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Original article

Does mediterranean diet correlate with cognitive performance among elderly? A cross-sectional study from Cyprus

Nezire Ince[1], *Pınar Gelener*[2], *Halit Tanju Besler*[1]

[1] Eastern Mediterranean University, Faculty of health Sciences, Department of Nutrition and Dietetic [2] University of Kyrenia, Faculty of Medicine, Neurology Department; Near East University of Medicine, Department of Neurology - E-mail: nezireince@hotmail.com;

Summary. *Purpose:* Today, the importance of the Mediterranean Diet is emphasized due to its beneficial effects on chronic and neurodegenerative diseases, which represent a serious health problem affecting an increasing number of elderly people. Our objective was to investigate whether MeDi influences cognitive functions in the elderly. *Methods:* 541 participants over 50 years of age were selected by "Stratified random sampling" method. Adherence to a Mediterranean Diet was measured using MeDi Adherence Screener. Neuropsychological tests were evaluated by Mini Mental State Examination (MMSE) and Subjective Cognitive Complaints Scale (SCC). Anthropometric measurements like body analysis, handgrip strength, waist and mid-upper arm circumference were also assessed. *Results:* Out of 541 participants, 25.3% had high, 68.4% had medium and 6.3% had low adherence to MeDi. The MMSE scores showed that 79% of the participants were normal, 20% had mild dementia and 1% had severe dementia. The SCC showed that 42% had good, 52% had moderate and 6% had poor subject memory. A weak and positive correlation was found between higher MeDi scores and higher MMSE scores. This correlation was particularly observed in attention-calculation, language and recall. There was a positive correlation between the consumption of canned tuna fish, legumes, dark green leafy vegetables, olives, olive oil and MMSE scores. Additionally age, right hand grip strength and Adherence to MeDi scores were significantly predictors of MMSE scores ($p<0.05$). *Conclusion:* In this study, higher adherence to MEDi is correlated with better cognitive functions. In addition to these results, right hand grip strength, which is an objective measure for frailty, is also correlated with MMSE scores.

Keywords: Mediterranean Diet, Nutrition, Cognitive performance

Introduction

Today, the importance of the Mediterranean Diet is emphasized due to its beneficial effects on chronic and neurodegenerative diseases, which represent a serious health problem affecting an increasing number of elderly people (1,2).

There is growing evidence in epidemiologic studies and randomized controlled trials suggesting that adherence to a Mediterranean Diet (MeDi) may be protective against chronic diseases, particularly on cardiovascular diseases and dementia (3).

The Mediterranean Diet is an antioxidant-rich dietary pattern which includes high consumption of unrefined cereals, fruit, vegetables, legumes and olive oil, moderate consumption of dairy products and alcohol and low meat consumption. The primary source of fat is the monounsaturated fatty acids in the form of olive oil (4,5).

Bioactive constituents, including dietary phenolic compounds, have antioxidant activity which reduces tau aggregation and neuroinflammation and interacts with intracellular signaling pathways (6). Oxidative stress and inflammation in particular have a significant effect on cognitive decline and brain ageing (7). Due to the high content of fruits, vegetables and olive oil, MeDi reduces oxidative stress and lipid peroxidation, which may lead to DNA damage

and neuronal death. Tocopherols and polyphenols are the antioxidant compounds of olive oil (8). Another mechanism is the anti-inflammatory effect via from fish and olive oil (3,9). Furthermore the MeDi provides a combination of vitamins E, B_6, B_{12}, folate, carotenoids, which are the other dietary antioxidants which exhibit synergitic neuroprotection against frontal and subcortical systems via memory tasks (8). Also, MeDi has been shown to decrease vascular risk factors, which decreases the risk of dementia (3).

Another possible mechanism is that MeDi increases neurotropic factors, neurotransmission, synaptic plasticity and leads to the elimination of beta amyloid from the brain (10).

Although the causes of dementia and cognitive decline in the elderly are multifactorial, research on modifiable risk factors like MeDi, physical activity and physical strength are important (11). In addition to these modifiable risk factors, frailty, which is a clinical syndrome characterised by an age-related decrease in physical functioning, is associated with cognitive decline, low physical activity, poor muscle strength and low adherence to MeDi (12).

The aim of this study was to investigate the relationship between adherence to a Mediterranean Diet and cognitive functions among elderly people living in North Cyprus.

Methods

Study Population and Design

The study population consisted of 541 male and female Turkish Cypriots aged 50 and over (mean age 60.42±8.71). Eligible participants were selected by stratified random sampling method from different cities (Nicosia, Famagusta, Kyrenia, Guzelyurt, Iskele) in North Cyprus between the years 2016-2017.

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures were approved by the Eastern Mediterranean University Scientific Research and Publication Ethics Committee (project number: ETK00-2016-0042). Written informed consent was obtained from all subjects.

Participants were face to face interviewed at home by a specifically trained dietician. Exclusion criteria included any type of diagnosed dementia, also conditions that cause any kind of cognitive impairement such as psychiatric condition, brain injury and using medications known to influence cognition.

The study questionnaire is divided into four sections that cover; general information, Mini Mental State Examination (MMSE) (13), Quantitative Food Frequency Questionnaire (QFFQ) and Mediterranean Diet Adherence Screener (MEDAS) (14).

Assesment of adherence to a Mediterranean Diet

Adherence to a Mediterranean Diet is measured using the validated 14-point Mediterranean Diet Adherence Screener. MEDAS consists of 14 questions, 12 of them was designed to evaluate the frequency of major ingredients of MeDi (olive oil, vegetables, fresh fruits, legumes, fish, nuts) and two items that were related to eating habits (primary oil and meat choice). Zero or one point was assigned to each of the 14 items, one point was given for using olive oil as the principal source of fat for cooking, preferring white meat over red meat, or for consuming: a) four or more tablespoons (1 tablespoon = 10 gram) of olive oil (including that used in frying, salads, meals eaten away from home, etc.); b) two or more servings of vegetables/day; c) three or more pieces of fruit/day (1 piece = 100 gram); d) < 1 serving of red meat or sausages/ day (1 serving = 90 gram); e) < 1 serving of animal fat/day (1 serving = 12 gram); f) < 1 cup (1 cup = 200 mL) of sugar-sweetened beverages/day; g) seven or more servings of red wine/week; h) three or more servings of legumes/week (1 serving = 150gram); i) three or more servings of fish/week (1 serving= 100g); j) fewer than two commercial pastries/ week; k) three or more servings of nuts/week (1 serving = 30gram); or l) two or more servings/week of a dish with a traditional sauce of tomatoes, garlic, onion, or leeks sautéed in olive oil. If the condition was not met, 0 points were recorded for the category. As a result, total MEDAS score could range from 0 to 14 points and was classified as Low (≤ 7points), Moderate (8-9 points) and High (≥ 10 points) Degree of Adherence.

Quantitative Food Frequency Questionnaire (QFFQ)

Dietary information was assessed by the validated quantitative food frequency questionnaire almost every season to consider seasonal differences. The number of servings per frequency was expressed in natural units (for example, slice of bread), household measures (for example, cup or spoon) or grams (cooked vegetables or meat). Pictures of foods were also shown to participants along with common household measuring tools to help participants estimate portion sizes. For all foods, the amount reported by the trained dietician and then was multiplied by the frequency variable to obtain the amount of consumed food item per day (in grams or mL). Frequency of consumption categories considered were: no consumption, once a month, two times per month, once or twice a week, three to four times per week, five to six times per week, every day and every meal. This questionnaire consists of minimum of 130 foods that belong to 5 food groups; milk and dairy products, meat-egg-legumes, fruits and vegetables, bread and cereals and fats-sugar-desserts-beverages. In Table 4, only the foods that are related to the Mediterranean Diet are represented.

Anthropometric Measurements

Among the anthropometric measurements; body weight (BW), body fat percentage and total body water were evaluated by using the Tanita TBF 300 scale to the nearest 0.1 kg without shoes and 0.5-1 kg deducted for clothes. Body Height (BH) while standing against a wall without shoes, waist and mid-upper arm circumference were measured by plastic measuring tape to the nearest 0.1 cm. Finally, hand grip strength was measured using a Takei hand dynamometer. Body mass index (BMI) was calculated as BW/BH2. The test was repeated three times and a mean value was calculated. All measurements were taken by the same trained dietician.

Physical Activity Level

Physical activity level was determined by recording 24-hour physical activity. Mean MET values based on specific activities within corresponding categories were used. Physical activity levels (MET×h) for specific activities were estimated by multiplying reported time (h) by MET (kcal/kg×h). Participants were categorised according to Physical Activity Levels as follows; Sedentary-Low Active (PAL: 1.40-1.69), Moderate Active (PAL: 1.70-1.99) and High Active (PAL: 2.00-2.40).

Cognitive Functions

The Turkish validated version of Mini Mental State Examination (MMSE) (15) was used as a cognitive screening tool, which is a standardised test assesing global cognitive functions. It measures orientation, attention, calculation, recall and language. The cut-point for cognitive function was as follows: 24-30 points: normal range, 23-18: mild dementia,17-0: severe dementia.

Subjective memory complaints were also investigated. The Subjective Cognitive Complaints Scale (SCCs) was used to assess subjective memory problems and forgetfulness. The scores were categorised as follows: 0: no symptoms (good subjective memory), 1-3: low symptoms (moderate subjective memory), 4-6: high symptoms (poor subjective memory).

All cognitive tests were performed and evaluated by trained neurologists.

Statistical Analysis

All statistical analysis was performed using Statistical Package for Social Sciences (SPSS) 21.0.

Descriptive statistics were used for the evaluation of the MMSE, SCCs and Adherence to MeDi scores.

Data was tested for normal distribution using the Kolmogorov-Smirnov, Q-Q plot and skewness-kurtosis tests. As the data showed normal distribution, parametric tests were used.

In order to determine the correlation between the MMSE, SCCs and Adherence to Mediterranean Diet scores, the Pearson correlation coefficient was used.

To test for any independent associations between both demographic-anthropometric factors and MMSE scores, Multivariate analyses were conducted using hierarchical regression, where age, BMI, Mid-Upper Arm Circumference, handgrip strength and physical activity were treated as the main predictors of MMSE scores and adjusted for socio demographic factors. All models were performed by multivariate linear regression. All statistically significant differences were set at $p<0.05$.

Results

The study population consisted of 541 participants (377 female, 164 male) aged over 50 years. The mean age was 60.42±8.71 years. None of the participants had been diagnosed with dementia. The general characteristics of the participants have been displayed in Table 1.

According to the MeDi scores; 25.3%, 68.4% and 6.3% of participants showed high, medium and low adherence to MeDi respectively (Fig.2).

The MMSE scores showed that 79% of the participants were in the normal range (MMSE score >24 points), 20% had mild dementia (MMSE 18-23 points) and 1% had severe dementia (MMSE score ≤17 points) (Fig.1a).

Out of 541 participants, 42% of them had no symptoms (good subject memory), 52% had moderate symptoms (moderate subject memory) and 6% had high symptoms (poor subject memory) according to the Subjective Cognitive Complaint scale (Fig.1b).

When we compared the correlation between the MMSE scores and MeDi, a weak and positive correlation was found between higher MeDi scores and higher MMSE scores. This correlation was particularly in attention-calculation, language and recall ($p<0.05$) (Table 2). Also, a weak and negative correlation was found between higher MeDi scores and SCCs scores ($p<0.05$) (Table 2).

The results of the hierarchical regression analyses are given in Table 3, where age, BMI, Mid-Upper Arm Circumference, handgrip strength and physical activity are treated as the main predictors of MMSE scores. According to Table 3, age ($\beta=-0.24$, $p<0.05$), right hand grip strength ($\beta=0.18$, $p<0.05$) and Adherence to Mediterranean Diet scores ($\beta=0.09$, $p<0.05$) were significant predictors of Mini Mental State scores. Resultantly, a one unit rise in age causes a 0.24 unit decrease in MMSE scores, while a one unit rise in right hand grip strength causes a 0.18 unit rise in MMSE scores and a one unit rise in the MeDi adherence score increases the MMSE scores by 0.09. Furthermore, BMI, mid-upper arm circumference, left hand grip strength and physical activity were not significant predictors of the Mini Mental State scores ($p>0.05$).

Table 1. Socio-Demographic and Health Characteristics of Participants (n=541)

Characteristics	Number (n)	Percentage (%) p<0.05
Age (Group)		
50-54 years	146	26.99
55-59 years	116	21.44
60-64 years	111	20.52
65 years and over	168	31.05
Gender		
Male	164	30.31
Female	377	69.69
Education		
None	34	6.28
Primary School	202	37.34
Completed high school	170	31.42
University and Postgraduate	135	24.95
Marital Status		
Married	468	86.51
Single or divorced	73	13.49
Work Status		
Working	160	29.57
Not working	381	70.43
Cigarette Smoking		
None	286	52.87
Ex-smoker	158	29.21
Current Smoker	97	17.93
Physical Activity Level		
Sedentary or Low Active	503	93.00
Moderate Active	33	6.00
High Active	5	1.00
Health Status		
Have at least one chronic disease	245	45.29
Healthy	296	54.71
Diseases (n=245)		
Hypertension	176	71.84
Diabetes	67	27.35
Cholesterol	56	22.86
Thyroid	52	21.22
Cardiovascular	37	15.10
Renal	2	0.82

Besides the Mediterranean dietary pattern as a whole, the consumption of different food groups were also investigated and correlated with the

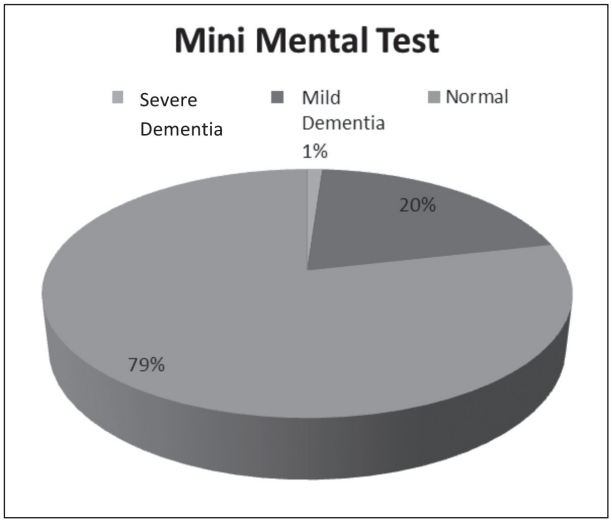

Figure 1a. The distribution of MMSE Scores

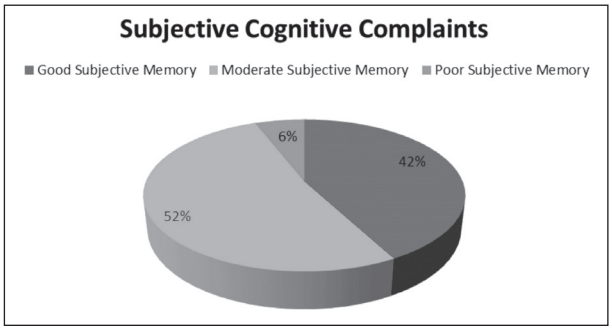

Figure 1b. The distribution of SCC Scores

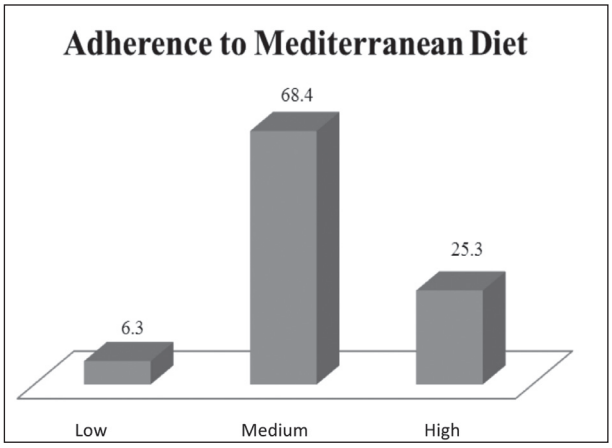

Figure 2. The Adherence to MeDi

MMSE scores. There was a positive correlation between the consumption of canned tuna fish (r:0.09, p:0.03), legumes (r:0.12, p:0.00), dark green leafy vegetables (r:0.20, p:0.00), olives (r:0.13, p:0.00) and olive oil (r:0.09, p:0.03) and MMSE scores. No correlation was found between fish (r:0.05, p:0.22) and nut (r:0.06, p:0.18) consumption and MMSE scores (Table 4).

Table 2. Correlation between mini mental test score, subjective cognitive complaints and adherence to Mediterranean Diet (n:541)

		Subjective Cognitive Complaints	Adherence to Mediterranean Diet
Orientation	r	-0.09	0.01
	p	0.04*	0.79
Registration	r	-	-
	p	-	-
Attention and Calculation	r	-0.16	0.09
	p	0.00*	0.03*
Recall	r	-0.05	0.08
	p	0.26	0.05*
Language	r	-0.12	0.10
	p	0.00*	0.02*
Mini Mental Test Total Score	r	-0.17	0.11
	p	0.00*	0.01*

**p<0.05*

Discussion

Numerous studies suggested that adherence to the MeDi is associated with improved cognitive performance and can be protective against dementia and Alzheimer's disease.

Studies published in the Mediterranean region, show encouraging results in relation to cognitive functions (1,7, 16). This study was the first and largest study that was held among elderly population in North Cyprus and its results are consistent with the literature.

Our findings suggest that there was a positive correlation between higher MeDi scores and higher MMSE scores. This correlation was particularly in attention-calculation, language and recall ($p<0.05$) (Table 2). Also, a negative correlation was found between higher MeDi scores and SCCs scores ($p<0.05$).

The protective effect of MeDi was also supported by the review of Aridi et al. and Hardman et al. that investigate the association between MeDi and cognition (9,16). Similar results were also found in two dif-

Table 3. Hierarchical regression model to predict MMSE Score according to age, BMI, physical activity, adherence to Mediterranean Diet score

Model	Estimates	Unstandardized coefficients		Standardized coefficients	t	p
		B	Std. Error	Beta		
Model 1	(Constant)	31.95	0.93		34.30	0.00*
	Age	-0.10	0.02	-0.28	-6.68	0.00*
Model 2	(Constant)	29.46	1.07		27.61	0.00*
	Age	-0.09	0.02	-0.24	-5.73	0.00*
	Right hand grip strength	0.06	0.01	0.19	4.51	0.00*
Model 3**	(Constant)	28.37	1.21		23.36	0.00*
	Age	-0.09	0.02	-0.24	-5.68	0.00*
	Right hand grip strength	0.06	0.01	0.18	4.40	0.00*
	Adherence to MeDi	0.13	0.06	0.09	2.09	0.04*

**p<0.05; ** R^2=0.12*

ferent large-scaled cohort studies, which indicated that the Mediterranean Diet is protective against dementia and decreases the risk of Mild Cognitive Impairment (MCI) and Alzheimer's disease (AD) (17,18).

According to one systematic review and meta-analysis, subjects in the highest MeDi score tertile had 33% less risk of cognitive impairment (MCI or AD) in comparison to the lowest tertile (19). In a similar way, the results of another study suggested that individuals with medium and high adherence to MeDi had a 15 to 21% and 39 to 40% reduction in Alzheimer's disease risk, respectively. Additionally, for every one-unit rise in the participants' MeDi adherence score, the risk of developing MCI decreased by 8% (2).

In the HELIAD study conducted in Greece, adherence to MeDi was associated with a decrease in dementia and better cognitive performances in language, visuospatial perception and particularly in memory. Additionally, in the same study, each unit increase in Mediterranean dietary score was associated with a 10% decrease in the odds for dementia (20).

Our finding is also consistent with these results. According to the result of our study; one unit rise in the MeDi adherence score increases the MMSE scores by 0.09.

Additionally, prospective studies investigating the relationship between MeDi, cognitive performance and the risk of dementia and also in the review of Roy J Hardman et al., high adherence to MeDi was found to be associated with slower cognitive decline. As a result, the risk for dementia, mainly AD, and conversion from MCI to AD were reduced (1,5, 21).

The results of many studies support that the Mediterranean Diet might be protective against cognitive decline as it comprises several foods and nutrients that are shown to be protective against cognitive dysfunction or dementia, such as fish (n:3 PUFA), olive oil (MUFA), fruits and vegetables, nuts and seeds (PUFA), folate, polyphenols and antioxidants (vitamin E, vitamin C, carotenoids, flavonoids) (1,21,22).

Besides the adherence to MeDi, our study also investigate the correlation between dietary components such as fish, vegetables, dairy products, olive oil consumptions and MMSE scores. It was found that there was positive correlation between the consumption of canned tuna fish (r:0.09, p:0.03), legumes (r:0.12, p:0.00), dark green leafy vegetables (r:0.20, p:0.00), olives (r:0.13, p:0.00) and olive oil (r:0.09, p:0.03) and MMSE scores. No correlation was found between fish (r:0.05, p:0.22) and nut (r:0.06, p:0.18) consumption and MMSE scores (Table 4).

Olive oil is one of the major components of MeDi. In a prospective, 4-year follow up Three-City Study conducted in France, a weak association was described between increased olive oil intake which and the risk of cognitive decline. However in an Italian Longitudinal Study on Aging involving an 8 year follow up, greater intake of monounsaturated fatty acids, mainly olive oil, was found to be related to better cognitive functions (23,24). Additionally, in a RCT by Martin-

Table 4. The correlation between Mediterranean Diet related food consumption, MMSE Scores and SCC Scores (n=541)

		MMSE Scores	SCC Scores
Fresh Fish	r	0.05	-0.03
	p	0.22	0.51
Canned Tuna	r	0.09	0.05
	p	0.03*	0.26
Legumes	r	0.12	-0.01
	p	0.00*	0.90
Nuts	r	0.06	0.02
	p	0.18	0.59
Dark Green Leafy Vegetables	r	0.20	-0.09
	p	0.00*	0.03
Fresh Fruits	r	-0.01	-0.02
	p	0.81	0.59
Olive	r	0.13	-0.09
	p	0.00*	0.04*
Olive Oil	r	0.09	-0.04
	p	0.03*	0.34

ez Lapiscina et al, MeDi supplemented with EVOO or mixed nuts (1 lt/week EVOO or 30 g/day mixed nuts) showed better cognitive performance versus control in all cognitive domains, particularly fluency and memory tasks (25).

Legume consumption of participants was also found to be correlated with MMSE scores in our study. In a recent study consisting of 214 elderly people aged 65 years and over, a positive association was found between MMSE scores and the participants' legume consumption one year after the start of the investigation (26).

Fish consumption, which is one of the main elements of MeDi and a good source for EPA and DHA (n:3 PUFA), was found to be the only predictor of dementia in Anastasiu et al.'s study. Fish consumption was negatively associated with dementia (20). In parallel to our study, according to the Women's Health study by Kim et al., consumption of tuna and dark meat fish once a week or higher was found to be associated with a lower decline in verbal memory, although total seafood consumption was not related with changes in global cognition over a 4-year period (27).

Leafy vegetables are also a good source of folate and B vitamins, which are effective for reducing homocysteine levels that are a risk factor for age-related cognitive decline (21). According to the result of our study, green leafy vegetables were correlated with MMSE scores. In the prospective study held by Morris et.al; it was shown that green leafy vegetables help to slow cognitive decline with ageing (28).

In our research, handgrip strength was also found to be associated with MMSE scores. Handgrip strength is easy and safe to evaluate in the elderly and is used as a measure of whole-body muscular strength. It is a proxy tool for the assessment of nutritional status, physical functions and frailty (29). Accumulating evidence suggests that higher levels of physical function are associated with better cognitive abilities. According to the study of Jang and Kim, greater handgrip strength was found to be associated with higher cognitive function in cognitively normal elderly Korean subjects (30).Similarly, from the population-based longitudinal Swedish Adoption/Twin Study of Aging, grip strength performance was associated with a positive change in the four cognitive abilities after 65 years of age (Verbal ability, Spatial ability, Processing speed, Memory) (31).

Conclusion

Our data suggests that MeDi is correlated with better cognitive functions based on the MMSE scores, particularly in the attention-calculation, language and recall domains in the elderly population living in North Cyprus. This correlation was also significant among the diet components olives, olive oil, green leafy vegetables and legumes.

Another important outcome was the significant positive correlation between cognitive functions and right hand grip strength test, which is an objective predictor of frailty and physical strength.

Among the lifestyle-related modifiable risk factors, optimising dietary behaviour is crucial to prevent or delay cognitive decline that is associated with normal aging and frailty. Due to the increasingly aging world population, we believe that increasing scientific and public recognition on the beneficial effects of MeDi is important and deserves further attention.

All the authors declared that "there is no conflict of interest".

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Correspondence:
Nezire Ince
Eastern Mediterranean University, Faculty of health Sciences, Department of Nutrition and Dietetic
Famagusta, Cyprus
Phone 00903926301084 - 00903926301081
E-mail: nezireince@hotmail.com / nezire.ince@emu.edu.tr