Factors Associated with the Prevalence of Diabetes Mellitus Among Elderly Men and Women Living in Mediterranean Islands: The MEDIS Study

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Abstract

BACKGROUND: The aim of the present work was to evaluate the relationships between socio-demographic, clinical, lifestyle and psychological characteristics and the presence of diabetes mellitus, among elderly individuals without known cardiovascular disease. METHODS: During 2005-2007, 1190 elderly (aged 65 to 100 years) men and women (from Cyprus, Mitilini, Samothraki, Cephalonia, Crete, Lemnos, Corfu and Zakynthos) were enrolled. Socio-demographic, clinical and lifestyle factors were assessed using standard procedures. Diabetes mellitus was defined as fasting blood glucose >125 mg/dl or use of special medication. RESULTS: 21% of males and 23% of females had diabetes. Only 70% of diabetic participants were on a special diet and 76% were receiving pharmaceutical treatment. Diabetic individuals had higher prevalence of hypertension (80% vs. 64%, $p < 0.001$) and hypercholesterolemia (63% vs. 51%, $p < 0.001$) and reported lower physical activity status ($p < 0.001$), compared with non-diabetic participants. After adjusting for various confounders, hypertension and hypercholesterolemia were associated with a 144% (95% CI, 1.37-4.35) and 83% (95% CI, 1.13-2.94) higher likelihood of having diabetes, while moderate and vigorous exercise correlated with a 82% (95% CI, 0.09-0.81) and 67% (95% CI, 0.11-0.97) lower likelihood of diabetes. CONCLUSIONS: A considerable proportion of our elderly sample had diabetes and other metabolic disorders, almost 25% of which were untreated. Promotion of physical activities, even in the elderly, may contribute to reducing their burden of diabetes and provide them with a better quality of living.

Keywords: type 2 diabetes · hypertension · lifestyle intervention · diet · physical activity · elderly · primary care

Introduction

According to the World Health Organization, approximately 150 million people have diabetes mellitus worldwide [1]. This number may double by the year 2025, because of population growth, ageing, unhealthy diets, obesity and sedentary lifestyles. In Greece, Katsilambros *et al.* from the Aegaleo Study group reported that the prevalence of diabetes increased from 2.4% to 3.1% between 1974 and 1990 among middle-aged men and women [2]. More recent results from the ATTICA Study revealed that the prevalence of type 2 diabetes mellitus was 7.6% in middle-aged men and 5.9% in middle-aged women, living in urban and rural areas of the Athens metropolitan region in 2001 [3]. Moreover, the ATTICA

Study investigators reported that the prevalence of diabetes was 25.4% and 31.0% among elderly (i.e. >65 years) males and females living in the above-mentioned area [3]. Previous results from the MEDIS study, where the focus was on an elderly Cypriot population only, indicated that the prevalence of diabetes mellitus was 26% in men and 18% in women [4]. Furthermore, Lionis *et al*. reported in 2001 that diabetes mellitus was prevalent in roughly 27% of the total population aged 65 yr and over, living in a rural community in Crete [5].

In the last few years, several studies have suggested bio-clinical and lifestyle factors to be more or less related to the development of diabetes mellitus [6-8]. Type 2 diabetes has been associated with atherosclerosis and increased risk of cardiovascular disease events, and is also a major cause of blindness, stroke and kidney failure [9]. During the last decade, the results of observational studies suggest that unhealthy diets promote the development of diabetes, not only through changes in body fatness, but also through insulin resistance [10, 11]. In addition, it was observed that physical activity influences several aspects of diabetes, including blood glucose concentrations, insulin action and cardiovascular risk factors [12]. Therefore, some studies suggested that lifestyle modifications such as healthy diet, education, exercise and smoking cessation can minimize the risk of developing diabetic complications [13]. Those dietary patterns in particular that include high consumption of wholegrain products, light to moderate alcohol intake and unsaturated fat may lower the risk for diabetes [14, 15]. The effects of such a diet on cardiovascular disease and on the prevention of cancer are well established. However, little is known about the association between Mediterranean diet and the prevalence of diabetes mellitus at population level and especially in the elderly.

As reported above, the burden of diabetes is much higher in the older population and is associated with more clinical complications than in younger people. However, valid data on the prevalence of type 2 diabetes in the elderly population are sparse in Europe, despite its enormous human and economic burden [9]. Furthermore, the Mediterranean region and Greece in particular have several geographical particularities, one of which is the islands. People living in the Aegean and Ionian Sea, and in Crete, have various cultural traditions that are quite different from those of people living on the mainland. The health status and facilities offered to the inhabitants of these islands have never been explored in the past. Thus, it was interesting to have a more detailed view from older adults in the Greek insular population. This study reports on the prevalence of diabetes and its determinants in a random sample of elderly men and women living in certain Mediterranean islands.

Methods

Participants

The MEDIS (MEDiterranean ISlands) study is a health and nutrition survey which aimed to evaluate bio-clinical, lifestyle, behavioral and dietary characteristics of elderly people living in Mediterranean islands. A random, population-based, multistage sampling method with 3 age groups (65-75, 75-85, >85) and 2 gender levels was used to select men (76 ± 7 yr) and women (74 ± 7 yr), from the Republic of Cyprus and the islands of Mitilini, Samothraki, Cephalonia, Crete, Corfu, Lemnos and Zakynthos in Greece. Individuals residing in assisted-living centers, as well as those with a clinical history of CVD or cancer were not included in the survey. The target sample size was 300 people from Cyprus, and 150 from each of the other islands. Of the people initially selected, 553 men and 637 women (n = 1190) agreed to participate (Cyprus, n = 300; Mitilini, n = 142; Samothraki, n = 100; Cephalonia, n = 115; Crete, n = 131; Corfu, n = 149; Lemnos n = 150; Zakinthos, n = 103). 460 (39%) of these participants were living in rural areas on the islands. The participation rate varied according to island, from 75% to 89%. A group of health scientists (i.e. physicians, dietitians and nurses) with experience in field investigation collected all the required information, using a quantitative questionnaire and standard procedures.

The collected data were confidential, and the study followed the ethical considerations provided by the World Medical Association (52nd WMA General Assembly, Edinburgh, Scotland, October 2000). The Institutional Review Board approved the design, procedures and aims of the study. Before the interviews, participants were informed about the aims and procedures of the study and gave their consent.

Measurements

Diabetes mellitus (type 2) was determined by fasting plasma glucose tests and was analyzed in accordance with the American Diabetes Association diagnostic criteria (i.e. fasting blood glucose levels greater than 125 mg/dl or use of special antidiabetic medication). Participants who had blood pressure levels ≥140/90 mmHg or used antihypertensive medications were classified as hypertensive. Fasting blood lipid levels were also recorded and hypercholesterolemia was defined as total serum cholesterol levels >200 mg/dl or the use of lipid-lowering agents. HDL- and LDL-cholesterol as well as triglycerides were also recorded. Weight and height were measured to obtain body mass index (BMI) scores (in kg/m²). Obesity was defined as BMI > 29.9 kg/m² [16].

The collected information also included basic demographic characteristics, such as age, gender, annual income and lifestyle factors, as well as various bio-clinical characteristics. Current smokers were defined as those who smoked at least one cigarette per day or had stopped cigarette smoking during the past 12 months. Former smokers were defined as those who previously smoked, but had not done so for a year or more. The remaining participants were defined as rare or non-current smokers. Passive smokers were those exposed to environmental tobacco smoke (at the workplace, at home, in restaurants, etc.) for more than 30 minutes per day.

Dietary habits were assessed through a semi-quantitative, validated and reproducible food-frequency questionnaire. The frequency of consumption of various food groups and beverages (i.e. meat and products, fish and seafood, milk and other dairy products, fruits, vegetables, greens and salads, legumes, cereals, coffee and tea and soft-drinks) was assessed on a daily, weekly or monthly basis. Furthermore, intake of various alcoholic beverages (i.e. wine, beer, etc.) was measured in terms of wine glasses adjusted for ethanol intake (e.g. one 100 ml glass of wine was considered to contain 12% ethanol).

To evaluate the level of adherence to the Mediterranean diet, the MedDietScore (possible range 0-55) was used [16]. Scores from 0 to 5 were assigned for the consumption of foods presumed to be close to this pattern (i.e. those for which daily consumption or more than 4 servings per week were recommended). Participants reported no consumption to daily consumption and were scored accordingly. On the other hand, for the consumption of foods presumed not to be part of this diet (like meat and meat products), the opposite scores were assigned (i.e. 0 when a participant reported almost daily consumption increasing to 5 for rare or no consumption). Regarding alcohol intake, 5 was assigned for consumption of less than 3 wineglasses per day, 0 for none or consumption of more than 7 wineglasses per day and scores of 4, 3, 2, and 1 for the consumption of 3, 4-5, 6, and 7 glasses respectively. This classification follows the Mediterranean dietary pattern that suggests an intake of 15-30 g of ethanol per day [16]. Higher values for this diet score indicate greater adherence to the Mediterranean diet.

The level of adherence to the Mediterranean diet was evaluated as the ratio of the mean diet score divided by 55, which gives the total possible achievable score (i.e. MedDietScore / 55 × 100%). Participants were encouraged to report the duration of their dietary habits (i.e. the years for which they had followed this dietary pattern). Physical activity was evaluated using the shortened version of the self-reported International Physical Activity Questionnaire (IPAQ) [17].

Frequency (times per week), duration (minutes per time) and intensity of physical activity during sports, occupation and/or leisure activities were assessed. Participants were classified as inactive, minimally active and HEPA active (health enhancing physical activity, a highly active category). Participants were instructed to report only episodes of activity lasting at least 10 minutes, since this is the minimum required to achieve health benefits. The criteria used were the following:

1. HEPA active when any of the following criteria were met:

    i) vigorous-intensity activity on at least 3 days achieving a minimum of at least 1500 MET-minutes/week, or

    ii) 7 or more days of any combination of walking, moderate-intensity or vigorous-intensity activity achieving a minimum of at least 3000 MET-minutes/week.

2. Minimally active, which is the classification for sufficiently active, when any of the following three criteria were met::

    i) 3 or more days of vigorous activity of at least 20 minutes per day,

    ii) 5 or more days of moderate-intensity activity or walking of at least 30 minutes per day, or

    iii) 5 or more days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving at least 600 MET-min/week.

3. Finally, individuals were classified as inactive when they did not meet any of the criteria which would have placed them in either of the other two categories. As was the case with die-

tary habits, participants were also encouraged to report the duration (in years) of their habitual physical activity.

Assessment of depressive symptoms

Symptoms of depression during the past month were assessed using the validated Greek translation of the shortened, self-report Geriatric Depression Scale (GDS) [18-20]. The following 'yes or no' items were included in the GDS questionnaire: "*Are you basically satisfied with your life? Have you dropped many of your activities and interests? Do you feel that your life is empty? Do you often get bored? Are you in good spirits most of the time? Are you afraid that something bad is going to happen to you? Do you feel happy most of the time? Do you often feel helpless? Do you prefer to stay at home, rather than going out and doing new things? Do you feel you have more problems with memory than most? Do you think it is wonderful to be alive now? Do you feel pretty worthless the way you are now? Do you feel full of energy? Do you feel that your situation is hopeless? Do you think that most people are better off than you are?*" Responses were coded with 1s (for answers that indicate depressive symptoms) and 0s (for answers that do not indicate depressive symptoms) yielding a possible total score between 0 and 15. Higher values indicate more severe depressive symptomatology [18].

Statistical analysis

Continuous variables are presented as mean ± SD, and categorical variables as frequencies. Prevalence was defined as the gender-specific ratio of people with diabetes mellitus to the number of persons in the group. Comparisons of continuous variables between groups were performed using the independent samples t-test (for normal distribution) and the Mann-Whitney U-test (for skewed distribution).

Associations between categorical variables were tested using the Pearson's chi-square test. Stepwise multiple logistic regression analysis evaluated the associations between the various lifestyle, behavioral, and bio-clinical characteristics of the participants in relation to the presence of diabetes.

Results are presented as odds ratios and the corresponding 95% confidence intervals. The variables that remained in the final model were those with p-values <0.1. Age, sex and other potential confounders were also tested in the final model, without altering the results obtained. The Hosmer-Lemeshow statistic was used to test models' goodness-of-fit. All tested hypotheses were 2-sided. A p-value <0.05 was considered to be statistically significant. SPSS version 14 software was used for all calculations (SPSS Inc., Chicago, Il, USA).

Results

The prevalence of diabetes was 21% in males (n = 115) and 23% in females (n = 145) in the overall sample (p = 0.41). When the focus was on very advanced age (i.e. >80 years), prevalence was 19%, both in males and females. Fasting blood glucose levels were 150 ± 49 mg/dl in diabetic and 96 ± 12 mg/dl in non-diabetic participants. Only, 70% of diabetic participants were on a special diet and 76% were receiving pharmaceutical treatment. 10% of the participants used insulin treatment. 80% of the diabetic patients reported compliance with anti-diabetic medications. The percentage of newly detected diabetes (i.e. individuals with fasting blood glucose >125 mg/dl, but unaware of their status) was 3%.

Multi-adjusted analysis showed no associations between compliance with anti-diabetic medication and

Table 1. Socio-demographic, psychological and lifestyle characteristics of the participants, by diabetes status

Parameter	Non-diabetic (n = 930)	Diabetic (n = 260)	All (n = 1190)	p
Age (yr)	74.0 ± 7.1	74.0 ± 6.7		NS
Males (%)	47	44	46	NS
Age category (%)				
65-80 yr	77	23		
> 80 yr	81	19		
Education (yr of school)	5.92 ± 3.3	5.57 ± 2.8	5.85 ± 3.2	NS
Current smokers (%)	14	14	14	NS
Physical activity (%)	38	26	36	<0.001
MedDietScore (0-55)	33.6 ± 4.1	33.5 ± 3.7	33.5 ± 4.0	NS
Depression scale (0-15)	8.2 ± 4.3	8.6 ± 4.2	8.3 ± 4.3	NS
Ethanol consumption (%)*	41	29	38	0.001

Legend: Data are means ± standard deviation or percentages. p-values were derived by comparing diabetic and non-diabetic participants. * >6 g/day. NS: not significant.

various characteristics of the participants, such as age ($p = 0.80$), gender ($p = 0.82$), education ($p = 0.23$) and financial status ($p = 0.70$), as well as living alone ($p = 0.92$). As for the geographical distribution of the prevalence of diabetes, several differences were observed ($p = 0.002$). Specifically, the highest prevalence was observed in Crete (29%), followed by the Aegean Islands where the prevalence was 26%, Cyprus (prevalence 19%) and the Ionian Islands (prevalence 17%). In urban areas, the prevalence appeared to be 24%, while in rural areas it was 19% ($p = 0.05$).

Table 1 describes various socio-demographic and lifestyle characteristics of the investigated sample. It shows that the prevalence of diabetes was higher in people aged 65-80 years than in people >80 years. Moreover, elderly people (i.e. all age categories) with diabetes presented lower rates of physical activity and lower percentages of alcohol consumption compared to the non-diabetic elderly ($p < 0.001$).

Table 2 describes the consumption of various foods or food groups on a weekly basis. Comparisons with the latest dietary recommendations for the adult general population of Greece (stated by the Ministry of Health and Welfare of Greece 1999 [22]), showed that the elderly participants in our study reported lower intakes of meat, fish and sweets (all p-values <0.05). Only 19.7% of non-diabetic and 14% of diabetic subjects drank the recommended amount of alcoholic beverages per day (i.e. 1-2 glasses of wine). The others either drank more or less. Moreover, 75% of the participants reported that they used olive oil in daily cooking. With regards to the other food groups or foods consumed, it was apparent that the study participants were close to (or even better than) the recommended levels of intake.

Table 3 presents anthropometric and bio-clinical characteristics of the study participants. As we can see, participants with diabetes had significant higher BMI ($p < 0.001$), waist and hip circumference ($p < 0.001$) than the non-diabetic subjects. The prevalence of obesity in both study groups was quite high, approximately 40%, but there was a significant difference between diabetic and non-diabetic subjects ($p = 0.004$). The prevalence of hypertension among the elderly diabetic patients was 80% but only 64% in subjects without diabetes ($p < 0.001$). There was also a significant difference in systolic blood pressure levels between non-diabetic and diabetic participants (138 ± 16.9 vs. 141.7 ± 18.0 mmHg, $p < 0.001$).

Finally, the prevalence of hypercholesterolemia (defined as elevated total cholesterol levels or use of special treatment) was much higher in diabetic compared to non-diabetic participants ($p < 0.001$). Diabetic individuals had lower levels of total serum cholesterol and LDL-cholesterol, but higher levels of triglycerides, than non-diabetic participants ($p < 0.001$) (Table 3). These differences in blood lipids may be due to the effectiveness of lipid lowering agents, which are used more frequently by diabetic than be non-diabetic participants.

Table 4 presents factors that affect the presence of diabetes in the participants. After adjusting for age, gender, BMI, MedDietScore, GDS, hypertension, hypercholesterolemia, education level, physical activity and current smoking habits, hypertension was associated with a 144% higher likelihood of having diabetes ($p < 0.05$). Additionally, having hypercholesterolemia was associated with an 83% higher likelihood of having diabetes ($p < 0.05$). Finally, moderate exercise performed 1-2 times/week was associated with a 82% lower likelihood of having diabetes ($p < 0.01$) in relation to high physical activity >5 times/week. Physical exercise performed 3-5 times/week was associated with a 67% lower likelihood of having diabetes ($p < 0.05$) in relation to high physical activity >5 times/week.

Table 2. Food groups and alcoholic beverages consumed by elderly people living in Mediterranean islands in the MEDIS study (by diabetes status)

Food	Dietary recommendations	Non-diabetic	Diabetic
Red or white meat	4-5 servings/wk	2.6 ± 1.0*	2.7 ± 1.0*
Fish	5-6 servings/wk	2.14 ± 1.2*	2.04 ± 1.17*
Non-refined cereals	56 servings/wk	54.7 ± 27.5	56.8 ± 30.4
Legumes	3-4 servings/wk	2.7 ± 1.3*	2.8 ± 1.1*
Fruits	21 servings/wk	33.4 ± 12.4*	36.4 ± 10.5*
Vegetables	42 servings/wk	56.4 ± 37.9*	55.6 ± 36.2*
Potatoes	3 servings/wk	3.0 ± 1.2	2.9 ± 1.2
Olive oil in cooking (%)	Use on daily basis	73	76.2
Sweets	3 servings/wk	1.9 ± 2.0*	1.4 ± 1.7*
Alcoholic beverages (%)	1-2 wineglasses/day	19.7	14.2

Legend: Data are means ± standard deviation or percentages. * $p < 0.001$ for mean values of non-diabetic and diabetic as compared to the recommended dietary intakes.

Table 3. Anthropometric and clinical characteristics of the MEDIS study participants (by diabetes status)

Parameter	Non-diabetic (n = 930)	Diabetic (n = 260)	All (n = 1190)	p
BMI (kg/m²)	28.3 ± 4.7	29.7 ± 5.0	28.6 ± 4.8	<0.001
Obesity (%)	33	42	35	0.004
Waist circumference (cm)	102.0 ± 12.1	107.0 ± 11.3	103.0 ± 12.1	<0.001
Hip circumference (cm)	107.0 ± 12.8	110.0 ± 12.9	108.0 ± 13.0	<0.001
Waist-to-hip ratio	0.95 ± 0.09	0.96 ± 0.11	0.96 ± 0.10	NS
Hypertension (%)	64	80	68	<0.001
Anti-hypertensive agents (%)	97	98	97	NS
SBP (mmHg)	138.0 ± 16.9	142.0 ± 18.0	139.0 ± 17.2	<0.001
DBP (mmHg)	80.0 ± 9.6	79.0 ± 9.1	80.0 ± 9.5	NS
Hypercholesterolemia (%)	51	63	54	<0.001
Lipid-lowering agents (%)	58	71	62	0.004
Total cholesterol (mg/dl)	225.0 ± 44.3	216.0 ± 48.8	223.0 ± 45.5	0.03
LDL-cholesterol (mg/dl)	142.0 ± 37.9	128.0 ± 37.4	139.0 ± 38.2	0.005
Triglycerides (mg/dl)	129.0 ± 60.3	160.0 ± 72.2	137.0 ± 64.8	0.001

Legend: Data are means ± standard deviation or percentages. p-values were derived by comparing diabetic and non-diabetic participants. SBP: systolic blood pressure. DBP: diastolic blood pressure. NS: not significant.

Discussion

This epidemiological survey evaluated the prevalence of type 2 diabetes mellitus in relation to various biological, clinical and lifestyle characteristics among elderly individuals living in Mediterranean islands. Data analysis showed that a considerable proportion of our elderly participants had diabetes, while roughly 2 out of 10 did not take any medication. Also, the elderly diabetic participants had higher BMI, waist and hip circumferences, higher levels of triglycerides and prevalence of hypertension and hypercholesterolemia, but apparently lower concentrations of total and LDL cholesterol (probably as a result of effective medication). Moreover, non-diabetic subjects presented higher levels of physical activity and were more likely to consume moderate alcohol as compared to diabetic participants. Finally, multi-adjusted analysis revealed that the presence of other co-morbidities, i.e. hypertension and hypercholesterolemia, was independently correlated with the likelihood of having of diabetes, while moderate physical activity, 1-2 times/week and often, 3-5 times/week, was associated with a lower prevalence of diabetes.

There are quite a few epidemiological studies that have evaluated the prevalence of diabetes among elderly people. In Greece, the ATTICA study concluded that almost 25% of males and 30% females over 65 years old had diabetes [3]. The Cretan study reported similar results among elderly people (i.e. 28.8% of males and 30.3% females) [5]. A previous report from the Cypriot cohort of the MEDIS study reported that the prevalence of diabetes was 26% in males and 18% in females [4]. In the US population, the prevalence of diabetes among elderly Caucasians was 18%, while in Afro-Americans it was 30% [22]. Furthermore, a survey in Europe reported that the prevalence of diabetes in elderly people appeared to be almost 24% [23], while another survey in an elderly Finnish population reported that prevalence was 22% among males and 28% among females [24]. In a recent meta-analysis by Rathmann *et al.*, the prevalence of diabetes among people aged 60-69 years varied from 11% to 19% in males and 13% to 25% in females in various western European countries [25]. Our analyses revealed that the prevalence of diabetes in our population (i.e. 21% of males and 23% of females) is similar to other westernized countries.

This high incidence of diabetes among elderly persons could be partially explained by the shift towards unhealthy dietary habits during the last decades. Recent studies in European countries in particular have shown strong evidence that the Mediterranean dietary pattern, observed in some Mediterranean countries in the 1950s and 1960s, has changed to a more "westernized" type of diet at all ages [26, 27]. In Greece, where this traditional dietary pattern was first observed after the Second World War, evidence suggests that the eating habits of young, middle-aged and elderly have changed to a more "westernized" pattern [28]. This change is mainly visible in areas of fast urbanization and economic development, where obesity is a major problem [26].

The moderate adherence to the Mediterranean diet (i.e. low mean level of the MedDietScore) observed in our work could be due to a loss of interest in food, chewing difficulties, or difficulties in preparing meals that elderly people often face. Also, financial problems could lead to the decrease in the overall score for this traditional dietary pattern. These changes in eating habits in relation to the high rates of obesity in our sample could partly explain the high prevalence of diabetes, which is quite similar to that in the industrialized world. What makes our study of special interest is that the recruited sample was from a very rare population-base, i.e. insular Greece, which is in many ways far from the industrialized world. In addition, our subjects were free from known cardiovascular disease, cancer or any other chronic disease that could modify their habits. However, in view of the fact that we have excluded people with known cardiovascular disease, the actual prevalence of diabetes in our elderly population might be slightly higher.

Exploratory data analysis revealed that the elderly diabetic participants had higher BMI levels and waist and hip circumferences. Also, the diabetics appear to exercise less than normal elderly. Moreover, other metabolic co-morbidities such as hypertension and hypercholesterolemia were present in people with diabetes. It is important to note that total and LDL cholesterol levels were lower in diabetic patients, a potential effect of the more frequent use of lipid lowering agents. Some studies also confirmed the association between increased BMI and waist circumference and the presence of hypertension, diabetes, incident cardiovascular events and death in the adult population, in both genders and various ethnic groups [29, 30].

Increased visceral adipose tissue is well known to promote insulin resistance, dyslipidemia and hypertension. Higher waist circumference is strongly associated with increased visceral fat [31]. Increased visceral adipose tissue and obesity promote insulin resistance in the liver, adipose tissue and muscles and explain the high triglyceride levels in our sample of diabetic elderly. Increased triglycerides are associated with a higher risk of mortality from CHD [32]. Higher visceral adipose tissue leads to intrahepatic lipid accumulation which has also been reported to be associated with impaired hepatic glucose metabolism [33]. Recent studies have also demonstrated increased intramyocellular lipid levels to be negatively associated with insulin sensitivity [34]. Continuous availability of glucose leads to an increase in triglyceride levels, because of a continuous increase in the intracellular availability of hepatic fatty acids used for triglyceride formation, which results from the inhibition of their oxidation by the high glucose availability [35].

Table 4. Results from stepwise multiple logistic regression performed to evaluate the effect of various bio-clinical, psycho-social and lifestyle characteristics of the participants in relation to the presence of diabetes

Age	Odds rario	95% confidence interval
Initial model		
Age (per 1 year)	1.00	0.97-1.04
Males vs. females	1.48	0.88-2.51
BMI (per 1 kg/m²)	1.00	0.97-1.04
Financial status (high vs. low)	1.48	0.88-2.51
MedDietScore (per 1 unit)	1.00	0.97-1.04
GDS (per 1 unit)	1.48	0.88-2.51
Hypertensive (y/n)	1.00	0.97-1.04
Hypercholesterolemia (y/n)	1.48	0.88-2.51
Education (per 1 year of school)	1.00	0.97-1.04
Physical activity status		
Low vs. none	1.00	0.97-1.04
Moderate vs. none	1.48	0.88-2.51
Vigorous vs. none	1.00	0.97-1.04
Smoking (y/n)	1.48	0.88-2.51
Final model		
Hypertensive (y/n)	1.48	0.88-2.51
Hypercholesterolemia (y/n)	1.00	0.97-1.04
Physical activity status		
Low vs. none	1.00	0.97-1.04
Moderate vs. none	1.48	0.88-2.51
Vigorous vs. none	1.00	0.97-1.04

Legend: BMI: body mass index. GDS: geriatric depression scale. y: yes. n: no.

Regarding the relationship between Mediterranean diet and obesity, some investigators have reported that there is no association between Mediterranean diet and BMI [36]. Other surveys reported that greater adherence to the Mediterranean diet was associated with lower odds of being obese and lower odds of having central obesity compared with a non-Mediterranean diet [37, 38]. The association between obesity, high BMI, waist circumference, diabetes, hypercholesterolemia and triglycerides in combination with the fact that many of the elderly people may be unaware of their condition leads to a higher risk of cardiovascular disease and mortality.

The level of adherence to the Mediterranean diet did not differ considerably between normal and diabetic participants. However, differences between non-diabetic and diabetic participants were observed regarding the food groups consumed and the adherence to the dietary recommendations made by the Ministry of Health and Welfare of Greece (Table 2). Diabetic individuals consumed adequate quantities of fruits and vegetables consistent with the recommended quantities, but they ate lower quantities of fish, legumes and meat and its products (Table 2).

Multi-adjusted analysis revealed that hypertension was associated with a 144% higher likelihood of having diabetes. Additionally, having hypercholesterolemia was associated with an 83% higher likelihood of having diabetes. This association between hypertension and diabetes confirm results of other investigators [39]. Endothelial dysfunction could be one of the common pathophysiological pathways explaining the strong association between hypertension and incidence of type 2 diabetes. Several studies have shown that markers of endothelial dysfunction are associated with new-onset diabetes [40], and endothelial dysfunction is closely related to hypertension [41]. In addition, C-reactive protein has been consistently related to the incidence of type 2 diabetes [42] and to increasing blood pressure levels [43], suggesting that inflammation might be another explanatory factor for the association between blood pressure, the metabolic syndrome and type 2 diabetes. Insulin resistance, which exists in diabetes, is linked to high cholesterol synthesis and decreased cholesterol absorption [44].

Moderate exercise 1-2 times/week was associated with a lower likelihood of having diabetes compared with physical inactivity. Exercise 3-5 times/week was associated with a much lower likelihood of diabetes. Studies relating to the effect of physical activity on the prevalence of diabetes among elderly people are infrequent in the literature. In one study, it was found that the prevalence of diabetes was 19% in men and 9% in women, while sport activity was negatively and independently associated with the prevalence of the disease [45]. In the U.S. as well, the prevalence of diabetes is increasing while less than 40% of adults with diabetes reported being regularly engaged in moderate or vigorous physical activity [46]. Additionally, it has been reported that there is an association between physical inactivity and glucose intolerance in older adults similar to that found in middle-aged adults [47]. Earlier results from the MEDIs study (especially the Cyprus cohort) appeared to indicate that participants who reported moderate physical activity had a 0.4 lower likelihood of having diabetes as compared to sedentary subjects, while people who reported vigorous physical activity had a 0.16 lower likelihood of being diabetic [4].

The assumed mechanism by which exercise improves glucose intolerance and diabetes is an increase in insulin sensitivity in muscles [48]. Moreover, physical activity seems to be adequate for protection of cardiovascular diseases in the diabetic elderly population [46]. Finally, international organizations have recommended that individuals with type 2 diabetes should strive to achieve a minimum of 1000 Kcal/week from physical activities. This should be performed at a moderate intensity level (40-70% VO_2max), 3-5 days/week, at a minimum accumulation of 30 minutes/day [49].

The present study has several strengths. It is one of the first to evaluate a large sample of "healthy", free-living elderly people in the Mediterranean islands. Therefore, the evaluation of the health status of these people, and the assessment of factors that may have influenced it, deserves special attention. The limitation of the study is mainly caused by its cross-sectional design. The findings may be influenced by a potential recall bias, particularly in the assessment of dietary habits and physical activity status.

Conclusions

The prevalence of diabetes is high in the elderly Greek, insular population. In the present study, this high prevalence was accompanied by a higher incidence of hypercholesterolemia, hypertension, excess weight and physical inactivity. The findings presented raised some concerns about the measures that need to be taken for health promotion among the elderly population, which has a clear impact on primary health care practitioners in Greece. These measures need to focus primarily on dietary and lifestyle modifications, as well as on compliance with medication among the elderly individuals living in these islands.

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