Nutrient intake and anthropometric characteristics of adolescent Greek swimmers

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Abstract

Objective: To examine the anthropometric characteristics and nutrient intakes of adolescent swimmers in Greece.

Design: Anthropometric measurements were taken by two trained dietitians during the training season. Weighed dietary records were kept by each athlete for seven consecutive days according to instructions.

Subjects: Thirty-five adolescent swimmers aged 15 to 18 years (20 boys and 15 girls) participated in the study. They were members of two Greek national teams and were all schoolchildren.

Setting: Subjects were studied during the training season.

Main outcome measures: Weight, height, body mass index, percentage of body fat and nutrient intakes.

Statistical analysis: T-tests or paired t-tests, when appropriate, were used to compare body mass index, percentage of body fat, energy intake, protein and vitamin and mineral intakes of boys with girls and to compare body fat measurements made using two methods.

Results: Body mass index and percentage of body fat were within the normal range. Mean caloric intake was 11 980 ± 3160 kJ for boys and 10 150 ± 2720 kJ for girls. Protein intake varied from 0.8 g/kg to 1.5 g/kg with no difference between the sexes. Carbohydrate intake was lower and fat intake higher than recommended. Vitamin and mineral intakes showed a wide variation among athletes. Their mean intakes exceeded the recommended values but some athletes had low intakes.

Conclusion: The study showed that the participating adolescent swimmers had an unbalanced diet and not an appropriate one that could maximise their athletic performance. This calls for nutrition education for the athletes as well as nutrition monitoring and assessment, in order to assist and enable physiologic growth and optimum athletic performance.

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Key words: adolescent swimmers, nutrition, dietary intakes, anthropometry, Greece

Introduction

Interest in sports has increased greatly over the last decades. Health as well as physical performance of athletes depend on many factors of which nutrition is today accepted as an important one (1). Appropriate dietary intervention together with proper training techniques can lead to numerous improvements in an athlete’s performance, including, for example, improved physical condition; better protection against injuries; faster wound healing and recovery; maintenance of a stable athletic performance both quantitatively and qualitatively; better endurance; and proper muscular growth (2,3). On the other hand inappropriate nutrient consumption affects an athlete’s ability to cope with competition or training and can lead to inconsistent performance. Studies in the past have revealed that often athletes are in negative energy balance (4), have low carbohydrate intakes (5) or low vitamin and mineral intakes (6). Adolescents in particular have increased energy and nutrient requirements for normal growth and development (7). Adolescent athletes therefore require specific nutritional support in order to maintain normal growth and physiologic maturation as well as to cope with athletic performance (8). More specifically, adolescent athletes require more energy depending on the intensity, duration and type of exercise performed. This energy is better utilised if it is supplied mostly by carbohydrates (9). Adolescent athletes also have increased protein needs to accommodate growth, maturation and exercise (9). Among the vitamins and minerals, iron is particularly important, as well as the B vitamins (9). Maintenance of adequate hydration is also important for child and adolescent athletes (10).

Obtaining sufficient energy and nutrients from food has been proved even more difficult for teenage athletes than other adolescents because their days are filled with training as well as normal activities including school attendance and homework (11). Parents, coaches and school officials need to support adolescents by helping them to have sufficient food intake at the times when their rigorous schedules allow them to eat.

Swimming is a sport well known from ancient times (12). Competitive swimmers have increased caloric and nutrient demands that could be met by eating more high calorie nutrient-dense foods (11). Inadequate energy consumption can have negative results on an athlete’s performance and physical condition (9).

In Greece, despite the great interest in sports since ancient times, there is no adequate information regarding the dietary practices and nutritional status of Greek athletes today. Moreover, very little is known about the dietary intake and nutritional habits of adolescent athletes.

The purpose of the present study is to partly fill this gap by investigating the anthropometric characteristics and the nutrient intakes of adolescent swimmers in Greece.
Methods

Subjects
The study was conducted from February 1999 to January 2000. Initially 40 elite adolescent swimmers agreed to participate in the study but only the ones who completed dietary records were included. The final sample consisted of 35 swimmers aged 15 to 18 years, consisting of 20 boys and 15 girls. They were members of two Greek national teams and were all school students.

The athletes were studied during the athletic training season. During this season, athletes trained in gymnastics in addition to swimming practice. In total they trained for two-and-a-half hours every day.

The study was approved by the research committee of the Technological Educational Institution of Thessaloniki.

Anthropometric data
Anthropometric measurements were taken for all athletes by one trained dietitian. Height was measured to the nearest centimetre without shoes (Harpenden stadiometer, Bergers Hill, West Sussex, UK) and weight was recorded to the nearest 0.1 kg with a portable digital scale (Tefal 74150, Langley Slough, Berkshire, UK) that was calibrated daily. Swimmers were weighed in their swimming wear. Weight and height were measured at one morning visit during the training season. Body mass index (BMI) was calculated for all athletes.

Percentage of body fat was estimated using skinfold measurements and the bioelectrical impedance method. Four skinfolds were measured: triceps, abdomen, suprailiac and thigh, using Lange skinfold calipers (Ponderal fat meter, Beta Technologies, Santa Cruz, California, USA). Body density was calculated using the formulas of Jackson et al. (13,14). Body density was converted to percentage of body fat using the Siri equation (15). Bioelectrical impedance measures of body fat were taken using the Maltron instrument (Maltron, BF 905, Rayleigh, Essex, UK). All subjects were instructed to drink water to ensure adequate hydration and to avoid caffeine two to three hours before the measurement of bioelectrical impedance. The subjects lay down and electrodes were placed on the right hand and foot for the measurements.

All data were compared with standards given by Worthington-Roberts and Williams (11).

Dietary intake
Each athlete kept weighed dietary records for seven consecutive days. Subjects had to weigh food according to instructions given orally to them and to their family by two dietitians. All foods and drinks consumed during each 24-hour period were weighed. Scales accurate to two grams (Waymaster, 750 K, Reading, UK) were provided to the athletes as well as cups and plates with known weight to hold the food during the weighing. After the completion of all measurements the dietitians checked the completed records. The average daily nutrient intake was calculated for each subject.

Energy expenditure
Energy expenditure was estimated as the sum of resting metabolic rate (RMR), calculated using the equation of Schofield (16), and physical activity based on all activities carried out during a training day and converted to their energy value using the tables of Ainsworth et al. (17).

Analysis of data
Dietary data was analysed using the Microdiet computer program (University of Salford, Salford, UK, Microdiet, version 8, 1993) for food analysis. Foods were coded using McCance and Widdowson’s food tables (18). Greek food recipes were added into the basic database.

The 1989 USA recommended dietary allowances (19) were used for assessing the adequacy of nutrient intake since no Greek standards were available. Since recommended dietary allowances do not refer specifically to athletes, the values used as standards for comparisons of more carbohydrate and protein intakes were taken from scientific papers (20,21).

All data were analysed using the SPSS statistical package (SPSS Inc, Chicago, SPSS for Windows, version 8.6, 1997). Data were expressed as means ± standard deviation. Ninety-five per cent confidence intervals for the means were also calculated. Statistical differences between the samples were determined by student’s t-test.

Results
The anthropometric characteristics measured are shown in Table 1. There was no difference between the mean BMI of boys and girls (P = 0.24). Percentage of body fat was statistically lower for boys compared with girls (P = 0.001). Skinfold measurements and bioelectrical impedance gave similar values for percentage of body fat (P = 0.611). Both BMI and percentage of body fat were within the normal ranges for age for both boys and girls.

Table 2 shows the results for energy and macronutrient intakes. A great variation in the energy intake between athletes was observed in this study. Mean energy intakes of both boys and girls (11 980 ± 3160 kJ, 10 150 ± 2720 kJ) were not statistically different to their estimated mean energy expenditure during the training season (11 380 kJ for boys and 9700 kJ for girls, P = 0.61 and P = 0.66, respectively). Five athletes were in negative energy balance. There was no difference between the energy intake of boys and girls (P = 0.24).

The mean carbohydrate intake as a percentage of the total energy intake was 44% for boys and 47% for girls. Carbohydrate intake varied from 4.1 g/kg of body weight to 6.7 g/kg for boys and from 4.8 g/kg of body weight to 7.2 g/kg for girls. Only seven athletes had carbohydrate intakes equal to or above the recommended (7 g/kg of body weight) (20).

Protein intakes varied from 0.8 g/kg of body weight to 2.5 g/kg for boys and from 1.1 g/kg to 1.5 g/kg for girls. The athletes with the lowest energy intakes also had lower than recommended protein intakes (21). There was no difference between protein intakes of boys and girls (P = 0.19).
The mean fat intake was 42.5% of energy for boys and 40.6% of energy for girls, much higher than the recommended level of 30% or less (9).

The vitamin and mineral intakes of the athletes are shown in Table 3. Although mean intakes for both boys and girls were above the recommendations (9) for the vitamins and minerals examined in the study, those athletes with the lowest energy intakes had lower than recommended intakes of vitamins B1, B2, and calcium, iron and zinc. A high mean intake of vitamin C was found. The mean vitamin C intake of the girls was higher than the boys \((P = 0.05)\).

Discussion

The anthropometric characteristics and dietary intakes of adolescent Greek swimmers have been examined in the present study. The data were collected during the training season in which the adolescent swimmers have the highest energy expenditure. There is no doubt that suitable nutrition plays an important role in athletic performance providing for the long-term needs of training and the short-term needs of competition (8,9). The results of this study indicated potential dietary problems that could limit the performance of the athletes.

The mean BMI and percentage of body fat were within the normal range for adolescent athletes. Percentage of body fat was estimated with two different methods but no difference was found between them, although a number of studies highlight limitations of the bioelectrical impedance method (22).

Energy intakes showed a wide variation among the athletes. Mean energy intake was not statistically different from mean estimated energy expenditure. Three boys and two girls were in negative energy balance when energy needs were calculated according to their resting metabolic rate and physical activity. Since the athletes were weighed once at the beginning of the study we do not know if they lost weight. Another possible explanation is the errors inherent in the methodology for assessing food intake. One of the main errors associated with diet records is under-reporting of food intake (23). The degree of under-reporting has not been calculated in this study.

Table 1. Anthropometric data of Greek adolescent swimmers (mean ± SD, 95% confidence interval)

<table>
<thead>
<tr>
<th>Boys (n = 20)</th>
<th>Girls (n = 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>16.3 ± 0.5 (16.0, 16.5)</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.78 ± 0.1 (1.73, 1.83)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>66.9 ± 10.6 (61.9, 71.9)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>23.1 ± 1.8 (20.5, 22.1)</td>
</tr>
<tr>
<td>Percentage of body fat</td>
<td>6.8 ± 2.2 (5.8, 7.8)</td>
</tr>
<tr>
<td>Based on four skinfolds</td>
<td>6.7 ± 2.6 (5.5, 7.9)</td>
</tr>
</tbody>
</table>

(a) BIA, bioelectrical impedance analysis

Under-reporting can occur because subjects fail to record portions of food correctly, omit foods eaten or restrict their food intake during the period of the study. The adolescents completed the weighed food diaries themselves and parents were not involved. Edwards et al. (24) believe that under-reporting may be unconscious and may be related to perceived body image.

The mean energy intake of the female swimmers in the present study was very similar to that reported by Barr et al. (25) for female swimmers aged 17 years (10 700 kJ). Mean energy intakes of both boys and girls were lower than those reported by Berning et al. (26) of 21 928 kJ for boys (15 to 18 years old) and 15 002 kJ for girls (14 to 17 years old).

Carbohydrate intakes also showed a wide variation and, for a number of athletes, they were found to be lower than recommended. It must be noted that Berning et al. reported an intake of carbohydrate of 46% to 48% of...
energy intake (26), similar to the one reported in this study (44% to 47%). A lower than recommended carbohydrate intake by swimmers can eventually lead to the depletion of glycogen stores (20). Research has suggested that the gradual and chronic depletion of stored glycogen may decrease endurance and exercise performance (27).

Girls had a higher mean carbohydrate intake and lower fat and protein intake compared with boys, consistent with an intake closer to that recommended. Fat intake also varied greatly among athletes and for most athletes it was found to be higher than recommended. It has been reported that a fat intake greater than 30% to 35% of the total energy intake is associated with various problems and reduces ability to sustain high intensity exercise during sports (9).

The general population of adolescents in Greece today has a high fat intake, higher than older adults and the elderly (30% to 35%) (28). Recent studies have shown that the fat intake decreases as age increases. The current high fat intake of Greek adolescents is attributed mainly to the intake of fast foods and the abandonment of the traditional diet (29).

Protein intake varied between athletes. Lemon (21) suggests a protein intake of 1.2 to 1.4 g/kg body weight for adult endurance athletes and 1.6 to 1.7 g/kg for those involved in strength training. However, to date children and adolescents have not been systematically studied and it is possible that the requirements for growth would further increase the dietary protein requirements of those who are physically active.

Macronutrient intakes found in this study are similar, in terms of proportional compositions, with the ones found for the general adolescent population in northern Greece (29), indicating that athletes do not change the composition of their diet to meet athletic needs.

This finding is similar to that reported for adult athletes (1). Many surveys have shown that the food consumption practices of athletes, and more specifically the percentage of energy contributed by each of the macronutrients, are similar to those of the general population. Many surveys have also shown that only a few athletes follow the best dietary patterns for optimal nutrition. Athletes eat too much fat at the expense of carbohydrate (1).

Vitamin and mineral intakes showed a wide variation among athletes and, although mean intakes were above recommended values, some athletes had lower intakes than the recommended dietary allowances for certain vitamins and minerals. The high mean intake of vitamin C has been found in other studies of Greek adolescents (30). Those athletes with the lower energy intakes were found to have lower intakes of vitamins B1 and B2 and of calcium, iron and zinc. Attention, therefore, must be given to those athletes in order to improve their nutritional status.

In conclusion, this study showed that the diet of participating adolescent swimmers did not follow the patterns recommended and was not appropriate for maximising athletic performance. This suggests nutrition education is urgently needed for adolescent athletes as well as nutrition monitoring and assessment, in order to assist and enable physiologic growth and optimum athletic performance. Any recommendations and education in regard to the diet of adolescent athletes should also include parents, coaches and others involved with sport administration.

| Table 3. Micronutrient mean daily intakes of Greek adolescent swimmers, expressed as mean ± SD (95% confidence interval) |
|---|---|---|---|
| Intakes (Boys (n = 20)) | RDA(a) | Intakes (Girls (n = 15)) | RDA(b) |
| Vitamin A (µg) | 1130.7 ± 879 (719.3, 1542.1) | 1000 | 1338.6 ± 449 (1089.9, 1573.3) | 800 |
| Vitamin B (mg) | 1.7 ± 0.6 (1.4, 1.9) | 1.5 | 1.6 ± 0.7 (1.2, 1.9) | 1.1 |
| Vitamin B2 (mg) | 2.5 ± 1.5 (1.8, 3.2) | 1.8 | 2.8 ± 1.2 (2.1, 3.4) | 1.3 |
| Niacin (N eq) | 27.3 ± 11 (22.1, 32.4) | 20 | 21.4 ± 9.1 (16.4, 26.4) | 15 |
| Vitamin. B12 (µg) | 5.2 ± 3.2 (3.7, 6.6) | 2.0 | 4.1 ± 2.7 (2.6, 5.6) | 2.0 |
| Folic acid (µg) | 310 ± 122 (252.9, 367.1) | 200 | 296 ± 174 (199.6, 392.4) | 180 |
| Vitamin. C (mg) | 180 ± 72 (146.3, 213.7) | 60 | 260 ± 149 (177.5, 342.5) | 60 |
| Calcium (mg) | 1421 ± 64 (1391, 1451) | 1200 | 1411 ± 120 (1344, 1477) | 1200 |
| Iron (mg) | 14.4 ± 5.4 (11.8, 16.9) | 12 | 19.1 ± 4.2 (16.7, 21.4) | 15 |
| Zinc (mg) | 20.1 ± 9.4 (15.7, 24.5) | 15 | 18 ± 3.2 (16.2, 19.7) | 12 |
| Phosphorus (mg) | 1622 ± 630 (1327, 1916) | 1200 | 1451 ± 426 (1215, 1686) | 1200 |

(a) RDA, USA recommended dietary allowances (19).

References
Nutrient intakes of swimmers


