Atherosclerosis xxx (2011) xxx–xxx

Contents lists available at ScienceDirect

Atherosclerosis

journal homepage: www.elsevier.com/locate/atherosclerosis

Very high childhood obesity prevalence and low adherence rates to the Mediterranean diet in Greek children: The GRECO study

Paul Farajian[a], Grigoris Risvas[a], Konstantina Karasouli[a], Georgios D. Pounis[a], Christina M. Kastorini[b], Demosthenes B. Panagiotakos[b], Antonis Zampelas[a,*]

[a] Unit of Human Nutrition, Department of Food Science and Technology, Agricultural University of Athens, Iera Odos 75, 11855 Athens, Greece
[b] Department of Science of Dietetics - Nutrition, Harokopio University, El. Venizelou 70, 17671 Athens, Greece

ARTICLE INFO

Article history:
Received 3 November 2010
Received in revised form 8 March 2011
Accepted 4 April 2011
Available online xxx

Keywords:
Children
Obesity
Greece
Mediterranean diet
Underweight
Risk factor

ABSTRACT

Objective: In order to provide estimates of overweight and obesity among Greek schoolchildren, and the adherence rates to the Mediterranean diet (MD), a nationwide survey was performed among fifth and sixth grade students aged 10–12 years old.
Methods: A stratified sampling in 10 regions of the country was applied to voluntarily enroll a representative sample of 4786 children. Children were weighed and measured and completed a semi-quantitative food frequency questionnaire with a supplementary section for the assessment of dietary aspects and physical activity levels. Additionally, the KIDMED index was used to evaluate the degree of adherence to the MD.
Results: According to the IOTF cut-offs, overweight (OW) and obesity (OB) prevalence among boys was 29.9% and 12.9%, while in girls 29.2% and 10.6%, respectively. Only 4.3% of the children had an optimal KIDMED score. KIDMED score did not differ between boys and girls and no differences were detected between normal weight and OW and OB children. However, children from semi-urban or rural regions had higher score. Furthermore, children with higher KIDMED score reported following a healthier diet and having higher physical activity levels.
Conclusion: The prevalence of childhood obesity in Greece is the highest ever reported together with low adherence rates to the dietary patterns of the MD. Current findings suggest an increased risk for even higher rates of obesity in adolescence and adulthood in the near future. Taking into account that children are also abandoning the traditional cardio-protective MD, the increased risk for future adverse health consequences seems evident.

1. Introduction

Several studies have focused on the short-term and long-term consequences of childhood obesity, and high body mass index (BMI) levels have consistently been found to be associated with cardiovascular disease risk factors such as insulin resistance, dyslipidemia, and increased blood pressure [1]. An important criterion of the validity of childhood BMI is its relation to adult obesity, and almost all longitudinal studies have found that children with high BMI levels are more likely to become obese adults than are thinner children [2,3]. Due to the tracking of BMI from childhood to adulthood, there is strong evidence that childhood obesity is associated with adult cardiovascular disease risk. In addition, it has been suggested that being underweight during childhood and overweight in adulthood also increases the risk for raised blood pressure during adulthood [4].

According to data from previous European cross-sectional and epidemiological studies, childhood obesity is an escalating health problem particularly in countries surrounding the Mediterranean sea that show very high overweight (OW) and obesity (OB) prevalence rates [5]. Since the early 1960s when the first results of the Seven Countries Study established that the traditional Mediterranean dietary pattern, as followed in Crete, was associated with lower ischemic heart disease [6], several studies have demonstrated that greater adherence to the Mediterranean diet is associated with a significant reduction in total mortality, improvement in longevity and lower incidence of atherosclerosis, coronary heart disease, metabolic syndrome and inflammation [7–9]. Yet, the fact that surveys conducted at local or regional level in Greece have noted that childhood obesity rates are among the highest in Europe [5,10], seems to go against the conventional belief of the population in Greece and the rest of the Mediterranean regions that since the

* Corresponding author. Tel.: +30 2105294701; fax: +30 2105294945.
E-mail address: azampelas@aua.gr (A. Zampelas).

0021-9150/$ – see front matter © 2011 Published by Elsevier Ireland Ltd.
doi:10.1016/j.atherosclerosis.2011.04.003

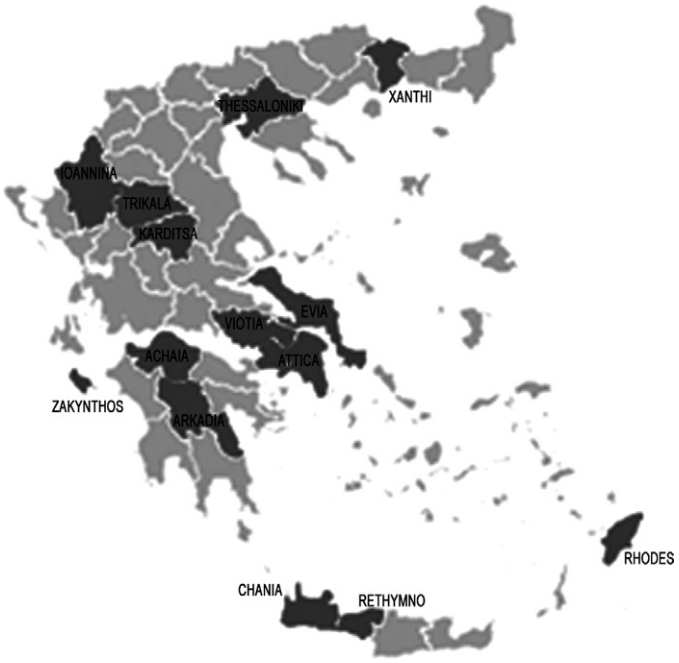

Fig. 1. The prefectures in Greece included in the study.

Mediterranean diet is healthy it should also protect against OW and OB. In fact, there are evidence that the adult and children Mediterranean population are gradually abandoning the traditional dietary pattern [11]. However data on how this nutrition transition affects OW and OB rates are scarce and it is not clear whether the adherence to the Mediterranean diet has any protective effect on the childhood obesity problem.

The aim of the present paper from the Greek Childhood Obesity (GRECO) study was to provide current national data on overweight and obesity prevalence in preadolescent schoolchildren (aged 10–12 years old) in Greece and, additionally, to evaluate the quality of children's diet by assessing the degree of adherence to the Mediterranean diet and its association with the obesity rates.

2. Methods and procedures

2.1. Sampling procedure

The study was carried out from October to May 2009. A stratified sampling scheme by age and sex group, based on the population distribution (National Statistical Services, 2001 census), in 10 regions of the whole country (i.e., Attica, Macedonia, Peloponnisos, Sterea Ellada & Evia, Ipeiros, Thessalia, Thrace, Aegean islands, Ionian islands and Crete) was used to obtain a representative sample of 5000 children. The number of children had been pre-specified using statistical power calculations in order to achieve a 85% power at 5% type I error when evaluating odds ratios equal to 1.10. Thus, using also the official catalogues provided by the regional directorates of primary education, a total of 4786 fifth and sixth grade schoolchildren with a mean age of 10.9 ± 0.75 years old (49.3% males and 50.7% females) were finally voluntarily enrolled (participation rate 95%). The number of schools that agreed to participate in the study was 117 from all over the country (10 regions and 14 prefectures) (Fig. 1). The prefectures were grouped based on their population in "Large urban areas" with a population size greater than 1,000,000; "Urban and Semi-urban Areas" with a population size ranging from 10,000 to 100,000 inhabitants. Finally, 52.0% and 48.0% of the sample came from large urban and urban and semi-urban areas, respectively.

The research and all the means used in the study were approved by the Hellenic Ministry of Education (Department of Primary Education) as the law provides in Greece for any studies conducted in the school environment during formal school hours, and the Agricultural University of Athens Research Committee.

2.2. Anthropometry and obesity and underweight definition

The measurements were conducted by investigators and stuff of the Unit of Human Nutrition of the Agricultural University of Athens. Investigators followed a series of planning meetings and were trained in survey methods during training sessions that included practical experience in weighing and measuring techniques. All study sites used the same measuring equipment and procedures and in each class the investigators' team consisted of at least two people.

All measurements were performed during morning hours. Body weight was recorded to the nearest 100 g with the use of a digital scale (Tanita TBF 300) and with subjects standing without shoes in light clothing. Standing height was measured using a portable stadiometer (Leicester height-measure) to the nearest 0.1 cm without shoes, with the head positioned according to the Frankfort plane. Body mass index (BMI) was calculated by dividing weight (kg) by standing height squared (m^2). Waist and hip circumferences were measured to the nearest 0.1 cm with the use of a non-elastic tape (Seca, Germany) and with the subject at a standing position. Waist circumference was measured at the end of a gentle expiration after placing the measuring tape in a horizontal plane around the trunk, at the midway between the lower rib margin and the iliac crest. Hip circumference was measured at the point yielding the maximum circumference over the buttocks. Waist to hip (W/Hp) and waist to height (W/Ht) ratios were also calculated. Percentage of body fat (%BF) and body fat mass were estimated by the foot to foot impendence method (Tanita TBF 300) with children standing barefoot.

Obesity and overweight among children were evaluated using the IOTF (International Obesity Task Force) age- and gender-specific body mass index (BMI) cut-off criteria [12]. Underweight for children was defined using the international cut-off points for BMI for thinness grades 1, 2 and 3 by gender defined to pass through BMI of 16, 17 and 18.5 respectively, at age 18 [13].

2.3. Dietary and eating behaviour assessment

Dietary assessment was based on a validated self-reported, semi-quantitative food frequency questionnaire (FFQ), consisted of 48 food items commonly used in the local Greek cuisine [14]. All participants were asked about their usual frequency of consumption of the food items (average over the last year) with the following response categories: Everyday, 3–6 times per week, 2 times per week, once a week, 1–2 times per month and seldom/never. Participants were also asked to quantify the portion of the food item they usually consumed, therefore standard size pictures of the food portions were also illustrated in the questionnaire for each of the food items in order to help the children to visualise the regular portion. Besides the basic food items, the questionnaire included 11 more supplementary questions assessing the type of the foods consumed (such as whole wheat vs. white bread, brown vs. white rice, low-fat dairy products vs. full-fat, and sugar-free vs. regular soft drinks).

2.4. Assessment of Mediterranean diet patterns

The KIDMED index (Mediterranean Diet Quality Index for children and adolescents) was used to evaluate the degree of adherence to the Mediterranean diet [15]. The KIDMED index was developed in an attempt to combine the Mediterranean diet (MD) guidelines

Please cite this article in press as: Farajian P, et al. Very high childhood obesity prevalence and low adherence rates to the Mediterranean diet in Greek children: The GRECO study. Atherosclerosis (2011), doi:10.1016/j.atherosclerosis.2011.04.003

for adults as well as the general dietary guidelines for children in a single index. It is based on the principles sustaining the Mediterranean dietary pattern as well as on those that undermine it. The index comprises of 16 yes or no questions. The total score ranges from −4 to 12 and is classified into 3 levels: ≥8, good adherence to the principles of the MD; 4–7, average adherence to the principles of the MD; and ≤3, very low diet quality in relation to the principles of the MD.

2.5. Physical activity assessment

All participants were asked to complete the Physical Activity Questionnaire for Older Children (PAQ-C) [16]. The instrument is designed for use in older children (ages 8–14 years) and consists of nine questions structured to discern moderate through vigorous physical activity (MVPA) during the last 7 d. The summary score for the PAQ-C is the average of the sum of the nine questions and it is designed to be used during the school year, rather than summer vacation or holiday periods (theoretical range 1–5).

2.6. Statistical analysis

Continuous variables are presented as mean ± SD, whereas categorical variables are presented as absolute and relative frequencies. Normality of variables' distribution was tested graphically using the P–P plots. The Student's *t*-test and one-way ANOVA, with Bonferroni correction to account for the inflation of type-I error due to multiple comparisons made, were applied to evaluate differences in mean values of normally distributed data. Associations between categorical variables were tested by contingency tables and chi-square test. In addition, discriminant analysis with the calculation of Wilk's lambda (theoretical range 0–1, the lower the better discriminating ability), was also applied to evaluate and hierarchy the food groups included in the KIDMED score, as regards the classification of children to normal weight and overweight/obese. All reported *P*-values are based on two-sided tests and compared with a significance level of 5%. SPSS 18.0 software (Statistical Package for Social Sciences, Chicago, IL, USA) was used for all statistical calculations.

3. Results

According to the IOTF cut-offs, the overall prevalence of childhood overweight (OW) was 29.5% and of obesity (OB) was 11.7%. The gender-specific prevalence for BMI categories is presented in Table 1. The prevalence of overweight and obesity was higher in boys than girls ($\chi^2 = 7.37$, $P = 0.02$) and the same result was shown after combining overweight and obese (OW/OB) subjects into one category ($\chi^2 = 4.40$, $P = 0.04$). Furthermore, no differences were observed in the prevalence of OW, OB, or combined OW/OB in the overall sample and in both genders according to residence in large urban or semi-urban areas (*P* for all > 0.05). Additionally, no differences were found between different age-groups (10, 11 and 12 years old) concerning OW and OB prevalence, for both genders and the overall sample. Concerning the prevalence of thinness (including thinness grades 1, 2 and 3), it was found to be significantly higher in girls than boys ($\chi^2 = 8.3$, $P = 0.04$).

Table 1
Prevalence of overweight, obesity and underweight in $n = 4786$ Greek 10–12 years old children according to the criteria suggested by IOTF.

	Overweight	Obese	Underweight
Boys (%)	29.9[a] (28.3, 30.9)	12.9[a] (11.5, 13.3)	3.3 (2.52, 3.48)
Girls (%)	29.2 (27.02, 29.58)	10.6 (9.15, 10.85)	5.0[a] (4.36, 5.58)
Total (%)	29.5 (27.7, 30.2)	11.7 (10.3, 12.1)	4.2 (3.64, 4.76)

[a] *P*-values derived through Pearson's χ^2-test for independence between boys and girls.

Anthropometric characteristics and body fat assessment results by gender and BMI category are presented in Table 2. In all the presented characteristics, by the exception of age, there was a significant difference between normal weight, OW and OB children, in both genders (*P* for all < 0.05).

The KIDMED score was 3.65 ± 2.27 in the overall sample; only 4.3% of children had an optimal score (≥8), while 46.8% were classified as low adherers to the MD. KIDMED score did not differ between boys (3.64 ± 2.29) and girls (3.66 ± 2.24) (*t*-test = 0.18, $P = 0.86$); no differences were observed between normal weight (3.70 ± 2.26) and OW/OB children (3.62 ± 2.26) (*t*-test = 1.08, $P = 0.28$). In addition, no differences were found between the different age groups (*F*-test = 0.19, $P = 0.83$). However, children from urban and semi-urban areas of the country had higher KIDMED score (3.75 ± 2.28) as compared with those form large urban areas (3.56 ± 2.25) (*t*-test = −2.96, $P = 0.003$).

Further analysis (i.e., discriminant analysis) revealed that from the food groups considered for the KIDMED score, five were significant in classifying children into normal weight and overweight/obese categories. Specifically, cereals intake had the highest classification ability (Wilk's lamda = 0.976, $P = 0.001$), followed by sweets (lamda = 0.986, $P = 0.011$), various snacks (lamda = 0.988, $P = 0.016$), poultry (lamda = 0.988, $P = 0.017$) and starchy products (lamda = 0.991, $P = 0.038$).

Anthropometric, dietary and lifestyle characteristics of children according to their adherence to the MD are presented in Table 3. BMI, %BF and central adiposity indicators did not differ between the KIDMED score groups. Compared with low adherers, children with moderate KIDMED score had higher IPAQ score. Concerning the frequency of food groups consumption, children with higher KIDMED score were more likely to consume more frequently starchy foods and cereals, fruits, fruit juice, vegetables, dairy products (milk,

Table 2
Anthropometric characteristics and body fat assessment results by gender and BMI classification.

	Boys			Girls			Total sample		
	Normal	OW	OB	Normal	OW	OB	Normal	OW	OB
Age (years)	10.98 ± 0.76	10.92 ± 0.75	10.92 ± 0.78	10.88 ± 0.77	10.87 ± 0.70	10.77 ± 0.75	10.92 ± 0.75	10.90 ± 0.73	10.85 ± 0.77
BMI (kg/m^2)	17.7 ± 1.7[a]	22.5 ± 1.4[b]	27.7 ± 2.5	17.8 ± 1.8[a]	22.7 ± 1.5[b]	27.6 ± 2.5	17.8 ± 1.8[a]	22.6 ± 1.5[b]	27.6 ± 2.5
Waist (cm)	64.0 ± 6.1[a]	74.4 ± 6.4[b]	85.5 ± 7.9	62.5 ± 6.0[a]	72.9 ± 6.2[b]	83.0 ± 7.5	63.2 ± 6.1[a]	73.7 ± 6.3[b]	84.4 ± 7.8
Waist/hip ratio	0.83 ± 0.06	0.85 ± 0.06[b]	0.88 ± 0.06	0.80 ± 0.07[a]	0.82 ± 0.07[b]	0.84 ± 0.06	0.82 ± 0.07[a]	0.84 ± 0.07[b]	0.86 ± 0.06
Waist/height ratio	0.43 ± 0.04[a]	0.49 ± 0.04[b]	0.56 ± 0.05	0.42 ± 0.04[a]	0.48 ± 0.04[b]	0.54 ± 0.05	0.43 ± 0.04[a]	0.49 ± 0.04[b]	0.56 ± 0.05
Body fat mass (%)	13.5 ± 4.5[a]	23.0 ± 4.7[b]	32.3 ± 5.8	18.4 ± 6.5[a]	29.7 ± 4.7[b]	37.0 ± 4.7	16.1 ± 6.1[a]	26.4 ± 5.8[b]	34.5 ± 5.8

OW = overweight; OB = obese.
[a] $P < 0.001$ for comparisons between normal-weight and overweight (OW) and obese (OB) children for the total sample, as well as for boys and girls separately (Bonferroni corrected).
[b] $P < 0.001$ for comparisons between overweight and normal-weight and obese (OB) children for the total sample, as well as for boys and girls separately (Bonferroni corrected).

Please cite this article in press as: Farajian P, et al. Very high childhood obesity prevalence and low adherence rates to the Mediterranean diet in Greek children: The GRECO study. Atherosclerosis (2011), doi:10.1016/j.atherosclerosis.2011.04.003

Table 3
Anthropometric, lifestyle and dietary characteristics according to KIDMED score categories.[a]

	KIDMED (−4 to 12)			P^{b}
	≤3	4–7	≥8	
N (%)	2240 (46.8)	2341 (48.9)	205 (4.3)	
Age (year)	10.94 ± 0.76	10.91 ± 0.74	10.90 ± 0.73	0.46
Male gender, %	48.4	49.3	51.7	0.59
Body mass index (kg/m^2)	20.4 ± 3.9	20.2 ± 3.7	20.4 ± 3.8	0.32
Waist circumference (cm)	68.9 ± 9.7	68.4 ± 9.6	68.4 ± 9.8	0.13
Waist/hip ratio	0.83 ± 0.08	0.83 ± 0.07	0.83 ± 0.08	0.55
Waist/height ratio	0.46 ± 0.06	0.46 ± 0.06	0.46 ± 0.06	0.10
% body fat	21.3 ± 9.0	20.9 ± 8.8	20.8 ± 8.5	0.26
IPAQ score (1–5)	2.87 ± 0.62	3.00 ± 0.58	3.05 ± 0.60	<0.001
Starchy foods and cereals				
Breakfast ready-to-eat cereals				<0.001
≥5 times/week vs. ≤4 times/week	29.5%	46.8%	74.6%	
Pasta and rice				<0.001
≥5 times/week vs. ≤4 times/week	51.0%	68.9%	85.9%	
Bread				0.02
≥7 times/week vs. ≤6 times/week	26.1%	29.5%	32.3%	
Legumes–Pulses				<0.001
≥2 times/week vs. ≤1 times/week	24.5%	54.4%	87.7%	
Fruits (at least one fresh fruit)				<0.001
≥7 times/week vs. ≤6 times/week	85.1%	96.8%	98.5%	
Vegetables (at least one portion of vegetables)[c]				<0.001
≥7 times/week vs. ≤6 times/week	31.2%	71.7%	98.0%	
Dairy products (at least 2 portions)[d]				<0.001
≥7 times/week vs. ≤6 times/week	48.1%	77.4%	92.2%	
Meat				
Red meat				<0.001
≥2 times/week vs. ≤1 times/week	28.8%	32.3%	44.6%	
Fish				<0.001
≥2 times/week vs. ≤1 times/week	19.9%	31.2%	53.2%	
Fast foods[e]				<0.001
≥2 times/week vs. ≤1 times/week	19.6%	17.4%	9.8%	
Nuts				<0.001
≥3 times/week vs. ≤2 times/week	6.4%	9.6%	18.6%	
Soft drinks (regular or diet)				<0.001
≥3 times/week vs. ≤2 times/week	17.7%	12.8%	9.9%	
Sweets and foods high in sugar (≥3 times/week vs. ≤2 times/week)[f]				
≥3 times/week vs. ≤2 times/week	22.8%	16.0%	9.6%	<0.001

[a] Values are means ± SD or percentages.
[b] *P*-values between all groups as derived from ANOVA or Chi-square test.
[c] Category including vegetables and fresh legumes consumption.
[d] Category including milk, cheese, and yogurt consumption.
[e] Category including burgers and souvlaki (traditional food with meat) consumption.
[f] Category including chocolate, chocolate bars and pastries.

cheese and yogurt), legumes, nuts, red meat, poultry, eggs, fish and seafood. High adherers to MD also reported less frequent consumption of ice cream, traditional Greek foods with meat (souvlaki and gyros), burgers, salty snacks, soft drinks, and sweets and foods high in sugar.

4. Discussion

In a nationwide, representative sample of Greek schoolchildren aged 10–12 years old, a very high prevalence of OW and OB, was observed. Based on the IOTF cut-offs, it was found that the prevalence of OW was 29.5% and the rate of OB was 11.7%. The rising prevalence of OW and OB in children has been associated with an increase in the prevalence of metabolic syndrome and type 2 diabetes [1,17]. Previous data on Greek children have revealed that OW and OB children had higher levels of plasma triglycerides (TG) and lower levels of HDL-C and physical fitness compared to their normal-weight peers [18]. In addition, it has been shown that the prevalence of insulin resistance is higher in OW and OB children compared with the normal-weight [17].

When comparing our results with other national data from Greece, it is evident that the percentages of overweight and obesity are higher. In the case of the study of Georgiadis and Nassis [19], the reported overall prevalence of OW and OB, from students 6–17 years old, were 17.3% and 3.6%, respectively. This discrepancy can be explained by the fact that the study presented national data of 1990–1991. Our results also differ considerably from those of Karayiannis et al. [20] reporting an overall prevalence of OW and OB in 11–16 years old children and adolescents of 15.3% and 1.8%, respectively, probably because of the fact that body weight and height data were self-reported and therefore could be less valid and reliable than direct measurements [21]. Finally, in a recent study examining 11-year trends (1997–2007) in overweight and obesity of 8–9 years old children, it was shown that the prevalence of overweight rose between 1997 and 2007 from 20.2% to 26.7% for girls and from 19.6% to 26.5% for boys. In addition, trend analysis showed an increase in the prevalence of obesity from 7.2% in 1997 to 11.2% in 2007 for girls and from 8.1% in 1997 to 12.2% in 2007 for boys [22].

Regarding underweight as a total of three grades of thinness, there is only one study in Greece referring to this problem and reporting that in 8–9 years old children the prevalence of underweight is stable over the decade (1997–2007) ranging from 7.5% to 9.6% and 9.6% to 12% for boys and girls, respectively, with girls having significantly higher rates than boys throughout the studied period [22]. Our results also demonstrate higher prevalence of

Please cite this article in press as: Farajian P, et al. Very high childhood obesity prevalence and low adherence rates to the Mediterranean diet in Greek children: The GRECO study. Atherosclerosis (2011), doi:10.1016/j.atherosclerosis.2011.04.003

underweight for girls than boys, a finding that agrees with data coming from other European countries where the overall reported prevalence of underweight ranged from 6.9 to 10.1% [23].

We also observed a gender difference in the prevalence of overweight and obesity since both OW and OB prevalence were higher in boys than in girls which is in agreement with recent data from European countries also showing that in most of them, the prevalence of overweight in boys is higher than girls [5,22,24]. However, we did not observe any differences in childhood OW and OB rates between large urban and semi-urban/rural regions of the country, which confirms similar findings from previous studies in Greece [19] and neither geographical disparities that have been observed in other Mediterranean countries [25].

In the present study only 4.3% of the children reported eating habits following the principles of the MD. Hence, our findings support previous evidence for low adherence to the dietary patterns of the MD, in children and adolescents in Mediterranean countries [26]. Although no differences were found in the BMI of the three different KIDMED score groups, results of our study provide evidence of the association between the level of adherence to the principles of the MD and the diet quality as well as a healthier lifestyle of children. In particular, it was shown that children with higher KIDMED score, also had more frequent consumption of fruits, vegetables, legumes, dairy products, fish, bread and nuts, and on the contrary had less frequent consumption of foods that according to the MD scheme should not be consumed regularly. However, due to the very low discriminating ability of the selected food groups (i.e., all foods had Wilk's lambda close to 1) it seems that these particular food groups consumption do not significantly contribute to children's classification into overweight/obese or non-obese groups. Moreover, children with higher KIDMED score reported having higher physical activity levels, indicative that besides following a healthier diet, also adopt a healthier lifestyle. The fact that high adherers to the MD also had more frequent consumption of red meat than the low adherers should be noted. This could probably be related to the fact that in order to ensure the adequacy of dietary iron intake in children, it is generally recommended to consume red meat more often than is suggested in the MD scheme. Therefore, it could be hypothesized that children's parents are encouraged to increase the weekly consumption of red meat.

The very low percentage of children with high adherence to the MD and the phenomenon of the nutrition transition could be related to the enhanced commercial availability of food, the overall improvement in socioeconomic conditions, and the high urbanization which has taken place in Greece over the last decades. The urbanization of life seems to be an important factor influencing the abandonment of the MD from the children, since we found that children from semi-urban areas had higher adherence to the MD compared with those form large urban areas.

The main strengths of our study are the nationally representative and large sample of school-children aged 10–12 years old and the relatively high response rate. Additionally, OW and OB rates were estimated with direct anthropometric measurements. An important limitation that has to be acknowledged is that the age range of the study, which was the late childhood and preadolescence, does not cover all age sections. Puberty, in particular, is a period of rapid growth in which boys and girls increase fat-free mass substantially, and in girls is associated with considerable increase in body weight and body fat-mass, therefore adolescence could be a critical period for developing obesity [27]. Future plans include to proceed into school-based childhood obesity prevention programs. It has been suggested that these kind of programs should target 10–14-year-old children, since it has been demonstrated that prevention trials including older children have positive outcomes in terms of reducing BMI [28]. Moreover, the cross-sectional design of the study does not allow for causal interpretations of the findings, and reverse causality may always exists in the relationship between diet and obesity.

In conclusion, the present study shows the alarming magnitude of the paediatric obesity problem in all areas and regions of Greece and the need for the establishment of long-term surveillance through population surveys in order to monitor secular trends in OB and to be able to reveal potential causative factors to combat the problem. Our findings support the notion and the general trend in Europe, showing that south European countries such as Spain, Italy, Portugal and Greece report the highest prevalence of obesity when compared to North European countries [5].

Recently the traditional MD was included on the UNESCO Representative List of the Intangible Cultural Heritage of Humanity as a "set of traditional practices, knowledge, skills, and consumption of food" (www.unesco.org/culture). Characterized by a nutritional model that "has remained constant over time passed on from generation to generation and providing a sense of belonging and continuity to the concerned communities". However, despite all the increasing evidence about the benefits of the Mediterranean diet, the present data witness the deviation from this diet towards a more Western-type diet with higher consumption of energy-dense foods and lower consumption of healthy foods that constitute the dietary pattern.

Taking into account recent studies suggesting that childhood obesity in most cases tracks into adulthood [2,3], the current findings are indicating an increased risk for even higher rates of obesity in adolescence and adulthood in the near future exceeding those currently reported for the Greek adult populations [29]. Since it is estimated that 30% of CHD and ischemic stroke and almost 60% of hypertensive disease in developed countries is attributed to excess BMI [30], the rising prevalence of childhood obesity in Greece is a serious public health issue, with an emerging need for preventing measures, and anti-obesity health policy interventions in order to improve the eating habits of the children that may continue into adulthood and reduce the risk for chronic diseases.

Acknowledgements

Funding for the study was provided by the General Secretariat of Consumers-Greek Ministry of Development, Hellenic Association of Food and Beverage Companies, Coca Cola Hellas, Coca Cola Hellenic Bottling Company, Cereal Partners Hellas, FAGE S.A., Unilever Hellas, Nestle Hellas, Kraft Foods Hellas.

References

[1] Power C, Lake JK, Cole TJ. Measurement and long-term health risks of child and adolescent fatness. Int J Obes Relat Metab Disord 1997;21:507–26.
[2] Freedman DS, Sherry B. The validity of BMI as an indicator of body fatness and risk among children. Pediatrics 2009;124:S23–34.
[3] Singh AS, Mulder C, Twisk JW, van Mechelen W, Chinapaw MJ. Tracking of childhood overweight into adulthood: a systematic review of the literature. Obes Rev 2008;9:474–88.
[4] Lloyd LJ, Langley-Evans SC, McMullen S. Childhood obesity and adult cardiovascular disease risk: a systematic review. Int J Obes 2010;34:18–28.
[5] Lobstein T, Frelut ML. Prevalence of overweight among children in Europe. Obes Rev 2003;4:195–200.
[6] Keys A. Coronary heart disease in Seven Countries. Circulation 1970;41–42(suppl I):1–211.
[7] Estruch R, Martínez-González MA, Corella D, et al. Effects of a Mediterranean style diet on cardiovascular risk factors: a randomized trial. Ann Intern Med 2006;145:1–11.
[8] Panagiotakos DB, Tzima N, Pitsavos C, et al. The association between adherence to the Mediterranean diet and fasting indices of glucose homoeostasis: the ATTICA study. J Am Coll Nutr 2007;26:32–8.
[9] Esposito K, Ciotola M, Giugliano D. Mediterranean diet, endothelial function and vascular inflammatory markers. Public Health Nutr 2006;9:1073–6.
[10] Lissau I, Overpeck MD, Ruan WJ, et al. Body mass index and over-weight in adolescents in 13 European countries, Israel, and the United States. Arch Pediatr Adolesc Med 2004;158:27–33.

Please cite this article in press as: Farajian P, et al. Very high childhood obesity prevalence and low adherence rates to the Mediterranean diet in Greek children: The GRECO study. Atherosclerosis (2011), doi:10.1016/j.atherosclerosis.2011.04.003

[11] Kafatos A, Diacatou A, Voukiklakis G, et al. Heart disease risk-factor status and dietary changes in the Cretan population over the past 30 years. The seven countries study. Am J Clin Nutr 1997;65:1882–6.
[12] Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ 2000;320:1240–3.
[13] Cole TJ, Flegal KM, Nicholls D, Jackson AA. Body mass index cut offs to define thinness in children and adolescents: international survey. BMJ 2007;335:194–8.
[14] Farajian P, Karasouli K, Risvas G, Panagiotakos DB, Zampelas A. Repeatability and validity of a food frequency and dietary habits questionnaire in children. Circulation 2009;119:e288.
[15] Serra-Majem L, Ribas L, Ngo J, et al. Food, youth and the Mediterranean Diet in Spain. Development of KIDMED, Mediterranean Diet Quality Index in children and adolescents. Public Health Nutr 2004;7:931–5.
[16] Kowalski KC, Crocker PRE, Faulkner RA. Validation of the Physical Activity Questionnaire for Older Children. Pediatr Exerc Sci 2007;9:174–86.
[17] Manios Y, Moschonis G, Kourlaba G, et al. Prevalence and independent predictors of insulin resistance in children from Crete, Greece: the Children Study. Diabet Med 2008;25:65–72.
[18] Manios Y, Yiannakouris N, Papoutsakis C, et al. Behavioral and physiological indices related to BMI in a cohort of primary schoolchildren in Greece. Am J Hum Biol 2004;16:639–47.
[19] Georgiadis G, Nassis GP. Prevalence of overweight and obesity in a national representative sample of Greek children and adolescents. Eur J Clin Nutr 2007;61:1072–4.
[20] Karayiannis D, Yannakoulia M, Terzidou M, Sidossis LS, Kokkevi A. Prevalence of overweight and obesity in Greek school-aged children and adolescents. Eur J Clin Nutr 2003;57:1189–92.
[21] Himes H. Challenges of accurately measuring and using BMI and other indicators of obesity in children. Pediatrics 2009;124:S3–22.
[22] Tambalis KD, Panagiotakos DB, Kavouras SA, et al. Eleven-year prevalence trends of obesity in Greek children: first evidence that prevalence of obesity is levelling off. Obesity 2009;18:161–6.
[23] Martínez-Vizcaíno V, Sánchez López M, Moya Martínez P, et al. Trends in excess weight and thinness among Spanish schoolchildren in the period 1992–2004: the Cuenca study. Public Health Nutr 2008;27:1–4.
[24] Lazarou C, Panagiotakos DB, Panayiotou G, Matalas AL. Overweight and obesity in preadolescent children and their parents in Cyprus: prevalence and associated socio-demographic factors – the CYKIDS study. Obes Rev 2008;9:185–93.
[25] Binkin N, Fontana G, Lamberti A, et al. A national survey of the prevalence of childhood overweight and obesity in Italy. Obes Rev 2010;11:2–10.
[26] Lazarou C, Panagiotakos DB, Matalas AL. Level of adherence to the Mediterranean diet among children from Cyprus: the CYKIDS study. Public Health Nutr 2008;12:991–1000.
[27] Dietz WH. Critical periods in childhood for the development of obesity. Am J Clin Nutr 1994;59:955–9.
[28] Kropski JA, Keckley PH, Jensen GL. School-based obesity prevention programs: an evidence based review. Obesity 2008;16:1009–18.
[29] Panagiotakos DB, Pitsavos C, Chrysohoou C, et al. Epidemiology of overweight and obesity in a Greek adult population: the ATTICA Study. Obes Res 2004;12:1914–20.
[30] World Health Report. Reducing risks, promoting healthy life. Geneva: World Health Organisation; 2002.

Please cite this article in press as: Farajian P, et al. Very high childhood obesity prevalence and low adherence rates to the Mediterranean diet in Greek children: The GRECO study. Atherosclerosis (2011), doi:10.1016/j.atherosclerosis.2011.04.003