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Decomposition of Mediterranean Dietary Pattern on Successful Aging, Among Older Adults: A Combined Analysis of Two Epidemiological Studies

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Abstract

Objective: To investigate the association of Mediterranean food group consumption with successful aging (SA), among people more than 50 years old. **Method:** Dietary habits, as well as several bio-clinical characteristics of the Greek participants enrolled in the ATTICA (*n* = 1,128 men and women

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from Athens metropolitan area) and the MEDIS (n = 2,221 men and women from selected Greek islands) cohort studies were investigated in relation to SA; SA was measured using a validated 10-scale index. **Results:** Multivariate discriminant food group analysis revealed that legumes consumption, followed by vegetables, cereals, and poultry were associated with higher levels of SA index (explained variability: 7.9%), mainly among islanders, but not among mainland participants. Further analysis revealed that alcohol consumption was positively associated with SA for mainlanders (ATTICA study) but inversely for islanders (MEDIS study; all p's < .05). **Conclusion:** The differential and hierarchical effect of various foods on SA and the diet-environmental interaction revealed in the present work may help health professionals to better understand the role of diet on SA, and to prioritize the nutritional needs of older people for better quality of life.

Keywords
successful aging, dietary habits, food groups

Introduction

Based on World Health Organization (1948) definition, health is the "state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." At the same time, longevity is one of the major achievements of modern societies, resulting in a rapid increase in elderly population, and making successful aging a challenge of the world society (Passarino, De Rango, & Montesanto, 2016). Successful aging encompasses various aspects of life, such as lifelong learning, longer work life, slower and more gradual retirement, and preservation of the employment with activities that increase the potential of the individual and maintain their health (Cosco, Prina, Perales, Stephan, & Brayne, 2014). To promote successful aging the capabilities of the older adults, their setting goals, but also the environment they live in are three intercorrelated factors that should be considered (Cosco et al., 2014). In the past, people in south European countries, such as Spain, Italy, and Greece not only tended to live longer but also healthier (Simopoulos, 2001). Diet was always viewed as an important health component and nutritional history can be traced back to the writings of ancient Greek philosophers, *Homer, Plato*, and *Hippocrates* (Hwalla & Koleilat, 2004). A diet that has received much attention the past decades is the Mediterranean diet; this dietary pattern is a way of eating based on the traditional foods and drinks (mainly wine) of the countries surrounding the Mediterranean Sea. Indeed,

people living in the Mediterranean basin have been endowed with a traditional dietary pattern that symbolizes local culture and agriculture, and emphasizes on the high or/and everyday consumption of plant-based foods, dairy products, and olive oil, low consumption of meat, poultry, as well as moderate alcohol consumption (Willett et al., 1995). Mediterranean diet has consistently been linked to reduced incidence of cardiovascular disease (CVD), some types of cancer and other chronic diseases (Martinez-Gonzalez & Bes-Rastrollo, 2014); a fact that could partially explain the higher life expectancy in these regions. However, as mentioned above, successful aging goes beyond morbidity; and so far, the role of diet in promoting successful aging has not been well studied and understood. Therefore, the aim of the present work was to investigate the association of different foods consumption with successful aging, and to prioritize food needs in promoting successful aging among people more than 50 years old, living on the mainland and the islands of Greece. A potential diet–environmental interaction (i.e., with the place of residence) was also tested. Environmental factors, like region, might result in groups of people with different cultural heritage, potentially affecting their dietary habits, the quality, and types of foods consumed, including different food sources of macro- and micronutrients that may independently affect aging.

Method

To increase the validity and generalization of the results, two cross-sectional, population-based, large-scale epidemiologic studies, the ATTICA and the MEDIS, conducted in Greece the past 15 years, were combined in this work.

Study Sample

The combined data set included individuals more than 50 years old, living in urban and insular Greek areas from the ATTICA and the MEDIS studies. The ATTICA study was a population-based observational study, carried out in the greater metropolitan Athens area, during 2001-2002. The principal goal of the study was to investigate the prevalence of CVD risk factors, their associations with various socioeconomic, lifestyle, and psychological characteristics and their prognostic value on CVD incidence. Of the initial 4,056 randomly selected individuals, 3,042 agreed to participate (75% participation rate); all participants were free of CVD and other chronic diseases, as assessed through a detailed clinical evaluation by the study's physicians. From the $n = 3,042$ participants of the ATTICA sample, a subgroup of $n = 1,128$ individuals more than 50 years old were analyzed in this work. More information about ATTICA

study may be found elsewhere (Panagiotakos et al., 2015). The other study is the MEDIS (Mediterranean Islands); this study was carried out in a variety of Mediterranean islands. Approximately, 3,000 older people from 26 Mediterranean islands of five countries were enrolled during 2005-2017. Individuals who resided in assisted-living centers had a clinical history of CVD or cancer, or had left the island for a considerable period of time during their life (i.e., >5 years) were excluded. From the n = 3,138 participants, more than 50 years old, living in the insular Mediterranean region, of the MEDIS study, a subgroup of n = 2,221 individuals from 20 Greek islands only were analyzed in this work. More information about MEDIS study may be found elsewhere (Tyrovolas et al., 2014). In both studies, a group of health scientists (cardiologists, general practitioners, physicians, dietitians, public health nutritionists, and nurses) with field experience collected all required information using standard, validated questionnaires and clinical procedures.

Bioethics

The ATTICA study was approved by the Institutional Ethics Board of First Cardiology Clinic (Athens University Medical School) and was carried out in accordance to the Declaration of Helsinki (1989) of the World Medical Association. Similarly, the Bioethics Committee of Harokopio University approved the MEDIS study (December 16 to 19, 2006). Participants of both studies were informed about the aims and procedures and gave their informed consent prior to their enrollment.

Measurements

Sociodemographic data. Age (years), gender (male/female), smoking, financial, and education status were assessed.

Lifestyle Characteristics

Current smokers were defined as those who smoked at least one cigarette or any type of tobacco per day at the time of the interview. Former smokers were defined as those who previously smoked, but had quit within the previous year. Current and former smokers were combined as ever smokers. The remaining participants were defined as nonsmokers. Regarding financial status, participants were asked to self-characterize their income during the previous 3 years as low, that is, inadequate to cover daily expenses, medium, that is, trying hard to cover daily expenses, good, that is, adequate to cover daily expenses, or very good, that is, very adequate to cover daily expenses, while

education level was described with school years. Physical activity was assessed through a translated version of the validated "International Physical Activity Questionnaire" (IPAQ; Papathanasiou et al., 2009), suitable for assessing population levels of self-reported physical activities, taking into consideration frequency (times per week) and duration (at least 10 min) of walking, moderate, and vigorous activities, as well as sedentary activity. Participants who did not report any physical activities were defined as physically inactive.

Dietary assessment. The evaluation of dietary habits in the ATTICA study was based on a semiquantitative food-frequency questionnaire (FFQ) that was provided by the Unit of Nutrition of Athens University Medical School (Katsouyanni et al., 1997). All participants were asked to report the average intake (per week or day) of several food items that they consumed (during the last 12 months). Similarly, dietary habits in the MEDIS study were assessed through a similar semiquantitative, validated, and reproducible FFQ (Tyrovolas, Pounis, Bountziouka, Polychronopoulos, & Panagiotakos, 2010). The frequency of consumption of various food types (i.e., meat and meat products, fish and seafood, milk and other dairy products, fruits, vegetables, greens and salads, legumes, cereals, pasta, olive oil, and alcohol) on a daily, weekly, or monthly basis, was assessed and then transformed into servings per week. These food groups are typically consumed within the Mediterranean regions and adequate data were provided for both study groups. Food groups like soda drinks and sweets were excluded due to lacking data. To evaluate the level of adherence to the Mediterranean diet, the *MedDietScore* (theoretical range: 0-55) was used (Panagiotakos, Pitsavos, & Stefanadis, 2006), with higher values indicating greater adherence. The tertiles of the score, that is, 34/55, 35-38/55 and ≥39/55 were used as cutoffs to classify participants as low, moderate or high adherers.

Anthropometric and clinical characteristics. In both studies, weight and height were measured using standard procedures and body mass index (BMI) was calculated (kg/m^2). Overweight was defined as BMI between 25 and 29.9 kg/m^2, while obesity was defined as BMI >29.9 kg/m^2. Type 2 diabetes mellitus was determined using American Diabetes Association diagnostic criteria (fasting blood glucose ≥126 mg/dL or the use of antidiabetic medication). Participants who had blood pressure levels ≥140/90 mmHg or used antihypertensive medications were classified as hypertensive. Hypercholesterolemia was defined as total serum cholesterol levels >200 mg/dL or the use of lipid-lowering agents according to the National Cholesterol Education Program Adult Treatment Panel III guidelines (Expert Panel on Detection,

Evaluation, and Treatment of High Blood Cholesterol in Adults, 2001). Symptoms of depression during the previous month were assessed using the validated Greek version of the shortened, self-report Geriatric Depression Scale (GDS; range 0-15; Fountoulakis et al., 1999). A cumulative variable (range 0-4) indicating the overall burden of classical cardiometabolic risk factors (i.e., obesity, history of hypertension, diabetes, and hypercholesterolemia) was developed (participants having none of the aforementioned risk factors received a score of 0, having one factor received score of 1, etc.).

Successful aging index (SAI). SAI, ranging from 0 to 10, previously developed and validated, was used in this work. SAI consists of 10 attributes that reflect and have been found associated with the aging process (Tyrovolas et al., 2014). Specifically, the index encompasses the following health-related, social, lifestyle, and clinical factors—education (years of school): 0 to 2 years = 0, 3 to 6 years = 0.33, 7 to 12 years = 0.66, >12 years = 1, financial status (self-reported): low = 0, moderate = 0.33, good = 0.66, very good = 1, social activities with friends (per week): none = 0, 1 time = 0.25, 2 times = 0.5, 3 to 5 times = 0.75, >5 times = 1, social activities with family (per week): none = 0, 1 time = 0.25, 2 times = 0.5, 3 to 5 times = 0.75, >5 times = 1, going to excursions: none = 0, 1 time = 0.25, 2 times = 0.5, 3-5 times = 0.75, >5 times = 1, physical activity (per week): none = 0, 1-2 times = 0.33, 3 to 5 times = 0.66, >5 times = 1, BMI classes: normal weight: 1, overweight = 0.5, underweight or obese = 0, GDS (0-15): 0 to 4 points (no depression) = 1, 5 to 10 points (mild depression) = 0.5, >10 points (severe depression) = 0, CVD risk score (i.e., obesity, history of hypertension, diabetes, hypercholesterolemia): none = 1, 1 factor = 0.75, 2 factors = 0.5, 3 factors = 0.25, 4 factors = 0, and level of adherence to the Mediterranean diet (*MedDietScore* 0-55): 0 to 34 points = 0, 35 to 38 points = 0.5, >38 points = 1.

Statistical analysis. Continuous variables are presented as mean ± *SD* and categorical variables as frequencies. Associations between categorical variables were tested using the chi-square test, while comparisons of continuous variables between groups were performed using the independent samples *t* test (for normally distributed variables) and the Mann–Whitney *U* test (for nonnormally distributed). Linear regression models were used to evaluate the association between various food groups (i.e., meat, poultry, fish, vegetables, legumes, cereals, dairy, potatoes, fruits, olive oil, and alcohol) and successful aging (dependent outcome). Hierarchical classification analysis, by calculating Wilks's λ—a test statistic used in multivariate

Table 1. Sociodemographic, Lifestyle, and Clinical Characteristics of *n* = 1,128 Older Adult (>50 Years) Participants From the ATTICA Study (Mainland) and *n* = 2,221 Older Adult (>50 Years) Participants From the MEDIS Study (Insular).

Characteristics	Overall sample	ATTICA study	MEDIS study	*p* value
n	3,349	1,128	2,221	
Age (*y*)	69 ± 10	60 ± 8	74 ± 7	<.001
Male (%)	52	50	53	.06
Current smokers (%)	24	36	18	<.001
Physically active (%)	41	42	41	.44
BMI (kg/m^2)	28 ± 4.4	27.5 ± 4.2	28.4 ± 4.5	<.001
Waist circumference (cm)	99 ± 14	95 ± 14	101 ± 13	<.001
Hypertension (%)	57	40	66	<.001
Diabetes (%)	21	15	24	<.001
Hypercholesterolemia (%)	53	55	51	.04
CVD risk factors (0-4)	1.6 ± 1.0	1.3 ± 0.9	1.7 ± 1.0	<.001
MedDietScore (0-55)	29 ± 7	23 ± 6.2	32 ± 5.1	<.001
Meat (servings/week)	4.4 ± 3.1	4.6 ± 2.3	4.4 ± 3.2	.34
Poultry (servings/week)	3.1 ± 2.5	1.2 ± 0.70	4.0 ± 2.6	<.001
Fish (servings/week)	4.3 ± 3.4	2.1 ± 1.3	4.5 ± 3.4	<.001
Dairy (servings/week)	3.9 ± 3.8	11.1 ± 5.1	3.1 ± 2.7	<.001
Cereals (servings/week)	17.3 ± 15.2	26.3 ± 17.1	12.6 ± 5.4	<.001
Potatoes (servings/week)	2.8 ± 3.3	5.3 ± 6.2	2.1 ± 1.4	<.001
Legumes (servings/week)	3.1 ± 2.3	5.4 ± 2.8	2.9 ± 2.2	<.001
Vegetables (servings/week)	12.5 ± 10.6	18.9 ± 14.6	9.8 ± 5.3	<.001
Fruit (servings/week)	7.2 ± 7.9	13.8 ± 13.4	5.2 ± 2.4	<.001
Olive oil (servings/week)	6.3 ± 1.9	5.9 ± 2.6	6.5 ± 1.6	<.001
Alcohol (servings/week)	1.3 ± 1.2	1.7 ± 1.3	1.2 ± 1.1	<.001
SAI (0-10)	2.7 ± 1.3	3.8 ± 0.8	2.6 ± 1.4	<.001

Note. Data are presented as mean values and *SD* or frequencies. The *p* values derived from Student's *t* test for normally distributed continuous data, χ^2 for categorical data and Mann–Whitney *U* test for non-normally distributed continuous data. BMI = body mass index; CVD = cardiovascular disease; SAI = successful aging index.

analysis of variance (i.e., the lower the better classification)—evaluated how well each food or food group contribute to the classification of successful aging (i.e., over or below the sample-specific median value). Values close to 1 indicate no discrimination, whereas values close to 0 mean total discrimination. The STATA software, version 14 (MP & Associates, Sparta, Greece) was used for all statistical analyses.

Results

In Table 1, baseline socio-demographic data, lifestyle, and clinical characteristics of the participants are presented. As it can be seen, the ATTICA study participants were younger as compared with the MEDIS study (Table 1); this can be explained due to the sampling procedures of the combined studies. ATTICA study included 18+ years old participants according to the age-sex distribution of the entire Greek population, whereas, MEDIS study included only older (60+ years) adults. As a result of the aforementioned age differences, hypertension ($p < .001$) and diabetes ($p < .001$) were found more apparent in islanders compared with mainland participants; however, hypercholesterolemia and smoking status were more prevalent among the participants from the mainland areas, that is, ATTICA study ($p = .04$ and $p < .001$). As regards dietary habits, MEDIS study islanders had higher *MedDietScore* as compared with the ATTICA study participants (32 ± 5.1 vs. 23 ± 6.2, $p < .001$). Moreover, islanders had lower mean SAI score compared with mainlanders (2.6 ± 1.4 vs. 3.8 ± 0.8, $p < .001$).

Food Groups and Successful Aging

To test the research hypothesis, linear regression models (i.e., 11 models as much as the number of the food groups) were constructed (Table 2). Poultry, fish, dairy, vegetables, fruit, potatoes, cereals, olive oil, and alcohol had a positive association with SAI, whereas meat had an inverse association with successful aging (all ps $< .05$), after adjusting for age and sex in the overall sample. Moreover, a significant interaction was observed between certain food or food groups and the sample studied (ATTICA or MEDIS) on SAI (all p values for interaction $<.01$). Thus, the analysis was stratified by the studied sample. Stratified analyses revealed that alcohol consumption was positively associated with successful aging for those living in the mainland ($b = 0.22 \pm 0.09$, $p = .02$), but inversely for the islanders ($b = -0.10 \pm 0.04$, $p = .04$). Moreover, the majority of food groups were not associated with successful aging among mainland participants (all ps $> .05$; Table 2), whereas fruit, potatoes, poultry, vegetables, cereals, and olive oil were positively associated with successful aging among islanders (all ps $< .05$), and meat was inversely associated with successful aging ($p = .001$). In Figure 1, the association between several food groups and successful aging is illustrated.

However, as MedDietScore was a part of SAI, the analyses were repeated excluding MedDietScore from SAI. Analyzing the entire sample, together and separately, the results remained similar; in particular in the overall sample only meat was inversely associated with the modified SAI ($p < .001$),

Table 2. Results From Linear Regression Models That Evaluated the Association Between Various Food Groups (Independent) and SAI (Dependent Outcome) of the n = 1,128 Older Adult (>50 Years) From the ATTICA Study (Mainland) and n = 2,221 Older Adult (>50 Years) Participants From the MEDIS Study (Insular).

	Overall sample	ATTICA study	MEDIS study
Model for: Meat (servings/week)	−0.03 ± 0.01, p < .001 [–0.05, –0.02]	−0.02 ± 0.05, p = .72 [–0.11, 0.07]	−0.03 ± 0.01, p = .001 [–0.05, –0.01]
Model for: Poultry (servings/week)	0.06 ± 0.02, p = .004 [0.02, 0.11]	0.24 ± 0.13, p = .07 [–0.02, 0.50]	0.08 ± 0.03, p = .002 [0.03, 0.13]
Model for: Fish (servings/week)	0.06 ± 0.01, p < .001 [0.04, 0.07]	0.15 ± 0.08, p = .045 [0.003, 0.30]	0.07 ± 0.01, p < .001 [0.05, 0.08]
Model for: Dairy (servings/week)	0.08 ± 0.01, p < .001 [0.06, 0.10]	0.04 ± 0.02, p = .004 [0.01, 0.07]	0.07 ± 0.01, p < .001 [0.05, 0.09]
Model for: Cereals (servings/week)	0.01 ± 0.003, p < .001 [0.01, 0.02]	0.004 ± 0.005, p = .39 [–0.006, 0.01]	0.02 ± 0.01, p < .001 [0.01, 0.04]
Model for: Potatoes (servings/week)	0.07 ± 0.01, p < .001 [0.05, 0.09]	−0.004 ± 0.01, p = .76 [–0.03, 0.23]	0.11 ± 0.02, p < .001 [0.07, 0.15]
Model for: Legumes (servings/week)	0.02 ± 0.01, p = .09 [–0.003, 0.05]	0.04 ± 0.03, p = .26 [–0.03, 0.10]	0.01 ± 0.01, p = .42 [–0.02, 0.04]
Model for: Vegetables (servings/week)	0.04 ± 0.004, p < .001 [0.04, 0.05]	0.01 ± 0.01, p = .15 [–0.003, 0.02]	0.07 ± 0.01, p < .001 [0.06, 0.08]
Model for: Fruit (servings/week)	0.03 ± 0.01, p < .001 [0.02, 0.04]	0.001 ± 0.01, p = .90 [–0.01, 0.01]	0.07 ± 0.01, p < .001 [0.04, 0.09]
Model for: Olive oil (servings/week)	0.10 ± 0.02, p < .001 [0.06, 0.13]	0.06 ± 0.05, p = .21 [–0.01, 0.13]	0.10 ± 0.02, p < .001 [0.01, 0.14]
Model for: Alcohol (servings/week)	0.29 ± 0.12, p = .02 [0.05, 0.53]	0.22 ± 0.09, p = .02 [0.04, 0.40]	−0.10 ± 0.04, p = .004 [–0.17, –0.03]

Note. To prevent colinearity, in each model, just one food group was entered; all models were adjusted for age and sex. Results are presented as b ± SE = Unstandardized b coefficients ± Standard error, their 95% CI = confidence interval, and p value. SAI = successful aging index.

while all other studied food categories were positively associated with the modified SAI (p < .05). Only for poultry, there was no statistical significant association with SAI (p > .05; data not shown).

Table 3 illustrates the different dietary pattern of older adults living in mainland and insular Greek areas, in relation to successful aging. In particular, hierarchical discriminant analysis showed that for islanders, fruits, cereals, potatoes, legumes, alcohol, vegetables, poultry (explained variability:

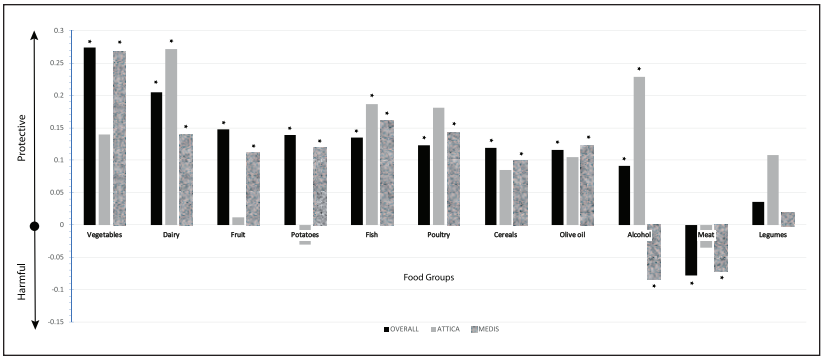

Figure 1. Hierarchical box-plot defined as the beta coefficient from linear regression analysis evaluating the association between several food groups and successful aging level, based on the overall sample and then separately for the two groups.
Note. ATTICA = Greek mainlanders; MEDIS = Greek islanders.
*$p < .05$.

33%), and less significantly, dairy, olive oil, and fish (explained variability: 0.7%) were associated with higher levels of SAI, that is, over 2.5 (median score; see Table 3). Accordingly, for mainland participants the dietary pattern differs, and vegetables and fish (explained variability: 15%), and less significantly cereals, dairy, meat, legumes, poultry, fruits, potatoes, olive oil, and alcohol consumption (explained variability: 6.7%) were associated with higher levels of SAI, that is, over 3.8 (median score). For the entire sample, alcohol drinking, followed by legumes, vegetables, cereals, poultry consumption (overall explained variability: 7.9%), were associated with higher levels of SAI (i.e., over 2.58 median score).

Discussion

The present work revealed that food consumption could affect not only health status but also the course of aging. It is widely acknowledged that adoption of a healthy lifestyle and a healthy diet, like the Mediterranean diet, is the cornerstone of achieving good health. As successful aging—a complicated and maybe a still not fully clarified meaning—is also defined according to health service utilization (Cosco, Stephan, & Brayne, 2015; Tyrovolas et al., 2011), a difference in health care access between the islanders and the people of the mainland might be partially responsible for the differences recorded concerning health condition and successful aging

Table 3. Classification Discriminant Analysis That Assessed the Contribution of Each Food Group on Having Higher SAI (i.e., Over the Median), of the n = 1,128 Older Adult (>50 Years) From the ATTICA Study (Mainland) and n = 2,221 Older Adult (>50 Years) Participants From the MEDIS Study (Insular).

Food categories	Overall sample λ, p value	ATTICA study λ, p value	MEDIS study λ, p value
Alcohol	0.974, p = .001	1.00, p = .84	0.964, p < .001
Legumes	0.981, p = .004	0.994, p = .49	0.962, p < .001
Vegetables	0.987, p = .02	0.925, p = .01	0.970, p = .001
Cereals	0.989, p = .03	0.965, p = .09	0.927, p < .001
Poultry	0.990, p = .03	0.997, p = .63	0.984, p = .02
Potatoes	0.993, p = .09	0.998, p = .72	0.945, p < .001
Dairy	0.995, p = .16	0.989, p = .34	0.995, p = .19
Fruit	0.996, p = .18	0.998, p = .693	0.916, p < .001
Fish	0.998, p = .32	0.930, p = .01	0.998, p = .44
Olive oil	1.000, p = .92	0.999, p = .79	1.000, p = .72
Meat	1.000, p = .93	0.993, p = .44	1.000, p = .75

Note. Results are presented as Wilks's Lambda (λ) and the corresponding p value; the lower the λ the higher the discriminating ability. Median SAI values: MEDIS: 2.5, ATTICA: 3.8 and overall: 2.5. SAI = successful aging index.

among the two samples. It has also been reported that regions far from the capital of Greece are often undersupplied by nursing or other health personnel (Oikonomou & Tountas, 2011), explaining again islanders' poor health and consequently lower successful aging. Another issue that needs attention is that ATTICA study participants were younger as compared with the MEDIS (Table 1); a fact that is attributed to the different sampling schemes followed on. In particular, ATTICA study enrolled free of CVD and other chronic diseases individuals, aged 18+, based on the age–sex distribution of the Greek urban population, whereas, MEDIS study enrolled free of CVD and other chronic diseases individuals, aged 60+, from selected islands. Thus, the higher prevalence of various cardiometabolic disorders and the lower SAI score observed among MEDIS study participants as compared with the ATTICA could be explained by this age difference. However, MEDIS study islanders had significantly higher MedDietScore, which may suggest that they have still kept, at least in part, the traditional diet of their ancestors. Despite the limitations due to the observational design of the present work, the presented findings deserve further attention from public health policy, as diet seems to play a cornerstone in successful aging process.

Regarding diet-aging link, our sample consumed foods found in abundance in the Mediterranean diet (Tur, Romaguera, & Pons, 2004), which was expected as all individuals were Greek. A positive effect of all foods examined, by the exception of meat, on successful aging was observed in the overall sample, only legumes did not reach statistical significance. Several studies have highlighted the benefits of Mediterranean diet in health, and especially its positive effect on longevity. In particular, Trichopoulou, Costacou, Bamia, and Trichopoulos (2003) examining 28,572 people aged 20 to 86 years found that Mediterranean diet contributed significantly to decreased mortality. The diet's positive impact on longevity has been also suggested elsewhere (Trichopoulou, 2004; Vasto et al., 2012), while Roman, Carta, and Ángel (2008) highlighted its beneficial effect on reducing CVD risk.

In separate analyses though, only fish and dairy showed a consistent positive effect on successful aging in both samples. In line with our findings, consumption of both dairy and fish has been positively associated with human longevity, while centenarians tend to eat more often yogurt, skim curd and fish (Kołłajtis-Dołowy et al., 2007). Also, as indicated by Yamori et al. (Yamori et al., 2006) seafood intake is the main attribution of Okinawan people's longevity, having a protective effect against chronic diseases, such as atherosclerosis, while long-term fish intake has been associated with less severe depressive symptomatology (Bountziouka et al., 2009). With regard to other food groups, vegetables, fruits, olive oil, potatoes, cereals, and meat had a significant positive—or negative regarding meat—association with successful aging only for islanders (no significant effect on successful aging was found in ATTICA study participants); a finding potentially indicative of the fact that nowadays people in Mediterranean countries have left behind the traditions and nutritional principles that were honored throughout history (Tourlouki et al., 2013), shifting toward a westernized dietary and lifestyle pattern. Finally, a differential effect of alcohol consumption among islanders and mainlanders was observed (i.e., protective effect on mainlanders, but not on islanders), which might indicate that either its effect is mediated by other health-related factors, or that there is a potential age-related effect on successful aging (Tynjala, Kangastupa, Laatikainen, Aalto, & Niemela, 2012) as MEDIS participants were older than ATTICA participants. In line with our findings, a recent study showed that the neurobehavioral effects of alcohol consumption differ between older and younger adults (Price, Lewis, Boissoneault, Frazier, & Nixon, 2018) reinforcing the possibility that alcohol may also have different effect on successful aging with regard to different age groups. Not to be disregarded that older adults, as MEDIS participants, usually take more medications than younger ones, raising the chance of unwanted drug interactions when combined with alcohol consumption (Qato, Manzoor,

& Lee, 2015). Of course, as diet is not the only determinant of successful aging, it could be speculated that other lifestyle parameters, not measured, thus, not controlled for, in this work, could have had a significant effect on the aforementioned result. There are many biomedical and psychosocial factors possibly affecting the cross of aging (Domènech-Abella et al., 2017); for example, sleep quality and daytime alertness have been identified as important aspects of successful aging in late life (Driscoll et al., 2008), while prolonged exposure to stress has been shown to shorten lifespan (Epel & Lithgow, 2014).

Last but not least, when foods were prioritized based on their significance in promoting successful aging, vegetables, dairy, and fruits were those with the highest contribution. Vegetables and fruits—both of which are highly associated with successful aging—have long been associated with beneficial health effects (Slavin & Lloyd, 2012), while dairy products' effect on health, that is, CVD and cancer prognosis, is not totally clarified (Visioli & Strata, 2014). The low discriminant ability of olive oil consumption in both ATTICA and MEDIS studies participants as regards successful aging, could be attributed to the high use of olive oil in daily cooking in both cohorts. Our findings are consistent with the Mediterranean diet's principles to a great extent, reinforcing its beneficial health effects.

All the aforementioned results could be discussed in the wider context of the effect of diet on human longevity indicating that each food, and in particular each Mediterranean diet component, could affect the trajectories of successful aging. Mediterranean diet, which is widely acknowledged as an excellent dietary pattern of a variety of high quality foods, has long been associated with better health status, and particularly lower incidence of CVD, some types of cancer, neurological disorders, and more recently with better quality of life and, therefore, successful aging (Milte & McNaughton, 2016). Moreover, as it was revealed here, many of the studied foods were not associated with successful aging among mainlanders, but only among islanders; thus, it could be speculated the existence of a diet-environmental interaction on successful aging. Several potential underlying mechanisms may exist. It could be hypothesized that there is a better quality of foods consumed in the islands—and generally in rural areas—and therefore better sources of macro- and micronutrients. Moreover, there might be differences in several dietary behaviors between islanders and urban participants (e.g., number of meals consumed per day, the meals with the family, the way of cooking, etc.) that may also explain, at least in part, the observed interaction. These observed divergences may help to expand knowledge regarding the diet-successful aging associations, but also to state the need for further investigation of factors that could possibly mediate or moderate the studied relationship. The

results of the present study could be used by public health policy makers while designing health promotion programs for middle-aged and older adults. Considering the lack of awareness regarding the effect of different foods on human health to be a major factor influencing unhealthy dietary choices (Arnold & Sobal, 2000), increasing the awareness of the healthful properties of certain and orienting food choice toward foods beneficial for successful aging.

Strengths and Limitations

To the best of our knowledge, this is the first study concerning different food group consumption and their association with successful aging of older Mediterranean adults. A major strength of the present study is the use of two different samples from large-scale studies. From an epidemiological perspective, using samples from different studies is useful to minimize the effect of several types of bias and to multiply the external validity of the findings (Aschengrau & Seage, 2014). In addition, this study involved semi-structured interviews to collect data from the participants, which are considered a more reliable way to investigate the responders' behaviors, compared with the use of self-reported instruments (Robson, 2002). This work has also certain limitations. Estimation of successful aging is a difficult task, because the definition of successful aging in the scientific community is controversial. The SAI that was used here and developed by adding aging determinants may not accurately estimate the true successful aging status through life course. This methodology, however, was based on a procedure that has already described, validated, and used in other aging-associated studies (Rockwood, Rockwood, & Mitnitski, 2010).

Conclusion

The present study may set the basis for next steps in diet-aging research, revealing the complexity of associations in the investigated outcome, as well as guiding health professionals toward more targeted nutritional counseling. The environmental interaction observed between the region of residence (mainland vs. islands) and food groups on successful aging may also suggest that diet is always an expression of people's culture. The hierarchical approach and differential "weight" given in each food in terms of promoting successful aging may help health professionals to focus on the promotion of specific foods/food groups with major importance for successful aging.

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