Energy Intake, Diet Composition, Energy Expenditure, and Body Fatness of Adolescents in Northern Greece

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Abstract

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Objective: The purpose of this study was to examine energy intake, energy expenditure, diet composition, and obesity of adolescents in Northern Greece.

Research Methods and Procedures: Anthropometric measurements were taken for all participants. Height, weight, and skinfold thickness at two sites were measured. BMI and percentage body fat were calculated. Energy intake and macronutrient and micronutrient intakes were determined by a 3-day weighed dietary diary. Energy expenditure was calculated based on calculated resting metabolic rate (RMR)[1] multiplied by an activity factor based on reported physical activity.

Results: Thirty-one percent of boys and 21% of girls had BMI corresponding to $\geq$25 kg/m^2 at 18 years and were classified as overweight. Both overweight boys and girls reported a lower energy intake compared with their non-overweight counterparts when expressed as kilocalories per kilogram body weight. Overweight children had a higher negative energy balance. Both overweight and non-overweight adolescents had higher than recommended fat intakes. Mean daily carbohydrate, protein, and fat intake, expressed as grams per kilogram body weight, of overweight adolescents were significantly lower compared with the non-overweight adolescents. Total daily carbohydrate intake, when expressed in grams, was found to be higher for non-overweight adolescents. Both overweight boys and girls had lower iron intakes than their non-overweight counterparts. Overweight boys had statistically lower fiber and niacin intakes than non-overweight boys. Both overweight and non-overweight adolescents had lower than recommended iron intakes. Furthermore, overweight adolescents consumed more snacks (potato chips, chocolate bars, pizza, cheese pie, and cream pie), more sugar, jam, and honey, and fewer legumes, vegetables, and fruits than their non-overweight counterparts.

Discussion: Reported energy intake of overweight adolescents was lower than their non-overweight counterparts. Regarding diet composition overweight subjects had significantly lower intakes of carbohydrates compared with non-overweight subjects. The food consumption pattern of overweight children showed less adherence to the traditional Mediterranean diet.

Key words: nutrition, adolescence, body fat, carbohydrates, overweight

Introduction

Dietary habits in Greece have changed dramatically over the past decades (1,2). Recent studies have shown that the traditional Greek diet is mainly kept today by the older generations (3,4). The younger population has adopted a more westernized diet. They eat fast foods more often, and for many schoolchildren, snacks, sweets, and soft drinks form a significant part of their diet (5,6).

The changes observed in the younger generations in Greece during the last decades are associated with an increased prevalence of obesity. In a study on 1031 6-year-old Greek children, it was shown that half the children could be classified as overweight according to the U.S. standards (7).

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[1] Nonstandard abbreviation: RMR, resting metabolic rate.

Another study involving 4901 subjects (2431 boys and 2470 girls) 6 to 12 years of age showed that boys 6 to 8.5 years old and girls 6.5 to 8 years old had mean BMI (kilograms per meter squared) values exceeding those of the age- and sex-specific 90th percentile of the U.S. standards (8). Other smaller studies in Greece also showed a high prevalence of obesity among Greek children (9,10). However, the situation is less clear for Greek adolescents, because there are very few studies regarding those ages (5,11).

It has been suggested that excessive energy intake is the primary cause of obesity (12). Other later studies have shown that obese children and adults may have equal or lower energy intake per day and have higher resting metabolic rate because of their higher body weight than subjects of normal weight. On the other hand, it has been shown that lean individuals exercise more than obese and have in total a higher energy expenditure (13).

Other scientists have looked at the composition of the diet and reported that excessive consumption of dietary fat may be a more important determinant of obesity than excessive consumption of either carbohydrate or protein (14–16). Dietary fat has been related with obesity because of its energy density, its palatability, its weak effect on satiety, and its more efficient conversion to body fat (17). In contrast, carbohydrates have lower energy density, are more satiating, and are converted to body fat less efficiently (18). Those observations imply that diet composition, as well as energy balance, are associated with obesity.

Studies in Greece, up to now, have not focused on body fatness and diet composition. However, given the importance of preventing body fatness in children and adolescents and the effect that obesity has on their health, now and in the future, there is a great need to study energy balance and diet composition of obese children and adolescents.

The purpose of this study was to partly cover this gap by studying energy intake, diet composition, energy expenditure, and obesity of adolescents in Northern Greece.

Research Methods and Procedures

Subjects

A total of 512 subjects, 11 to 14 years of age, in the first, second, and third grade of high school were selected to participate in the study. The city of Thessaloniki was divided into four sections (northern, eastern, western, and southern). One public school from each section was chosen randomly. All pupils from the first three grades of these schools participated in the study. In terms of socioeconomic status, pupils were from all types of families (working class, middle class, and upper class families). Therefore, the sample was representative of the pupil population in Thessaloniki. Ethical approval was given by the Greek Ministry of Education. Two pupils dropped out during the study and eight pupils did not respond properly. The final sample was 502 pupils.

Four groups of adolescents were identified for the study: boys and girls with BMI corresponding to $\geq$25 kg/m^2 at 18 years, classified as overweight, and boys and girls with BMI corresponding to $<$25 kg/m^2 at 18 years, classified as non-overweight, according to the international standards suggested by Cole et al. (19). The final sample consisted of 83 overweight and obese boys, 185 non-overweight boys, 48 overweight and obese girls, and 186 non-overweight girls.

Procedure and Measurements

Anthropometric measurements were taken for all participants. One person conducted the anthropometric measurements to avoid interexaminer variability. Body weight was measured with a digital scale with an accuracy of $\pm$100 grams (seca 707; seca Corp., Hamburg, Germany). Height was measured to the nearest 0.5 cm without shoes with the use of stadiometer (seca 220). BMI was calculated by dividing weight (kilograms) by height squared (meters squared). Skinfold thichnesses at two sites (triceps and subscapular) were measured using a Harpenden skinfold caliper (British Indicator, London, United Kingdom). Skinfolds were measured in duplicate, and the average measurement was used. In case there was a discrepancy of $>$10% between duplicate measurements, the measurement was repeated. Percentage body fat was estimated from skinfold measurements, using the formula of Slaughter et al. (20).

Food intake was determined by a 3-day weighed dietary diary. One spring balance accurate to $\pm$2 grams was provided to each participant at school. After receiving the appropriate instructions written by two dietitians who participated in the study, the adolescents, with the help of their parents, weighed, described, and wrote down all items of food and drink consumed for 3 consecutive days including 1 weekend day. Food records were obtained after the 3 days of recording. If there were gaps or questions on the food records, dieticians contacted the respondents by telephone.

Twenty-four-hour energy expenditure was calculated by totaling RMR plus energy cost for activity. RMR was calculated using the equation of Schoffield for the specific age (21). These equations have been checked and found applicable for the Greek population in previous studies (3,5). The energy cost for activity has been calculated based on an activity record, kept by the pupils, for 3 consecutive days, on the same days as energy intake. Dietitians explained how to complete the activity records, regarding type and level of exercise during the day. For each participant, RMR value was multiplied with an average metabolic value according to his/her activities, using the tables by Ainsworth et al. (22).

Data Analysis

The diaries completed by the adolescents have been coded using McCance and Widdowson's food tables (23). All data were analyzed using the Microdiet food program

Table 1. Anthropometric data of the study population

	Overweight*		Non-overweight	
	Boys (n = 83)	**Girls (n = 48)**	**Boys (n = 185)**	**Girls (n = 186)**
Age (years)	13.2 ± 0.5	13.3 ± 0.5	13.3 ± 0.6	13.3 ± 0.6
Weight (kg)	68.5 ± 12.1‡	62.9 ± 7.7‡	48.6 ± 8.8	48.3 ± 6.9
Height (cm)	165.1 ± 9.2†	159.4 ± 5.8	160.1 ± 9.8	159.3 ± 6.5
BMI (kg/m^2)	25.0 ± 2.6‡	24.8 ± 2.8‡	18.8 ± 1.8	19.3 ± 2.0
Body fat (%)	22.8 ± 3.9‡	29.8 ± 5.0‡	15.7 ± 4.3	22.6 ± 5.0
Lean body mass (kg)	52.8 ± 8.8‡	44.0 ± 4.6‡	40.9 ± 7.4	37.2 ± 4.5

Values are means ± standard deviation.
* Cole anthropometric standards.
† $p < 0.05$.
‡ $p < 0.001$.

(version 8; University of Salford, Salford, UK). Greek food recipes were added in the basic database according to the Food Composition Tables and Composition of Greek Cooked Food and Dishes (24).

Statistical Analysis

Data are expressed as means ± standard deviation, and the statistical differences between overweight and non-overweight adolescents of the same sex were determined with an unpaired Student's t test, after checking for normality of distribution of the dependent variable. Otherwise, a Mann-Whitney test was performed. All data analyses were performed by using the SPSS statistical package (version 8.6; SPSS, Chicago, IL), and the level of statistical significance was set at $p < 0.05$.

Results

Table 1 shows the anthropometric characteristics of the adolescents of both sexes, overweight and non-overweight. There were no differences in age between non-obese and obese children for either girls or boys. As expected, weight, BMI, and body fat were significantly higher ($p < 0.05$) in overweight boys and girls compared with the non-overweight groups. It should be noted that lean body mass was higher ($p < 0.05$) in the overweight groups and that overweight boys were taller than non-overweight boys ($p < 0.05$).

Table 2 describes the average daily energy intake and expenditure of the subjects. The overweight adolescents of both sexes reported a lower energy intake than did the

Table 2. Daily energy intake and energy expenditure of overweight and non-overweight adolescents

	Overweight*		Non-overweight	
	Boys (n = 83)	**Girls (n = 48)**	**Boys (n = 185)**	**Girls (n = 186)**
Energy intake (kcal)	2290 ± 930†	1720 ± 689†	2465 ± 858	2062 ± 652
kcal/kg body weight	33.4 ± 14.8‡	28 ± 10.7‡	52 ± 20.8	43.9 ± 16.3
kcal/kg lean body mass	44.3 ± 18.4‡	39.2 ± 14.9‡	61.6 ± 24.3	56.5 ± 19.9
Energy expenditure (kcal)	3112 ± 368‡	2385 ± 177‡	2540 ± 270	2078 ± 160
RMR	1870 ± 213‡	1535 ± 103‡	1518 ± 158	1339 ± 93
Physical activity factor	1.7 ± 0.1	1.5 ± 0.0	1.7 ± 0.1	1.5 ± 0.1
Energy intake − Energy expenditure (kcal)	−822 ± 991‡	−665 ± 720‡	−88 ± 874	−16 ± 709

Values are means ± standard deviation. RMR, resting metabolic rate.
* Cole anthropometric standards.
† $p < 0.05$.
‡ $p < 0.001$.

Table 3. Daily macronutrient intakes of overweight and non-overweight adolescents

	Overweight*		Non-overweight	
	Boys (n = 83)	**Girls (n = 48)**	**Boys (n = 185)**	**Girls (n = 186)**
Protein (% energy)	13.6 ± 3.6	13.8 ± 3.5	13.8 ± 3.4	13.8 ± 3.5
g/kg body weight	1.8 ± 0.9‡	1.4 ± 0.7‡	3.9 ± 2.1	3.3 ± 1.8
Carbohydrate (g)	257 ± 121†	175 ± 84†	285 ± 108	220 ± 78
Percent energy	43.9 ± 10.5	41.4 ± 11.1	45.5 ± 8.8	42.7 ± 8.9
g/kg body weight	3.8 ± 1.8‡	2.9 ± 1.2‡	6.0 ± 2.6	4.7 ± 1.9
Starch (g)	100.3 ± 67.3‡	65.9 ± 45.4†	130.7 ± 71.3	92.6 ± 55.9
Fat (g)	113 ± 54	89 ± 49	115 ± 51	102 ± 41
Percent energy	42.5 ± 9.1	44.8 ± 9.3	40.7 ± 7.9	43.5 ± 8.1
g/kg body weight	1.7 ± 0.9‡	1.4 ± 0.7‡	2.4 ± 1.2	2.1 ± 0.9
Fiber (g)	15 ± 9.7†	12 ± 6.2	19.2 ± 11.4	14.4 ± 9.1

Values are means ± standard deviation.
* Cole anthropometric standards.
† $p < 0.05$.
‡ $p < 0.001$.

non-overweight subjects ($p < 0.05$). The difference was greater when energy intake was expressed as kilocalories per kilogram body weight (both sexes; $p < 0.01$) and as kilocalories per kilogram lean body mass. Calculated energy expenditure (kilocalories per day) was found significantly higher ($p < 0.01$) for the overweight subjects. There was no statistically significant difference in the reported physical activity between overweight and non-overweight subjects. The difference in energy expenditure was mainly caused by RMR values.

Macronutrient intake is shown in Table 3. As can be seen, mean fat intake expressed as grams per kilogram body weight was significantly lower for overweight boys and girls than non-overweight ones ($p < 0.001$). When carbohydrate intake was expressed as grams per kilograms body weight, it can be seen that the overweight subjects had a significantly lower carbohydrate intake ($p < 0.001$), nearly one half of the non-overweight group. When carbohydrate intake was expressed as total grams, it was found to be significantly higher in non-overweight adolescents. Starch intake was significantly lower in both overweight boys and girls compared with non-overweight ones. Protein expressed as energy percentage did not differ in its proportion of intake between the study groups. Also, when protein intake was expressed as grams per kilogram body weight, overweight adolescents had significantly lower values ($p < 0.001$) than non-overweight. In Table 3, fiber intake is also shown. Overweight boys reported consuming less fiber ($p < 0.05$) compared with non-overweight boys.

Vitamin and mineral intake as reported by overweight and non-overweight adolescents is presented in Table 4. Both overweight boys and girls had lower iron intakes than their non-overweight counterparts. Overweight boys had statistically lower niacin intake than non-overweight boys. Both overweight and non-overweight adolescents had lower than recommended mean iron and folate intakes. Furthermore, overweight boys had lower than recommended mean intakes of vitamin A (25).

Table 5 presents the weekly food consumption of the pupils, based on the 3-day weighed diaries. Overweight adolescents reported a lower consumption of fruits, vegetables, legumes, brown bread, and yogurt, compared with their non-overweight counterparts. Furthermore, the overweight group had a significantly higher consumption of snacks often consumed at school (cheese pie, cream pie, milk chocolate, salami, sausages, french fries, pizza, potato chips, and chocolate bars).

Discussion

Height, weight, BMI, and percentage body fat based on skinfold thickness were measured in this study in two groups of adolescents, overweight and non-overweight, of both sexes. BMI and percentage body fat are good indices for assessing obesity.

Of the total sample, 31% of boys and 21% of girls had BMI corresponding to ≥25 kg/m^2 at 18 years. The rate of overweight in adolescents found in this study is lower than the one found among younger children in an earlier study in Greece (7). This may be because of the difference of the age of the participants, the difference in time period, or differences in the standards and criteria used to assess overweight

Table 4. Daily micronutrient intakes of overweight and non-overweight adolescents

	Overweight*		Non-overweight	
	Boys (n = 83)	**Girls (n = 48)**	**Boys (n = 185)**	**Girls (n = 186)**
Iron (mg)	9.8 ± 4.4†	8.1 ± 4.8†	11.4 ± 5	9.4 ± 4.2
Calcium (mg)	1279 ± 504	1028 ± 608	1357 ± 578	1123 ± 485
Vitamin A (RE)	765 ± 781	1355 ± 4736	961 ± 1013	823 ± 1002
Thiamin (mg)	1.5 ± 1.6	1.5 ± 2.3	1.8 ± 1.9	1.2 ± 0.6
Riboflavin (mg)	2 ± 1.8	1.6 ± 1.3	1.9 ± 1.2	1.7 ± 1.2
Niacin (mg)	25.7 ± 12.6†	21.7 ± 12.1	29.1 ± 12.1	24.2 ± 10.6
Vitamin C (mg)	107 ± 115	129 ± 135	135 ± 151	106 ± 98
Folate (μg)	224 ± 187	234 ± 213	262 ± 206	204 ± 135

Values are means ± SD.
* Cole anthropometric standards.
† $p < 0.05$.

and obesity. Furthermore, the prevalence of overweight in this study was found to be higher for boys than for girls. A possible explanation for this could be that girls of this age seem to be more interested in their weight and figure (26).

Overweight adolescents in this study, both boys and girls, reported a lower energy intake using a 3-day weighed dietary diary compared with the non-overweight groups. This can be shown by the percentage difference between reported energy intake and calculated energy expenditure. These results correspond well with those of other studies showing that overweight persons report a lower energy intake than their lean counterparts (13). A possible explanation for this may be under-reporting. Dietary under-reporting has been shown to be particularly prevalent in obese subjects (27–29). Ortega et al. (29) reported 9.1% of under-reporting for overweight adolescents, whereas Bandini et al. (30) found under-reporting of 30% in overweight adolescents.

Sedentary lifestyle and lack of physical activity are thought to have at least as important a role as diet in the etiology of obesity. In this study, there was no statistically significant difference between the reported physical activity of overweight and non-overweight subjects. It should be mentioned, however, that physical activity was not measured but calculated according to answers given by the adolescents, and, therefore, there are errors inherent in the methodology. There is a great possibility that the overweight subjects overestimated the time they spent in sports, and in this case, the true physical activity of overweight adolescents could be less than the results suggest (29).

With respect to differences in diet composition, it seems that the overweight adolescents in this study consumed less carbohydrates than their non-overweight counterparts. The differences of the means, when expressed as percentage of energy intake, were not statistically significant, but overweight adolescents had a significantly lower carbohydrate intake, when expressed both in total grams and in grams per kilogram body weight. There was no difference in protein intake expressed as energy percentage between the overweight and non-overweight groups. The results of this study are similar with the results reported by Gazzaniga and Burns (14) in U.S. preadolescents and Ortega et al. (29) in Spanish adolescents. They both found that overweight subjects consumed less carbohydrate compared with their lean counterparts. They also showed that lean boys consumed significantly more fiber than overweight boys. This is also a finding of this study. No statistically significant difference was found between fat and protein intakes of the non-overweight and the overweight individuals when expressed as percentage of energy intake, but it is worth mentioning that both groups had fat intakes significantly higher than recommended. This also has been shown in another study in Greece carried out by Roma-Giannikou et al. (9). Protein and fat intakes, when expressed in grams per kilogram body weight, were significantly lower for overweight adolescents compared with non-overweight ones. This finding can be attributed to higher body weight of overweight subjects or to their tendency of under-reporting.

When micronutrient intakes are concerned, overweight adolescents had lower intakes of niacin and iron. A significant part of adolescents did not meet the recommended intakes for folate, vitamin A, and iron (25).

Overweight adolescents consumed more snacks (potato chips, chocolate bars, pizza, cheese pie, cream pie), more sugar, jam, and honey, and less legumes, vegetables, and fruits than their non-overweight counterparts. Their food consumption pattern shows less adherence to the traditional

Table 5. Weekly food consumption of overweight and non-overweight adolescents

Food item	Overweight* (n = 131)	Non-overweight (n = 371)
Beef	0.95 ± 0.46	0.98 ± 0.48
Mincemeat	1.34 ± 0.73	1.28 ± 0.65
Lamb, goat	0.70 ± 0.47†	0.60 ± 0.47
Pork	1.11 ± 0.79‡	1.52 ± 0.95
Sausages	1.97 ± 0.94‡	1.25 ± 1.20
Ham	1.25 ± 2.58	0.94 ± 1.28
Salami	1.20 ± 1.70‡	0.62 ± 0.41
Chicken	1.41 ± 0.65†	1.23 ± 0.51
Fish	1.38 ± 0.56	1.25 ± 0.55
Milk whole	9.84 ± 5.21	8.58 ± 5.41
Milk chocolate	1.87 ± 0.30‡	0.50 ± 0.80
Yogurt	1.21 ± 1.23‡	2.10 ± 0.35
Feta cheese	6.42 ± 3.20	6.10 ± 5.20
Other cheeses	2.61 ± 1.91†	2.10 ± 1.92
Cheese pie	2.16 ± 1.85‡	1.22 ± 0.81
Cream pie (Bougatsa)	2.13 ± 1.58‡	0.91 ± 0.78
Pizza	2.03 ± 0.78‡	1.43 ± 1.21
Eggs	3.31 ± 2.22	3.17 ± 3.25
Lentil soup	0.32 ± 0.62‡	1.78 ± 0.45
Dry bean soup	0.75 ± 0.54‡	1.05 ± 1.02
Bread white (slices)	29.05 ± 12.32	30.75 ± 16.27
Bread brown (slices)	0.26 ± 0.75‡	3.17 ± 2.35
Sesame bread (koulouri)	1.35 ± 2.32‡	4.35 ± 3.18
Butter	2.32 ± 3.27‡	4.93 ± 6.05
Margarine	2.85 ± 4.06	2.43 ± 2.31
Olive oil	9.40 ± 6.32	10.17 ± 8.31
Seed oil	4.73 ± 4.25†	3.76 ± 3.56
Raw vegetables	5.73 ± 4.77‡	8.10 ± 6.57
Boiled vegetables	1.36 ± 0.87‡	2.30 ± 3.70
French fries, potatoes (baked, boiled)	3.58 ± 2.17‡	2.13 ± 0.67
Pasta	1.28 ± 0.88	1.25 ± 0.78
Rice	1.17 ± 0.71	1.28 ± 0.43
Apples, Pears	8.90 ± 6.45‡	11.88 ± 6.24
Citrus fruit	8.17 ± 7.06‡	11.57 ± 8.08
Bananas	2.93 ± 2.00	3.24 ± 2.90
Grapes	2.53 ± 2.17†	5.60 ± 4.77
Kiwi fruit	2.18 ± 1.97‡	4.58 ± 2.93
Juices (natural)	2.95 ± 2.15	3.40 ± 2.45
Sugar (tsp)	14.57 ± 8.25‡	9.95 ± 6.85
Honey (tsp)	1.79 ± 2.50‡	0.45 ± 0.95
Jam (tsp)	5.42 ± 6.87‡	2.31 ± 3.98
Chocolate nut spread (tsp)	2.39 ± 3.25†	1.67 ± 3.79
Cake	1.14 ± 1.23	1.33 ± 0.82
Croissant filled	3.18 ± 1.45	1.47 ± 0.85
Cookies, biscuits	1.45 ± 1.60	2.00 ± 0.87
Sweets	1.38 ± 1.81	1.69 ± 1.37

Table 5. (continued)

Food item	Overweight* (n = 131)	Non-overweight (n = 371)
Ice cream	6.90 ± 2.18	4.30 ± 1.67
Corn snacks	1.94 ± 4.98	1.42 ± 2.91
Potato chips	2.03 ± 0.78‡	0.93 ± 0.80
Chocolate bars	3.78 ± 1.65‡	2.50 ± 0.35
Cola drinks	4.23 ± 3.78	4.47 ± 3.02
Carbonated soft drinks	2.11 ± 1.76	2.29 ± 2.03
Fruit drinks	1.99 ± 1.04‡	1.58 ± 1.02

Values are means ± standard deviation.
* Cole anthropometric standards.
† $p < 0.05$.
‡ $p < 0.001$.

Mediterranean diet and an adoption of a more westernized diet compared with the non-overweight group.

These results give us information on energy intake, diet composition, energy expenditure, and body fatness of adolescents in Northern Greece. The prevalence of overweight in children and adolescents in Greece can be mainly attributed to their improper diet composition. This study has shown that overweight adolescents followed a more western diet compared with their non-overweight subjects. Given that eating habits are developed during childhood and adolescence, the findings of this study suggest that nutrition education is necessary in school programs. In this way, we can possibly achieve changes in the diet of young people, a better adherence to the traditional diets, and prevention of the upward trend of overweight in this age. Further studies on nutrition habits of Greek adolescents are needed.

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