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ORIGINAL ARTICLE

Prevalence of obesity and body mass index correlates in a representative sample of Cretan school children

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Abstract

Objective. This study aimed to estimate the prevalence of overweight and obesity and investigate associated factors in a representative sample of Cretan school children. *Methods.* As part of a cross-sectional study in children aged 10–12 years (n = 481, 48% boys) in 27 (urban and rural) schools in Crete, Greece, the rates of overweight and obesity were estimated and multiple logistic regression was used to explore the relationship between several factors and body mass index (BMI). *Results.* It was shown that 28% and 13% of children were overweight and obese, respectively. Factors affecting children's BMI classification included: gender (95% CI: 0.21 to 0.56); birth weight (95% CI: 1.33 to 3.46); parental overweight or obesity (95% CI: 1.11 to 6.5 and 95% CI: 4.37 to 30.7 for one and both overweight or obese parents, respectively), paternal educational level (95% CI: 0.89 to 3.48 and 95% CI: 1.49 to 6.13 for low and high educational level, respectively); and cardiovascular fitness levels (95% CI: 0.87 to 0.92). *Conclusion.* The combined prevalence of overweight and obesity was alarmingly high in the current population (41%); several physiological, behavioural and social factors were shown to affect children's BMI status. These findings highlight the extent of the child obesity problem in Crete and support the need for actions to be taken at a national level to tackle the obesity epidemic.

Key words: *Obesity, children, BMI, parental, Crete*

Introduction

The problem of childhood obesity is well-documented and discussed in a vast number of scientific papers. However, both the causes and the treatment of the condition are still unclear; as a result, the situation continuously deteriorates and the prevalence of increased adiposity in youth is escalating.

Worldwide, 155 million children are currently overweight, of which 30 to 45 million are obese; the corresponding European figures are 14 million and 3 million, respectively. In percentages, the mean prevalence of child overweight and obesity in Europe is about 20% and 5%, respectively (1). However, there is substantial variability between countries and exploration of these discrepancies reveals that Southern European regions experience this new epidemic to a greater extent. Particularly for obesity, contemporary Greeks are ranked among the fattest in the European Union, with approximately 70% of middle-aged men and women, and more than 30% of children and adolescents being classified as overweight or obese, while the problem seems to be more recent for males (2–5). Crete, on the other hand, is one of the Mediterranean islands with the highest rates of pre-adolescent overweight and obesity (33%), and the highest rates of adolescent overweight and obesity (35%) (6). However, the already reported rates come from scarce data of interventions or small-scale studies, which in no case aimed to reveal the extent of the childhood obesity problem in the Cretan island (7,8).

The multi-factorial nature of obesity hinders the understanding of its exact aetiology. Genetic

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predisposition constitutes an indisputable contribution that 'loads the gun'; however, a 'trigger', namely environmental factors promoting sedentary lifestyles and unhealthy eating patterns, is essential for the establishment of obesity (9). For children, family plays an equally important role by influencing these two parameters, especially in younger ages (10).

The aim of the current paper was to estimate the prevalence of overweight and obesity and investigate potential factors (e.g., region of residence, parental educational level, etc) associated with increased levels of overweight and obesity in a representative sample of Cretan school children.

Methods

Study population

Between October 2005 and March 2006, 522 children (54% girls) aged 10–12 years were recruited from 20 schools located in Iraklio county and 7 schools located in Lasithi county of Crete, Greece. Among those, full anthropometric, dietary, physical activity and cardiorespiratory fitness data had been recorded for 481 children (92%). Multistage random sampling was used to select the schools.

The island of Crete consists of four different counties, namely Lasithi, Iraklio, Rethimno, and Hania. According to the National Statistical Service of Greece (Census 2001), the population of the three latter counties is homogeneous, with regard to education, income and unemployment. As can be seen in Table I, these three counties are also similar in residential terms (~55% of the population are in urban areas) whereas the county of Lassithi is the only one that differs, with 75% of its population living in urban areas. In this context, the counties of Lasithi and Iraklion (as representative of the other three counties) were chosen to participate in the study and the final sample (n=481) was found to be representative of the students of the 5th grade of elementary school in the Cretan island in terms of parental age and parental educational level. Approval to conduct the study was granted by the Ethical Committee of Harokopio University of Athens and the Greek Ministry of Education.

Table I. Representativeness of the study population.

	Counties			
	Hania*	Rethimno*	Iraklio*	Lassithi
Total Population				
Urban	54.6%	56.9%	56.0%	75.4%
Rural	45.4%	43.1%	44.0%	24.6%
Sample size				
Urban			54.6%	71.0%
Rural			45.4%	29.0%

*These counties did not differ between them regarding education, income and unemployment rates, and they were similar in the distribution of population in urban and rural areas. The county of Iraklio was randomly selected amongst the three to be included in the study.

Anthropometric measurements

Body weight was measured with a digital scale (Seca 861) with an accuracy of ± 100 g. Subjects were weighed without shoes, in the minimum clothing possible, i.e., underwear. Standing height was measured without shoes to the nearest 0.5 cm with the use of a commercial stadiometer (Leicester Height Measure). Body mass index (BMI) was calculated as weight (in kg) divided by height squared (in meters). Children were classified as normal weight, overweight and obese according to the International Obesity Task Force (IOTF) BMI age- and gender-specific cut-offs corresponding to an adult BMI value of 25 kg/m^2 for overweight and 30 kg/m^2 for obesity (11). After brief observation by a researcher of the same sex as the child, pubertal stage was recorded (12). Breast development in girls and genital development in boys was used for pubertal classification.

Physical activity assessment

Assessment of children's moderate-to-vigorous physical activity (MVPA) was performed by using a standardised activity interview, based on a structured questionnaire adapted from the Amsterdam Growth Study and completed by a member of the research team (13,14). Children were asked to report the time spent on various physical activities (alone, with peers or under the supervision of a trainer) on two consecutive weekdays and one weekend day. The time devoted weekly to organised moderate (such as running, ballet/dancing, horse riding, cycling, and rowing) and vigorous (such as basketball/football/handball, swimming, skiing, gymnastics and canoeing) activities was considered as the organised moderate-to-vigorous physical activities (OMVPA). In our analyses, we used OMVPA and not total MVPA, because studies have shown that OMVPA is more accurately measured in children due to reduced recall bias (15). The total weekly time spent on sedentary activities (TV viewing, video games and recreational computer usage) was also recorded.

Fitness assessment

Fitness was assessed following the EUROFIT Tests Protocol designed by the Committee of Experts on

Sports Research, which has been extensively used in Europe for children's fitness assessment in the school setting (16). During the cardiovascular fitness assessment, subjects started running at a speed of 8.5 km/h and speed was increased at various stages. The subjects moved between two lines at a distance of 20 m apart, reversing direction and continuing backwards and forwards in accordance with a pace dictated by a sound signal on an audiotape, which got progressively faster (0.5 km/h every minute). Each stage of the test was made up of several shuttle runs but the actual score of the subject was the last one-half stage fully completed before they dropped out; therefore, the stages were 0.0, 0.5, 1.0, 1.5, 2.0 etc. The number of shuttle runs, which each child completed, was estimated and referred to as the Endurance Run Test (ERT) score.

Dietary assessment

A combination of one 24-hour recall and a 3-day food diary was used to collect information regarding children's dietary intake (17). The dietitians of the research group collected information using a 24-hour recall during the first day of the morning visit at each school. During the interview each child was familiarised with portion sizes and the relevant procedures in order to successfully complete a food record at home in the forthcoming days, preferably two weekdays and a Sunday. When the food records were returned at school, a team member checked the records for any misreported or missing information. Food intake was subsequently analysed using the Nutritionist V diet analysis software (First Databank, San Bruno, CA), which was extensively amended to include traditional Greek food and recipes, as described in Food Composition Tables and Composition of Greek Cooked Food and Dishes (18). The databank was updated with nutritional information of chemically analysed commercial food items widely consumed by school children in Greece (19,20). The distribution of usual intakes was estimated using the National Research Council method (NRC method) which attempts to remove the effects of day-to-day variability (within subject) in dietary intakes (21–23). More specifically, the equation used for the calculation of adjusted (usual) intake was the following:

([Subject's mean – group mean] × SDbetween-person/ SDobserved) + group mean

SD: Standard deviation.

Data obtained from parents

Information on educational level, current height and weight and smoking practices for both parents was collected using a questionnaire. Parental years of education were used to categorise them into low (≤9 years), medium (10–14 years) and high (>14 years) educational level.

Statistical analysis

Normally distributed continuous variables are expressed as mean values ± SD; categorical variables are summarised as absolute and relative (%) frequencies. Normality of distribution was evaluated through the Kolmogorov-Smirnov test. Associations between categorical variables were determined using the chi-squared test. Binary univariate logistic regression was primarily used to check for factors associated with children's BMI status (overweight or obese versus normal weight). The variables checked were: children's age, gender, birth weight, location of residence, energy intake, cardiovascular fitness, OMVPA and sedentary behaviours; parental BMI status, educational level and smoking practices. Subsequently, data were modelled using multiple logistic regression analysis. The final model was derived using the backward elimination method, where all statistically significant risk factors obtained from the univariate analysis (birth weight, parental BMI, paternal educational level, energy intake and cardiovascular fitness) and other factors with established or suggested effect on BMI (age, gender, maternal educational level, OMVPA and sedentary behaviours) were entered in the initial multivariate model and removed one at a time keeping only the statistically significant ones. Age and gender were locked in the model regardless of their effect on BMI status. To evaluate whether the gender modifies the association between the other factors included in the final model and BMI status, all possible 2-way interaction terms (i.e., gender * one of the other factors) were entered in the model. However, no interaction term was significant. Therefore, they were not included in the final model. P-values less than 0.05 from the two-sided hypotheses were considered statistically significant. All calculations were performed using STATA 9.2 software.

Results

Descriptive characteristics of the sample are summarised in Table II. The prevalence of overweight and obesity in the current population was 28% and 13%, respectively (Table III). No significant correlations were found for stage of puberty and BMI, for neither boys nor girls (data not shown). Prevalence rates according to gender and area type (urban/ rural) are depicted in Table III and Table IV, respectively; chi square analysis revealed that none of the two factors had an effect on children's BMI status

Table II. Descriptive characteristics of the population.

	Boys n = 231		Girls n = 250		Total n = 481	
Anthropometry						
BMI (kg/m^2)[a]	19.97	(3.86)	19.33	(3.87)	19.63	(3.88)
Birth weight (kg)[a]	3.36	(0.63)	3.25	(0.54)	3.30	(0.58)
Physical activity						
OMVPA (h/week)[b]	1.25	(0, 3.63)	0	(0, 3)	0	(0, 3)
TV watching (h/day)[a]	2.42	(1.28)	2.33	(1.17)	2.37	(1.22)
Cardiorespiratory fitness						
Fitness level (ERT score)[a]	24.5	(13.4)	21.6	(9.91)	21.6	(11.9)
Dietary intake						
Energy intake (kcal/day)[a]	1819	(559)	1592	(431)	1696	(506)
Parental BMI status						
Both parents normal weight	46	(20%)	42	(17%)	88	(18%)
One parent overweight/obese	112	(48%)	142	(56%)	254	(53%)
Both parents overweight/obese	73	(32%)	66	(25%)	139	(29%)

BMI: Body mass index, OMVPA: Organised Moderate-to-Vigorous Physical Activity, ERT: Endurance Run Test.
[a]Data are presented as mean (standard deviation) for continuous and absolute and relative (%) frequencies for categorical variables.
[b]Data are presented as median (25th, 75th percentile).

(p = 0.155 and p = 0.214 for gender and area of residence, respectively).

As described in the methods section, regression models were used to investigate the effects of several variables on children's BMI classification (Table V). Non-significant variables excluded from the model were OMVPA, sedentary behaviours, area of residence, parental smoking practices and maternal educational level. The final regression model included age, gender, birth weight, parental BMI, paternal educational level, energy intake and cardiovascular fitness (Table V).

Discussion

The current study is the first to report on the prevalence of overweight and obesity in a representative sample of the island of Crete. Greece in general and the island of Crete in particular experience very high rates of childhood overweight and obesity (6). However, the already reported rates come from scarce data of intervention or small-scale studies, which did not aim to reveal the extent of the childhood obesity problem in the Cretan island (7,8). The results of this study on a representative sample of Cretan school children revealed that 28% of the study population was found to be overweight and 13% obese, using the proposed cut-off points (11). Overall, 41% of the participating children were either overweight or obese. These figures confirm that childhood obesity in Crete is among the highest in the world (6).

The above finding is mainly attributed to the adoption of a more Westernised lifestyle, with the

Table III. Prevalence of normal weight, overweight and obesity according to gender.

	Boys		Girls		Total	
	n	%	n	%	n	%
Normal weight[a]	127	55	158	63	284	59
Overweight[b]	69	30	68	27	135	28
Obese[c]	35	15	25	10	63	13
Overweight and obese	104	45	93	37	197	41

There were no significant differences in BMI status according to gender (p=0.2).
BMI: Body mass index. [a]All children with BMI-for-age below the reference values of Cole et al. (2000) equivalent to an adult BMI of 25.
[b]All children with BMI-for-age between the reference values of Cole et al. (2000) equivalent to an adult BMI of 25 and those equivalents to an adult BMI of 30.
[c]All children with BMI-for-age greater than the reference values of Cole et al. (2000) equivalent to an adult BMI of 30.

Table IV. Prevalence of normal weight, overweight and obesity according to location of residence.

	Rural		Urban	
	n	%	n	%
Normal weight[a]	49	65	237	58
Overweight[b]	21	29	115	28
Obese[c]	5	6	54	13
Overweight and obese	26	35	169	41

There were no significant differences in BMI status according to location of residence (p=0.2).
BMI: Body mass index. [a]All children with BMI-for-age below the reference values of Cole et al. (2000) equivalent to an adult BMI of 25.
[b]All children with BMI-for-age between the reference values of Cole et al. (2000) equivalent to an adult BMI of 25 and those equivalents to an adult BMI of 30.
[c]All children with BMI-for-age greater than the reference values of Cole et al. (2000) equivalent to an adult BMI of 30.

Table V. Final regression model of the effect of several factors on BMI classification (overweight or obese vs. normal weight) (n = 481).

Independent variable list	Odds ratio	p-value	95% confidence interval
Age (years)	0.71	0.294	0.37–1.35
Gender (female vs. male)	0.34	<0.001	0.21–0.56
Birth weight (per kg)	2.15	0.002	1.33–3.46
Parental BMI status			
one parent overweight or obese vs.both parents normal weight	2.69	0.03	1.11–6.5
both parents overweight or obese vs.both parents normal weight	11.59	<0.001	4.37–30.7
Paternal education			
low vs. medium	1.76	0.101	0.89–3.48
high vs. medium	3.03	0.002	1.49–6.13
Energy intake (kcal/day)	0.999	0.02	0.998–0.999
Fitness level (ERT score)	0.90	<0.001	0.87–0.92

Factors excluded from the final model: maternal educational level, parental smoking practices, OMVPA, sedentary behaviours and location of residence.
BMI: Body mass index, ERT: Endurance Run Test, OMVPA: Organised to Moderate Physical Activity.

main features of consumption of an energy-dense diet (high in convenience foods, fats and sugars, and low in fruit, vegetables and fibre) and the adoption of more sedentary activity patterns (24,25). Of equal importance are the attitudes and beliefs of those responsible for children's raising and/or feeding. Indeed, grandparents and other guardians still link food availability and consumption to health, wealth and well-being. Additionally, they often have different perceptions of ideal body weight and growth, as they still perceive a chubby child as a well-fed, healthy child. As a result they unwittingly overfeed the children they care for, without realising the negative consequences of increased weight on their children's current and future health (5,26).

In terms of obesity correlates, gender, birth weight, cardiovascular fitness, parental BMI status and paternal education were found to affect children's BMI classification. With regards to gender, available literature is generally inconsistent (27) although higher prevalence of overweight and obesity among Greek boys has been reported in the past (28). In accordance with our results, increased birth weight has also been found to increase the risk for child and adult overweight and obesity by other researchers. It has been suggested that these effects result from changes in factors affecting future weight status, such as lean body mass and physical activity. However, it remains unclear whether the positive association of birth weight with BMI is due to lean or fat body mass (29).

In the current study parental BMI status had the greatest effect on BMI classification, as children with one overweight or obese parent were on average 2.7 times more likely to be overweight or obese compared with their peers with normal weight parents; this likelihood increased to 11.6 times if both parents were overweight or obese. In line with our findings, available evidence indicates that parental obesity is a major predictor of child obesity, possibly due to both genetic and environmental influences (30,31). Based on evidence derived from twin studies, 70% of the variability in BMI is attributed to genetic differences, while the remaining 30% is the result of differences in the environment (32). Indeed, it seems that children adopt their parents' eating habits as a result of environmental exposure, as well as the inheritance of 'food choice genes'. Furthermore, parents play a crucial and direct role in shaping children's eating and activity habits by influencing behaviors, attitudes, feeding styles and by acting as role models, and by being responsible for food availability and leisure time activity allocation (33). Finally, as suggested by Vanderater et al. and Maffeis et al., the strength of the relationship between parental BMI status and children's risk for overweight and obesity is such that it can serve as a mediator of other potentially 'obesogenic' factors, such as physical activity and television viewing (34,35); this may explain the lack of association between these parameters and children's BMI classification in our sample, which is discussed in more detail below.

In the current study, higher paternal educational level was found to increase the risk for children's overweight and obesity. For the traditional Greek patriarchic household, as is the case in towns and rural areas in Crete, the father is the 'head of the family' and therefore paternal educational level largely reflects the socioeconomic status of the household. Thus this observation is in line with the findings of Papadimitriou et al. (36), who concluded that 'improvement in the socioeconomic conditions in Greece resulted in an increase in body weight in Greek school children in the 20th century'.

In terms of the energy balance components, energy intake had a minor, though statistically significant, negative association with children's BMI classification. This seemingly paradoxical observation can be potentially attributed to higher rates of underreporting of energy intake and/or significantly lower levels of physical activity among the overweight and obese. Indeed, the high prevalence of overweight and obesity in our sample (41%) may explain this finding given that, similar to adults, children with increased BMI are also more likely to underreport their energy intake and have lower physical activity levels compared with their normal weight peers (27,37). It is however, also possible that parents in Crete are becoming more aware of the obesity epidemic and its risks, and thus it is possible that some of the obese children, especially girls, are on a diet (38,39).

In terms of energy expenditure, we found no relationship between OMVPA or sedentary activities and children's weight status, possibly due to the inherent difficulties in assessing physical activity levels in children (27), in combination with the previously mentioned strong relationship between parental and children's BMI that may have moderated any potential effect (34,35). However, cardiovascular fitness was found to be negatively associated with BMI classification. This negative association is in line with other published data in Greek (40,41) and other populations (42,43), and can be used as an indirect measure of physical (in)activity levels that failed to be recorded (7,13).

Differences between rural or urban residence and BMI classification were not significant, although there was a trend for higher rates of increased overweight and obesity levels in urban environment. Furthermore, in the regression analysis, location of residence did not seem to affect children's weight status. Another survey, which was conducted in Cretan boys and examined the 20-year trends in obesity, showed no existing differences in overweight and obesity rates between urban and rural areas in both baseline (1982) and follow-up measurements (2002) (44).

Although the cross-sectional nature of the study and the complex social structure of our population constitute recognised limitations, all the evidence presented above support and add to the better understanding of the child obesity problem in the highly affected region of Crete.

In conclusion, our findings indicate that the prevalence of overweight and obesity in Cretan school children has reached alarming proportions, which probably place Crete at the top of the European child obesity pyramid. In addition several physiological, social and behavioural factors were shown to affect the risk for child overweight and obesity in our population. Disappointingly, despite the extent of the problem, there are no established guidelines or treatment options to address this issue, although some encouraging efforts have been made (8). The findings of the current study can guide public health policy to target risk of overweight and obesity with appropriate intervention strategies early in life. As part of the actions taken to establish a National Platform on Nutrition and Physical Activity, a national childhood obesity prevention program, with active parental involvement, should be developed and implemented at school-level so as to effectively tackle this epidemic.

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