total fat, SFA, and alcohol (all $P \leq 0.001$). The traditional and Western patterns were also associated with higher %E from total fat; the former, though, was additionally associated with higher %E from MUFA ($P \leq 0.001$). The snack-type pattern was associated only with higher %E from PUFAs ($P \leq 0.001$).

Discussion

This is the first analysis to explore the dietary patterns in a nationally representative sample of adults in Greece. Using PCA, three main dietary patterns – traditional, Western, and prudent – were derived overall and by sex, with distinct food consumption behaviors, as well as demographic, lifestyle, and mental health determinants; a fourth snack-type pattern was identified in women.

Table 4 – Energy and nutrient intakes per quintile of dietary pattern scores overall and by sex.

Diet factor	Traditional		Western		Prudent		Snack-type	
	Q1	Q5	Q1	Q5	Q1	Q5	Q1	Q5
Overall								
Energy, kcal/d	1839 (941)	2404 (913)***	1301 (565)	2781 (972)***	2416 (991)	1924 (844)***		
Protein, %E	17.7 (7.5)	15.7 (4.4)***	17.2 (6.4)	16.5 (5.1)***	15.6 (5.3)	18.7 (6.5)***		
Carbohydrates, %E	50.8 (15.7)	43.0 (13.0)***	48.6 (14.8)	44.9 (13.7)***	49.6 (15.6)	46.7 (13.8)***		
Total fat, %E	33.8 (10.5)	43.9 (9.8)***	37.2 (10.9)	39.5 (10.6)***	36.1 (10.8)	37.4 (10.2)***		
SFA, %E	11.8 (4.9)	13.5 (4.1)***	11.2 (4.3)	13.4 (4.2)***	12.4 (4.6)	12.0 (4.1)***		
MUFA, %E	14.0 (5.7)	21.3 (6.4)***	18.0 (7.1)	16.9 (6.1)***	15.7 (6.2)	16.6 (5.8)***		
PUFA, %E	5.5 (4.5)	6.0 (2.8)***	5.2 (2.2)	6.3 (3.8)***	5.5 (3.9)	5.9 (3.4)*		
Alcohol, g/d	8.6 (21.9)	8.1 (19.9)***	2.2 (5.9)	15.9 (32.2)***	16.9 (31.4)	4.5 (13.8)***		
Women								
Energy, kcal/d	1617 (786)	2101 (764)***	1463 (694)	2228 (781)***	2164 (884)	1711 (704)***	1420 (597)	2256 (915)***
Protein, %E	17.6 (8.2)	15.7 (4.8)***	16.7 (6.3)	16.8 (4.5)	14.9 (5.8)	19.0 (6.3)***	18.0 (5.4)	14.7 (6.2)***
Carbohydrates, %E	52.4 (16.6)	43.6 (12.8)***	49.5 (14.2)	45.2 (14.2)***	48.7 (13.1)	48.1 (14.4)**	46.0 (13.3)	48.7 (14.0)***
Total fat, %E	32.1 (10.6)	44.3 (8.9)***	37.4 (10.1)	40.2 (10.9)***	38.2 (10.4)	36.3 (10.0)***	38.8 (10.8)	38.2 (11.3)
SFA, %E	11.6 (4.9)	13.5 (4.0)***	10.7 (4.2)	14.2 (4.3)***	12.9 (4.5)	11.9 (4.1)***	13.2 (4.5)	11.8 (4.7)***
MUFA, %E	13.1 (5.5)	21.3 (5.6)***	17.8 (6.4)	17.1 (6.2)***	16.7 (6.1)	16.2 (5.5)***	18.0 (6.6)	16.5 (6.5)***
PUFA, %E	5.3 (5.1)	6.3 (3.0)***	6.1 (3.3)	5.8 (3.1)***	6.0 (4.5)	5.4 (2.8)*	4.6 (2.3)	7.3 (4.7)***
Alcohol, g/d	9.9 (25.2)	3.3 (7.6)***	1.6 (3.9)	8.3 (18.2)***	8.7 (20.7)	3.5 (13.1)***	1.0 (3.9)	11.9 (25.9)***
Men								
Energy, kcal/d	2101 (950)	2706 (979)***	1494 (665)	3200 (956)***	2651 (1044)	2266 (913)***		
Protein, %E	18.7 (6.4)	15.4 (4.5)***	17.4 (6.8)	16.5 (4.7)***	15.7 (4.2)	18.3 (6.4)***		
Carbohydrates, %E	48.2 (14.9)	42.3 (13.4)***	47.0 (15.5)	44.2 (13.3)***	49.5 (16.2)	44.2 (12.3)***		
Total fat, %E	34.4 (9.6)	44.2 (10.8)***	37.2 (11.8)	40.1 (9.9)***	35.0 (10.3)	39.0 (10.3)***		
SFA, %E	11.9 (4.5)	13.5 (4.3)***	11.2 (4.4)	13.6 (4.1)***	12.0 (4.6)	12.3 (3.9)***		
MUFA, %E	14.6 (5.2)	21.5 (7.2)***	18.2 (7.7)	17.2 (5.8)***	15.2 (5.7)	17.7 (6.4)***		
PUFA, %E	5.2 (2.8)	5.9 (2.6)***	5.0 (1.9)	6.4 (3.7)***	5.2 (3.1)	5.9 (2.9)**		
Alcohol, g/d	11.2 (25.7)	12.0 (27.4)	6.3 (13.9)	17.8 (35.0)***	24.8 (37.2)	6.0 (12.8)***		

%E, percentage of energy intake; Q1, quintile 1, including individuals with the lowest dietary pattern score; Q5, quintile 5, including individuals with the highest dietary pattern score; SFA, saturated fatty acid; MUFA, monounsaturated fatty acid; PUFA, polyunsaturated fatty acid; SD, standard deviation; BMI, body mass index.

Data are presented as mean (SD). P-values refer to regression analysis adjusted for age, sex, living area, education level, employment status, BMI, and smoking status. Sex was not a covariate in the sex-stratified analysis.

*P < 0.05, **P ≤ 0.01, ***P ≤ 0.001.

In this analysis, we identified both patterns that are consistently reported in the literature: the healthy ‘prudent’ pattern and the unhealthy ‘Western’ pattern.^{11,16,17,22,35} Yet, the pattern that explained the greatest part of the total variance was the traditional pattern. This pattern was considered as a proxy Mediterranean dietary pattern because, although it effectively had high loadings for fundamental components of the Mediterranean diet,^{36–38} such as non-starchy vegetables and olive oil, it had weak loadings for others, such as whole grains, fish, and legumes. On the contrary, it had high loadings for core foods of the Greek cuisine, such as cheese. In men, the traditional pattern, further loaded positively for eggs and negatively for white meat, characteristics that relate more to the Western dietary pattern. The dietary behaviors of this in-between dietary pattern led to both healthier dietary intakes, with high %E from unsaturated fats, and less healthy ones, with high caloric and SFA intake. Our findings are in line with previous findings showing that the Mediterranean diet, in its original definition, is being progressively westernized, leading to a nutrition transition reflected by a shift toward high-saturated, high-sugar, refined, and processed foods.³⁹ These findings suggest a westernization of the Mediterranean diet, as described in the literature, and are consistent with compiling evidence, suggesting that the Mediterranean diet is now progressively disappearing in the Mediterranean countries.^{39–42}

The Western pattern identified in this analysis is in line with similar patterns identified across literature, which are characterized by positive loadings for red and/or processed meat, refined grains, desserts, SSBs, and high-fat products. In Greece, previous studies in the general population have revealed a Western-type pattern, although this also included healthier dietary behaviors, such as high fruit and vegetable intakes,⁴³ or was vaguely described, based mainly on its association with increased CVD risk.⁴⁴ Highest vs lowest adherence to the Western pattern was linked to higher intakes of energy, SFA, and alcohol and lower intake of carbohydrates, consistent with the high meat, egg, and dairy content of this pattern.

The fourth dietary pattern, which was identified only in women, was described by ready-to-eat and easy-to-prepare foods. Notably, although the snack-type pattern had positive loadings for salty snacks, sweets, and nuts, there was a tendency for counterbalancing the high caloric content of such foods with increased sweetener intake. Few studies have previously identified a group of consumers characterized by high consumption of foods commonly classified as snacks, such as chips, crackers, beverages, desserts, and confectionary.^{22,45} The identification of such a pattern in this analysis could be partially explained by the level of aggregation of chosen foods, which identified groups of snacks (e.g. salty, sweets) separately.

The description of dietary patterns by demographic and lifestyle characteristics showed both consistent and contradictory results to the existing literature findings. In line with previous findings, individuals adherent to the healthier patterns (i.e. traditional and prudent) had better dietary habits in terms of breakfast consumption frequency and eating food prepared outside home, and they were less likely to smoke and more likely to exercise. This analysis also showed that the socio-economic status had a strong influence on food consumption. However, the direction of the results contradicted previous findings; the Western and snack-type patterns were associated with positive employment status and high education level, whereas the opposite was observed for the traditional and prudent patterns. Existing evidence shows that higher socio-economic and educational status is associated with healthier food consumption, such as fruit, vegetables, and whole grains, and lower socio-economic and educational status is associated with processed and unprocessed meats and energy-dense food consumption, such as fast food and sweets.^{21–23,46,47} These contradictory findings are complemented by the BMI results, with higher prevalence of overweight and obesity being reported for the traditional and lower for the Western and snack-type ones. A potential explanation for these findings is the overall profile of the individuals adhering to each pattern. Women and men adhering to the Western pattern are considerably younger, and in their productive age; hence, their energy requirements would be expected to be higher than those of older and/or potentially unemployed adults. Therefore, the caloric intake, despite high for this pattern, might still counterbalance energy needs. Moreover, these results refer to a period of national economic crisis; recession periods have been associated with lower diet quality, deterioration of dietary habits, and lower adherence to the Mediterranean diet.^{48,49} Adherent to the traditional pattern, individuals were more likely to reside outside the urban Attica area, potentially with higher access to agricultural products from own or close environment production; therefore, olive oil and vegetables could have been obtained at no or low cost, whereas other healthy foods, such as seafood and whole grains that are more expensive, were not consumed in high amounts. However, because there are no available nationally representative data in Greece referring to a time point before the recession, no safe assumptions can be made.

An interesting finding of this analysis was the significant associations of sleep quality and depression with dietary patterns. In particular, we found that the traditional and prudent patterns were associated with lower sleep disorders prevalence; this is in line with limited existing evidence, which suggests, however, that healthy patterns are associated with higher sleep quality and lower prevalence of sleep disorders.⁵⁰ Remarkably, although sleep disorders are known to increase with age,⁵¹ individuals who were highly adherent to the traditional and prudent patterns were older than those who closely adhered to the Western and snack-type patterns. The suggested mechanisms underlying this finding involve mainly tryptophan, a precursor to sleep-promoting hormones; higher-in-protein dietary patterns provide greater amounts of tryptophan, potentially leading to better sleep quality. In terms of depression, we found positive associations for snack-type pattern in women and Western pattern in men.

Currently, the evidence on the association of Western-type patterns and the likelihood of depression is conflicting, with studies reporting either a positive or no association, mainly due to differences in study characteristics and methodological limitations.^{52,53} Overall, this analysis suggests that an association between sleep quality, mental health, and dietary patterns may exist, which warrants further research.

Our study had several strengths. This is the first analysis to derive dietary patterns, using PCA, in a nationally representative sample of Greek adults with broad age range.^{43,44,54,55} The data collection period covered over 1.5 year, taking into account the seasonal consumption of certain foods and capturing the exposure to foods consumed during certain periods (e.g. holidays). The source of dietary data was multiple 24 hR, rather than food frequency questionnaires that are commonly used for the identification of dietary patterns.^{17,18,56} Although food records of 3–7 days are considered as the gold standard, we used the AMPM to administer our 24 hR, a method that maximizes the reported food consumption accuracy and standardizes the reported foods description. Different levels of food aggregation were used, leading to the identification and description of the previously confounded snack-type pattern. The dietary patterns were derived by PCA, a data-driven method used to investigate dietary patterns in various populations globally.^{21,57–59} A wide range of demographic and lifestyle variables were included to describe the derived dietary patterns.

Limitations should also be considered. PCA, although a data-driven method with reasonable reproducibility and validity,^{58,60} involves subjective decision-making in some steps of the analytical process. The identified dietary patterns explained a low percentage (4.3%–6.4%) of the total variance in dietary intake, which is, nonetheless, similar with the findings of other studies.^{21,22,50,57,61} The amount of explained variance largely depends on the number of food groups included in the PCA, and it decreases with greater numbers of food groups;⁶² yet, our findings from the analysis of 30 food groups were still similar to those from that of 20 food groups.⁵⁷ Moreover, we had a large percentage of energy intake misreporters, consistent with what has been previously reported; after excluding them, in sensitivity analyses, the derived patterns remained generally the same.

In conclusion, three main dietary patterns were identified among Greek adults with distinct demographic, lifestyle, and mental health characteristics. These findings provide new insights into the diverse food consumption behaviors among Greek adults and a picture of the dietary intake patterns in a period of a national economic crisis. In terms of public health, our findings are critical for achieving a wide range of policy and research objectives, including surveillance, planning, evaluation, national monitoring, and public interventions. The patterns derived from this study can be further used for exploring their association with health outcomes, such as chronic diseases.

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Ethical approval

The study was approved by the Ethics Committee of the Department of Food Science and Human Nutrition of the Agricultural University of Athens and by the Hellenic Data Protection Authority.

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Competing interests

None declared.

Authorship

A.Z. conceptualized and designed the study and was the principal investigator of the study. A.Z. and R.M. coordinated the design of the data collection instruments and coordinated and supervised data collection. G.M. supervised medical data collection. D.K., A.V.M., I.D., and I.B. were involved in every step of the study and made substantial contributions to the design and methodology of data collection, as well as the acquisition of data and training of field workers. T.N. coordinated mobile unit data collection. S.M.T. and K.A. contributed to the mobile unit data collection and analysis. D.B.P. coordinated sample collection methodology. D.K. carried out the statistical analyses and drafted the manuscript. E.M. supervised the design and preparation of the database, supervised the statistical analysis, and revised the manuscript. E.F., E.M.T., E.T., T.E.S., A.V., E.S., M.C., A.K., G.K., S.Z., and A.P. contributed to parts of methodology. All authors approved the

final manuscript as submitted. E.F., E.T., T.E.S., A.V., E.S., A.K., G.K., S.Z., and A.P. contributed to the writing of the protocols and the data collection on the field. All contributors approved the final manuscript as submitted. G.P.C., G.De., G.Di., I.M., and E.R. acted as external advisory committee members. All members of the advisory committee approved the final manuscript as submitted.

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Appendix

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Appendix A. Supplementary data

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