nutrition and health

Original Article

Nutrition and Health
1–9

DOI: 10.1177/02601060211072363
journals.sagepub.com/home/nah
SAGE

Adherence to the Mediterranean Diet and Successful aging in Greeks living in Greece and abroad: the epidemiological Mediterranean Islands Study (MEDIS)

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Abstract

Background: Whether older immigrant populations from the Mediterranean region, continue to follow the MD long after they immigrated is not known. **Aim:** Compare adherence to the MD and successful aging levels between Greeks living in Greece (GG) and Greeks living abroad (GA). **Methods:** Anthropometrical, clinical, psychological, sociodemographic, dietary and lifestyle parameters were assessed in a cross-sectional manner in a sample of 252 GG and 252 GA. Mediterranean Diet Score (MedDietScore range 0-55) was used to assess adherence to the MD. Successful aging was evaluated with the validated successful aging index (SAI range 0-10). **Results:** GA presented higher adherence to MD ($p < 0.001$); they were consuming significantly more cereals, legumes, vegetables, and fruits compared to GG. GG consumed significantly more dairy (3.8 ± 2.9 vs. 1.9 ± 2.2, $p < 0.001$) and potatoes (2.4 ± 1.6 vs. 1.9 ± 1.5, $p < 0.001$) compared to GA. Meat ($p = 0.27$), poultry ($p = 0.72$), fish ($p = 0.68$), olive oil ($p = 0.16$) and alcohol consumption ($p = 0.05$) were comparable between the two groups (all p's > 0.05). MedDietScore was positively associated with SAI among both groups after adjusting for possible confounders (0.041 ± 0.014, $p = 0.003$ GG and 0.153 ± 0.035, $p < 0.001$ GA). Also, legumes, cereals, fruits and vegetables were found to be beneficial for successful aging. **Conclusion:** Adherence to the MD is associated with higher levels of successful aging among people of the same genetic background living in different environments. However, traditional dietary habits are gradually abandoned in their native countries, when, at the same time, are considered cultural heritage and preserved accordingly among immigrants.

Keywords

Successful aging, healthy aging, immigrant population, Mediterranean diet, acculturation, nutrition transition

1. Introduction

Across the world the older population is increasing rapidly and is expected to reach 83.7 million in 2050; this is almost double than the recorded 43.1 million in 2012, according to the US Census Current Population Report (Ortman et al., 2014). Additionally, most people aged 65 and older are reported to have at least one chronic disease such as coronary heart disease (CHD), hypertension, diabetes, stroke and cancer, while 77% have at least two chronic diseases (Ward and Schiller, 2013). These observations increase concerns about the quality of life of older populations and the burden to the healthcare system. Supporting healthy, independent, and functional older adults could lead to lower

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healthcare costs and continuous contributions to society and families.

Scientists focused on successful aging for many years hoping to identify its' components and clarify possible mechanisms of action. However, even today there is no consensus on the definition and constituents of successful aging. The first attempt to define successful aging was focused on the absence of disease but then transitioned to more multifactorial models (Rowe and Kahn, 1987). Current definitions consider everyday life habits, physical and cognitive function, engagement in productive activities and social involvement (Crowther et al., 2002; Depp and Jeste, 2006; Sadler and Biggs, 2006; Ng et al., 2009). For example, the World Health Organization describes healthy aging as the ability to maintain functional abilities and continue performing pleasant activities as growing older (World Health Organization (WHO), 2018).

Adherence to MD has been associated with multiple health benefits among older adults, including better quality of life, lower incidence of cardiovascular diseases, lower all-cause mortality, lower risk of frailty and improved cognition (Roman et al., 2008; Lopez-Garcia et al., 2014; Zbeida et al., 2014; Tektonidis et al., 2015; Galilea-Zabalza et al., 2018; Tanaka et al., 2018; Zaragoza-Martí et al., 2018; Romanidou et al., 2020). However, adherence to the MD appears to vary considerably between populations and maybe affected by the environment and the shared characteristics of each population.

The aim of the present work was to determine the role of the living environment on the adherence to the Mediterranean diet, comparing Greeks living in Greece and Greeks born in Greece but living abroad. Furthermore, we aimed to identify the effect of the MD on indexes of successful aging.

2. Methods

2.1. Study population and Experimental design

The Mediterranean Islands (MEDIS) study is a population-based, observational survey that took place in 27 Mediterranean islands and 7 countries in total and recruited n = 3,723 individuals > 65 years old. The recruitment process occurred between 2005 and 2020 with a random, population-based, multistage sampling scheme to enroll older men and women volunteers. The participation rate varied across the different locations from 75% to 89%. In the present work, a random sample of n = 252 Greek men and women living in 20 Greek islands (i.e., Greeks of Greece) and n = 252 Greek men and women living in the USA and Australia (i.e., Greeks Abroad), in a cross-sectional manner. All study participants were born in Greece thus were genetically similar, since the immigrant population in Greece is consistently very low (1.63% in 1991), as reported by the Hellenic Statistical Authority (Hellenic Statistical Authority - ELSTAT, 1991). All the required information was collected using a quantitative questionnaire and standard procedures by a group of health scientists (physicians, dietitians, public health nutritionists and nurses) with experience in field investigation. Exclusion criteria included residing in assisted-living centers, having clinical history of CVD or cancer, and absence from the island or the studied country for a considerable amount of time (i.e., >5 years). These exclusion criteria were chosen since the study aimed to evaluate lifestyle patterns that could be modified by existing chronic health conditions or environmental factors, other than living milieu.

2.2. Socio-demographic characteristics

Basic socio-demographic characteristics including age (measured in years), sex (man/woman) and place of residence (Greece, USA, and Australia) were assessed.

2.3. Lifestyle, Dietary and Physical activity assessment

Evaluation of smoking status was performed by following standard procedures for observational studies. 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 non-smokers. Physical activity habits were assessed using the short version of the self-reported International Physical Activity Questionnaire (IPAQ) and evaluated by the metabolic equivalents (METs) minutes per week where individuals with at least 3 METs were classified as "physically active" and the rest as "physically inactive". Dietary habits were evaluated using a semi-quantitative, validated, and reproducible FFQ (Tyrovolas et al., 2010). Frequency of consumption was assessed on a daily, weekly or monthly basis for various food groups (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). The level of adherence to the Mediterranean diet was evaluated using the previously developed and validated Mediterranean Diet Score (MedDietScore) with theoretical range 0–55 where higher values indicate greater adherence (Panagiotakos et al., 2006).

2.4. Anthropometric and clinical characteristics

Standard procedures were used to measure weight and height to calculate body mass index (BMI) (kg/m^2). Diabetes mellitus was determined by fasting plasma glucose and was analysed in accordance with the American Diabetes Association diagnostic criteria

(glycated haemoglobin A1C ≥ 6.5 or fasting blood glucose level greater than 126 mg/dl or 2-h plasma glucose > 200 mg/dl during an oral glucose tolerance test-OGTT- or a random plasma glucose > 200 mg/dl or by history of previously established diagnosis of diabetes). Participants who had blood pressure levels >140/90 mmHg or used antihypertensive medications were classified as hypertensive. Fasting blood lipids levels (HDL-, LDL-cholesterol and triglycerides) were also recorded and hypercholesterolemia was defined as total serum cholesterol levels >200 mg/dL or the use of lipid-lowering agents according to the NCEP ATPIII guidelines (Expert Panel on Detection & Treatment of High Blood Cholesterol in Adults, 2001). The coefficient of variation for the blood measurements was < 5%. A cumulative variable (range 0–4) indicating the overall burden of classical cardiometabolic risk factors (i.e., obesity and hypertension, diabetes, and hypercholesterolemia) was developed (participants having none of the aforementioned risk factors received score 0, having one factor score 1, etc.).

2.5. Successful aging index

Successful aging is a complex phenomenon with several definitions, including biomedical, social functioning, psychological and subjective models. Following this multidimensional approach, we used a previously developed and validated successful aging index (SAI) (total score ranging from 0 to 10) associated with the aging process (Tyrovolas et al., 2014). SAI encompasses health-related, social, lifestyle and clinical factors, including education, financial status, physical activity, BMI, depression, participation in social activities with friends and family, number of yearly excursions, total number of clinical CVD risk factors (i.e., history of hypertension, diabetes, hypercholesterolemia, and obesity) and level of adherence to the Mediterranean diet.

2.6. Statistical analyses

Continuous variables are presented as mean ± standard deviation (SD) and categorical variables as frequencies. Comparisons 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 non-normally distributed variables. Multiple linear regression models were used to evaluate the association between the level of adherence to the Mediterranean diet (i.e., MedDietScore – independent variable) with SAI (outcome) among Greeks of Greece, Greeks living abroad and the overall sample. Hierarchical classification analysis, using the Wilks's λ, was used to evaluate how well each food group contribute to the classification of successful aging (over or below SAI median value for each participant-group), the lower the better classification. STATA software version 15 (M. Psarros & Associates, Sparti, Greece) was used for all calculations.

3. Results

Basic lifestyle, socio-demographic and clinical characteristics of the study participants, i.e. Greeks living in Greece (GG) and Greeks living Abroad (GA), are presented in **Table 1**. GA were more physically active ($p < 0.001$) and were smoking less at the time of the study ($p = 0.008$) compared to GG. Assessment of the CVD risk factors showed that clinical characteristics were slightly more positive among GA compared to GG, but the difference did not reach statistical significance (p = 0.72). Healthcare visits were more common among GA compared to GG (5.6 ± 5.6 GA vs. 3.8 ± 3.8 GG, $p = 0.02$) while assessment of health care accessibility showed that the majority of GA considered access to health care being very easy (58% of GA vs. 14% of GG, $p < 0.001$). Also, GA had higher successful aging scores compared to GG ($p < 0.001$).

3.1. Dietary habits

The MedDietScore (range 0-55) showed that GA had higher adherence to the Mediterranean diet compared to GG (37 ± 4.4 vs. 27 ± 5.9, $p < 0.001$). Additional analysis of food groups included in the MedDietScore indicated that GA were consuming significantly more cereals (10 ± 4.4 vs. 14 ± 5.4, $p < 0.001$), legumes (2.4 ± 1.5 vs. 4.1 ± 3.0, $p < 0.001$), vegetables (11 ± 6.1 vs. 12 ± 4.9, $p = 0.02$) and fruits (5.1 ± 2.4 vs. 5.7 ± 2.0, $p = 0.001$) compared to GG, while intake of dairy (3.8 ± 2.9 vs. 1.9 ± 2.2, $p < 0.001$) and potatoes (2.4 ± 1.6 vs. 1.9 ± 1.5, $p < 0.001$) was significantly higher among GG compared to GA. Meat, poultry, fish, olive oil and alcohol consumption was comparable between the two groups (all p's > 0.05).

To further evaluate the research hypothesis, multiple linear regression analysis was applied. It was revealed that after adjusting for age, sex, smoking habits, and access to health care services, MedDietScore was positively associated with SAI in both groups; GG (0.041 ± 0.014, $p = 0.003$) and GA (0.153 ± 0.035, $p < 0.001$) **(Table 2)**.

The contribution of individual food groups on having higher SAI (i.e., over the median) was tested with the classification discriminant analysis presented in **Table 3**. The results showed that in the GG vegetables and meat were significantly associated with higher SAI while cereals, dairy, fruits, olive oil, potatoes, fish, alcohol and poultry were less significantly associated with higher SAI levels, over the median value of 3.0. Additionally, in the GA legumes, dairy, fruits, potatoes, and poultry were significantly associated with higher SAI, while vegetables, olive oil, fish, alcohol and red meat were less significantly associated with high SAI over the median value of 5.0. In overall for all the participants, legumes, cereals, vegetables, dairy, fruits, and olive oil (explained variability: 30.2%) were significantly associated with higher SAI compared

Table 1. Socio-demographic, clinical and lifestyle characteristics of the n = 252 Greeks living in Greece and n = 252 Greeks living abroad.

	Overall sample (n = 504)	Greeks of Greece (GG) (n = 252)	Greeks Abroad (GA) (n = 252)	*p-value*
Age (years)	73 ± 8.8	76 ± 7.7	71 ± 9.1	*<0.001*
Men (%)	46	48	44	*0.42*
Current smokers (%)	14	18	10	*0.008*
Physical activity (%)	71	54	87	*<0.001*
BMI (kg/m^2)	28.9 ± 5.0	27.9 ± 4.3	29.9 ± 5.5	*<0.001*
Obesity (%)	37	29	45	*<0.001*
Hypertension (%)	51	60	42	*<0.001*
Diabetes (%)	24	25	23	*0.68*
Hypercholesterolemia (%)	44	40	48	*0.06*
CVD risk factors (0-4)	1.6 ± 1.1	1.5 ± 1.1	1.6 ± 1.1	*0.72*
Healthcare visits (times/year)	4.8 ± 4.9	3.8 ± 3.8	5.6 ± 5.6	*0.02*
Health care – Access				*<0.001*
Very easy (%)	29	14	58	
Easy (%)	41	45	32	
Moderate (%)	21	28	9.0	
Difficult (%)	8.0	12	1.0	
Very difficult (%)	1.0	1.0	0.0	
MedDietScore (0-55)	32 ± 6.9	27 ± 5.9	37 ± 4.4	*<0.001*
Meat (srvs/wk)	4.2 ± 3.1	4.4 ± 3.1	4.0 ± 3.1	*0.27*
Poultry (srvs/wk)	5.0 ± 3.1	4.8 ± 3.0	5.0 ± 3.1	*0.72*
Fish (srvs /wk)	4.4 ± 3.1	4.4 ± 3.3	4.5 ± 2.8	*0.68*
Dairy (srvs /wk)	2.9 ± 2.8	3.8 ± 2.9	1.9 ± 2.2	*<0.001*
Cereals (srvs /wk)	12 ± 5.3	10 ± 4.4	14 ± 5.4	*<0.001*
Potatoes (srvs /wk)	2.2 ± 1.5	2.4 ± 1.6	1.9 ± 1.5	*<0.001*
Legumes (srvs /wk)	3.3 ± 2.5	2.4 ± 1.5	4.1 ± 3.0	*<0.001*
Vegetables (srvs /wk)	11 ± 5.6	11 ± 6.1	12 ± 4.9	*0.02*
Fruits (srvs /wk)	5.4 ± 2.2	5.1 ± 2.4	5.7 ± 2.0	*0.001*
Olive oil (srvs /wk)	6.4 ± 1.5	6.3 ± 1.7	6.6 ± 1.2	*0.16*
Alcohol (srvs /wk)	0.5 ± 1.0	0.6 ± 1.0	0.4 ± 0.9	*0.05*
SAI (0-10)	4.0 ± 1.6	3.1 ± 1.2	5.1 ± 1.4	*<0.001*

Data are presented as mean values and SD or percentages. P-values derived from Student's t-test for normally distributed or Mann-Whitney U-test for non-normally distributed continuous data and chi-square for categorical data.

to potatoes, fish, alcohol, red meat and poultry (explained variability: 2.1%) which were less significantly associated with higher SAI levels, i.e., over the median value of 3.95.

4. Discussion

In the present study we attempted to determine the role of the living environment on the adherence to the Mediterranean diet by comparing Greeks living in Greece and Greeks born in Greece but living abroad. Furthermore, we aimed to identify the effect of the MD on indexes of successful aging. Contrary to our hypothesis we found that GA had higher MedDietScore, thus higher adherence to the MD, compared to GG. Furthermore, the data showed that adherence to the MD is associated with higher levels of successful aging among people of the same genetic background living in different environments, even after adjusting for possible confounders. The food groups associated with higher SAI were different between the two groups and included vegetables and red meat among GG and legumes, fruits, potatoes, and poultry among GA. Finally, all the evaluated food groups that are included in the MedDietScore were found to be beneficial for SAI for at least one of the two groups, except for dairy which were found to be harmful among GG and the overall study sample.

These results agree with previous studies that associated high adherence to MD with healthier aging, better chances for longevity and lower all-cause mortality (Di Daniele et al., 2017; Assmann et al., 2018; Soltani et al., 2019; Trichopoulou and Benetou, 2019). More specifically, in a large cohort of French adults it was shown that following the MD at midlife was associated with higher chances for healthy aging later in life (Assmann et al., 2018). Similarly, results from the Nurses Health study indicated that high adherence to MD was significantly associated with a 46% higher possibility of healthy aging (Samieri et al., 2013). Additionally, results from a study population like ours found an independent relationship between higher adherence to MD and greater successful aging

Table 2. Results from linear regression models that evaluated the association between the level of adherence to the Mediterranean diet and successful aging, among Greeks of Greece (n = 252) and Greeks Abroad (n = 252).

Models	b	SE	95% CI	*p*
All participants				
Model 1 for **MedDietScore** (per 1/55) – adj. for age and sex	0.123	0.009	0.106; 0.140	*<0.001*
Model 2 for **MedDietScore** (per 1/55) – Model 1 + smoking habits	0.122	0.009	0.105; 0.140	*<0.001*
Model 3 for **MedDietScore** (per 1/55) – Model 2 + access to health care services	0.106	0.011	0.084; 0.128	*<0.001*
Greeks of Greece				
Model 1 for **MedDietScore** (per 1/55) – adj. for age and sex	0.045	0.013	0.019; 0.07	*0.001*
Model 2 for **MedDietScore** (per 1/55) – Model 1 + smoking habits	0.044	0.013	0.019; 0.069	*0.001*
Model 3 for **MedDietScore** (per 1/55) – Model 2 + access to health care services	0.041	0.014	0.014; 0.068	*0.003*
Greeks Abroad				
Model 1 for **MedDietScore** (per 1/55) – adj. for age and sex	0.130	0.018	0.095; 0.165	*<0.001*
Model 2 for **MedDietScore** (per 1/55) – Model 1 + smoking habits	0.131	0.018	0.095; 0.167	*<0.001*
Model 3 for **MedDietScore** (per 1/55) – Model 2 + access to health care services	0.153	0.035	0.083; 0.223	*<0.001*

Results are presented as unstandardized b coefficients, Standard Error, 95% CI: Confidence Interval and *p-value*.

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= 252 Greeks of Greece and n = 252 Greeks living abroad.

Food Categories	Overall sample Λ, *p-value*	Greeks of Greece Λ, *p-value*	Greeks Abroad Λ, *p-value*
Legumes	0.901, p < 0.001	1.000, p = 0.92	0.975, p = 0.02
Cereals	0.933, p < 0.001	0.999, p = 0.71	1.000, p = 0.96
Vegetables	0.951, p < 0.001	0.960, p = 0.001	0.999, p = 0.61
Dairy	0.957, p < 0.001	0.986, p = 0.07	0.981, p = 0.04
Fruits	0.974, p < 0.001	0.995, p = 0.27	0.978, p = 0.02
Olive oil	0.982, p = 0.004	0.997, p = 0.43	0.998, p = 0.53
Potatoes	0.992, p = 0.05	0.992, p = 0.15	0.981, p = 0.04
Fish	0.993, p = 0.07	0.997, p = 0.36	0.999, p = 0.59
Alcohol	0.998, p = 0.36	0.987, p = 0.07	0.994, p = 0.26
Red meat	0.998, p = 0.39	0.979, p = 0.02	0.998, p = 0.47
Poultry	0.998, p = 0.46	0.976, p = 0.38	0.980, p = 0.03

Results are presented as Wilk's Lambda (Λ) and the corresponding *p-value*; the lower the Λ the higher the discriminating ability.
Median SAI values: Overall: 3.95, Greeks of Greece: 3.0 and Greeks Abroad: 5.0.

levels (Foscolou et al., 2020). All-cause mortality found to be inversely related to MD adherence following a dose-dependent trend according to a recent meta-analysis (Soltani et al., 2019).

Interestingly, Greeks living abroad seemed to have higher adherence to the Mediterranean diet compared to those living in Greece. The Mediterranean diet is the keystone of the Greek culture and a matter of pride for most Greeks, especially those living abroad. It is possible that Greeks living abroad are more dedicated and more sensitive to preserving their cultural inheritance and pass those healthy habits to the younger generations, resulting in lower rates of nutritional acculturation. On the contrary, Greeks living in Greece seem to be more likely to adopt characteristics of the Western lifestyle, including dietary habits, and move away from the traditional Mediterranean diet. The phenomenon of nutrition transition has been observed globally, mostly in countries of low and medium income, and is characterized by replacing healthy food habits, such as plant-based options, with more energy dense foods, processed carbohydrates, added sugars, fats, and animal products (Satia, 2010; Popkin et al., 2012). Nutrition transition was studied in southern Mediterranean countries where food availability has increased significantly resulting in higher energy consumption and in transitioning to different food sources (Belahsen and Rguibi, 2006). Finally, Greek children and adolescents were found to have several dietary habits of the Western diet (Yannakoulia et al., 2004). A recently published study from the Greek island of Crete, the cradle of the Mediterranean diet, showed that older people have moderate adherence to the Mediterranean diet; the authors suggested poor social support from family and the community, low socioeconomic status and worsening psychological status as potential reasons (Apostolaki et al., 2020).

Health conditions that develop later in life such as frailty, sarcopenia, cardiovascular diseases, and cognitive and physical dysfunction negatively affect the process of aging. Two recent reviews reported that adherence to MD may be protective against developing frailty, probably because

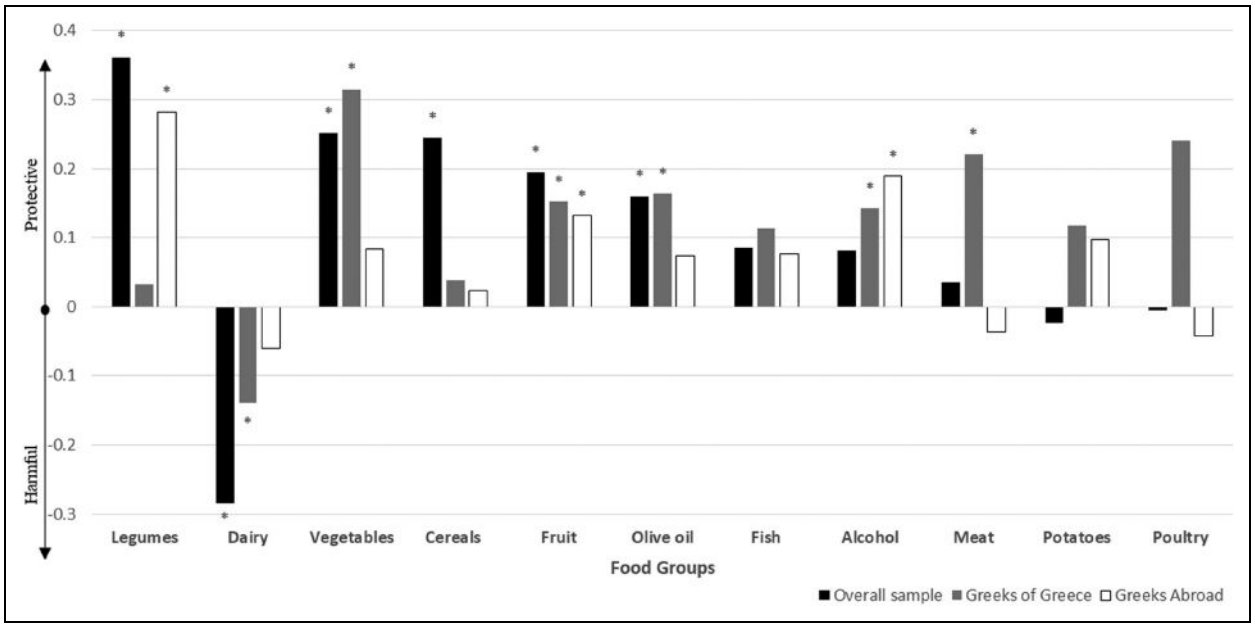

Figure 1. depicts the association between each food group included in the MedDietScore with successful aging among the overall sample and for each individual group of GG and GA. Regarding the overall sample, legumes, vegetables, cereals, fruits, and olive oil had a significant ($p < 0.05$) protective effect on SAI as well as fish, alcohol and meat which seemed to be protective but did not reach statistical significance. Only dairy was found to be significantly ($p < 0.05$) harmful regarding SAI of the total study population. Stratified analysis by group revealed that among GG red meat, fruits, vegetables, olive oil and alcohol were positively associated with SAI ($p < 0.05$) while dairy were found to be harmful on successful aging. Among GA only fruits, legumes and alcohol had a significant positive association with SAI while red meat, poultry and dairy seem to have harmful effect on SAI, but this observation did not reach statistical significance.

of higher intake of antioxidant intake (Capurso et al., 2019; Romanidou et al., 2020). Endothelial aging could also decrease due to greater intake of monounsaturated fat and antioxidants (Marín et al., 2013). A comparison study between the US National Health and Nutrition Survey (NHANES) and the Israeli National Health and Nutrition Survey (MABAT ZAHAV) found physical and cognitive functioning to be significantly higher among people with higher adherence to MD in both studies (Zbeida et al., 2014). Individual nutritional components of MD have also been studied among older adults in relation to various age-related conditions. For example, long-chain omega-3 fatty acid consumption either from fish or fish oil supplements seems to be beneficial on brain health and cognition of older humans (Huhn et al., 2015).

Evaluation of individual food groups comprising the MD showed that only fruit consumption was consistently beneficial for successful aging among both study groups. This finding agrees with the Melbourne Collaborative Cohort Study and a subgroup analysis of the participants being at least 70 years old at follow up that found fruits to be positively associated with successful aging (Hodge et al., 2014). Additionally, the Prospective Urban Rural Epidemiology (PURE) study recruited participants 30 to 70 years old from North America and Europe, South America, the Middle East, south Asia, China, southeast Asia, and Africa and followed them for 7.4 years (Miller et al., 2017). After adjusting for potential confounding factors higher consumption of fruit, vegetable and legume, as well as fruit consumption alone were inversely associated with total mortality, major cardiovascular conditions and death from cardiovascular incidence. Citrus fruits found to be inversely associated with depression among participants of the Mediterranean Healthy Eating, Lifestyle and Aging (MEAL) study (Godos et al., 2018). The same study found a dose-dependent relationship of depressive symptoms with flavanones and anthocyanins, phytonutrients that can be found in fruits.

Dairy consumption was found to be harmful for successful aging among GG and the overall sample. This finding is contrary to previous research suggesting that consumption of dairy products is associated with decreased risk for cardiovascular diseases, hypertension, and colorectal cancer, possible due to the dairy matrix including whey protein, short chain saturated fatty acids and oligopeptides, among others (Godos et al., 2019; Grosso, 2021). A possible explanation of this finding may be that we did not control for fat and sodium content and the type of dairy product i.e. milk, cheese, yogurt with fruits. Fat content of dairy might affect health, due to high content of saturated fat, which may increase the risk for heart disease, type 2 diabetes, and Alzheimer's. The American Heart Association (AHA) recommends choosing fat free or low-fat dairy products to get enough calcium without saturated fat (Van

Horn et al., 2016). The present work found alcohol to be significantly and positively associated with successful aging in both study groups. The participants in our study were consuming approximately one serving of alcoholic drink per day.

Legumes, cereals, fruits, and vegetables were supporting successful aging the most among the evaluated food groups. The health benefits of legumes and cereals are attributed to their various bioactive components. For example, a recent review of in vitro studies focused on the role of resistant proteins and carbohydrates that are present in legumes on human health in relation to prevention of inflammatory disorders, colorectal cancer, and management of type 2 diabetes (Hernáez et al., 2019). Additionally, analysis from a random sub-group of the PREDIMED trial (PREvencion con Dieta Mediterránea) revealed that increased consumption of olive oil, nuts, legumes, and whole grains for one year is associated with improved HDL function among people with high risk for cardiovascular disease (Clemente and Olias, 2017). Furthermore, fruit and vegetable consumption was evaluated in a systematic review in relation to health outcomes showing a possibly decreased risk for developing CVD, colon cancer, depression and pancreatic diseases which could lead to lower levels of successful aging (Angelino et al., 2019).

4.1. Strengths & Limitations

The presented study is innovative because it compares populations of the same origin living in different environments. The majority of migration studies in the literature compares immigrants with the native population of the host country which cannot answer the question of what their health status would be if they never left their home country. Thus, to the best of our knowledge, the presented work is the first to report results on the levels of successful aging from the comparison between older Greek immigrant populations and their Greek counterparts living in Greece. As such, the unique design and population of the present study will help us understand the relationship between successful aging, lifestyle habits and living environment while minimizing the impact of the genetic background on the outcome. However, the results of the current study should be interpreted with caution due to the following limitations. The cross-sectional design could be considered a limitation since the study results cannot provide evidence about causal relationships between the studied factors and outcomes. Finally, successful aging was not evaluated based on cognitive behavior, mobility, and physical function measurements of the participants. Nonetheless, the successful aging index used in the current work has already been validated (Tyrovolas et al., 2014). Future studies should have a larger study group and focus on more than one country, to confirm that the present findings apply to many immigrant populations.

5. Conclusion

Our study showed that GA adhered more to MD, consumed more healthy food groups such as legumes, vegetables, and fruits, and found to have higher levels of successful aging compared to GG. The MD was positively associated with successful aging among both GG and GA. Thus, health professionals should encourage Greeks living in Greece to consume more healthy foods and increase adherence to MD since it seems to be beneficial for successful aging.

Acknowledgments

Authors are grateful to all participants of the MEDIS study, and all the study investigators.

Author's contributions and consent for publication

All authors made considerable contributions in organizing the study and preparing the manuscript. The final manuscript is approved by all authors for publication.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon request.

Declaration of conflicting interests

The authors declare that there is no conflict of interest.

Ethical approval

The study followed the ethical considerations provided by the World Medical Association (52nd WMA General Assembly, Edinburgh, Scotland, October 2000) and all research was conducted according to the World Medical Association Declaration of Helsinki. The study design was approved by the Institutional Ethics Board of Harokopio University (16/19-12-2006), the Human Ethics Committee of La Trobe University (FHEC 11/27), as well as the Institutional Review Board of Rutgers University (Pro20170001777). Participants were informed of the aims and procedures of the study and gave their verbal or written consent prior to being interviewed.

Funding

The MEDIS study was supported by research grants from the Hellenic Heart Foundation, the Graduate Program of the Department of Nutrition and Dietetics, Harokopio University, and Rutgers University, NJ, US.

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