ENERGY BALANCE AND BODY COMPOSITION IN STUDENT ATHLETES

Balanço energético e composição corporal entre atletas escolares

Balance energético y composición corporal de atletas escolares

Original Article

ABSTRACT

Objective: To relate the energy balance and the body composition of student athletes. **Methods:** This is a cross-sectional analytical study, whose data was collected between the years 2010 and 2012. The sample consisted of 134 male and female adolescents, aged 10 to 18 years, engaged in any of five distinct activities: judo, swimming, tennis, rhythmic gymnastics and artistic gymnastics. The skinfolds were used as method for assessing body composition and the energy balance (EB) was calculated by subtracting the total energy intake (TEI) from the value of their estimated energy requirement (EER). All statistical procedures were performed using SPSS 19.0. Student's t-test was used to compare data between genders, and the correlations were performed using Pearson's correlation coefficient. Values of $p \leq 0.05$ were considered significant. **Results:** The older individuals in both genders showed higher values of mid-upper arm circumference (MAC) and body fat percentage (BFP). It was possible to perceive a significant negative correlation between EB and BFP for males, and a positive, but not significant, correlation in females. It was also observed that a majority of the participants (51.1%) showed a positive energy balance. **Conclusion:** A positive energy balance was found in a majority of the adolescents evaluated and this data was negatively correlated with body composition only in boys. Among women, however, there was no correlation between these variables.

Descriptors: Anthropometry; Adolescents; Nutritional Assessment.

RESUMO

Objetivo: *Relacionar a composição corporal e o balanço energético de atletas escolares.* **Métodos:** *Trata-se de um estudo transversal e analítico, cuja coleta de dados ocorreu entre os anos de 2010 e 2012. A amostra constituída por 134 adolescentes de 10 a 18 anos, de ambos os sexos, praticantes de cinco modalidades distintas: judô, natação, tênis, ginástica rítmica e ginástica artística. As dobras cutâneas foram utilizadas como método para avaliação da composição corporal e o balanço energético (BE) foi calculado a partir da subtração do valor energético total consumido (VET) pelo valor das necessidades energéticas estimadas (NEE). Os procedimentos estatísticos foram realizados no programa SPSS 19.0. Utilizou-se o teste t de Student para a comparação dos dados entre sexos e as correlações foram realizadas pelo coeficiente de correlação de Pearson. Valores de $p \leq 0{,}05$ foram considerados significativos.* **Resultados:** *Os mais velhos de ambos os sexos apresentaram maiores valores de circunferência muscular do braço (CMB) e percentual de gordura (%G). Foi possível perceber uma correlação negativa e significativa entre BE e %G para o sexo masculino e uma correlação positiva, porém sem significância no sexo feminino. Observou-se também, que a maioria (51,1%) dos participantes apresentou balanço energético positivo.* **Conclusão:** *Um balanço energético positivo foi encontrado na maioria dos adolescentes avaliados e esse dado se correlacionou negativamente com a composição corporal apenas nos meninos. No entanto, no sexo feminino, não foi observada correlação entre essas variáveis.*

Descritores: *Antropometria; Adolescente; Avaliação Nutricional.*

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RESUMEN

Objetivo: *Relacionar la composición corporal y el balance energético de atletas escolares.* **Métodos:** *Se trata de un estudio transversal y analítico cuya la recogida de datos se dio entre los años de 2010 y 2012. La muestra se constituyó de 134 adolescentes entre 10 y 18 años, de ambos los sexos, practicantes de cinco modalidades distintas: judo, natación, tenis, gimnasia rítmica y gimnasia deportiva. Las pliegas cutáneas fue el método utilizado para la evaluación de la composición corporal y el cálculo del balance energético (BE) fue realizado a partir de la disminución del valor energético total consumido (VET) por el valor de las necesidades de energía estimadas (NEE). Los procedimientos estadísticos fueron realizados en el programa SPSS 19.0. El teste t de Student fue utilizado para la comparación de los datos entre los sexos y las correlaciones fueron realizadas a través del coeficiente de correlación de Pearson. Valores de p≤0,05 fueron considerados significativos.* **Resultados:** *Los mayores de ambos los sexos presentaron mayores valores de la circunferencia muscular del brazo (CMB) y del porcentaje de grasa (%G). Se percibió una correlación negativa y significativa entre el BE y la %G para el sexo masculino y una correlación positiva pero sin significancia para el sexo femenino. También se observó que la mayoría (51,1%) de los participantes presentó balance energético positivo.* **Conclusión:** *Un balance energético positivo fue encontrado en la mayoría de los adolescentes evaluados y ese dato se correlacionó de manera negativa con la composición corporal solamente para los niños. Sin embargo, para el sexo femenino, no se observó correlación entre las variables.*

***D*escriptores:** *Antropometría; Adolescente; Evaluación Nutricional.*

INTRODUCTION

The beginning of adolescence is characterized by a period of accelerated increase in body mass and height. The age of onset, duration and intensity of this growth spurt, however, is genetically defined and varies considerably from individual to individual[1].

Changes in body composition may respond differently throughout adolescence, not only due to changes resulting from sexual maturation[2], but also according to sex[1] and to whether or not being included in regular physical exercise practice[3].

Physical exercise plays an essential role in the improvement and development of the adolescent. It is known that the practice of physical activity, when incorporated into childhood and adolescence will probably persist during adulthood[4]. At that age, specifically, sport promotes benefits related to skeletal health, besides being related to the control of blood pressure and obesity[5].

Despite this recognized benefit of sports practice for the development and growth of adolescent athletes, being engaged in sports not always ensures satisfactory changes in body composition. The body changes that occur in this phase require a greater energy and nutritional intake. Inadequate diet can pose negative effects on sexual maturation and healthy growth[6]. Some studies conducted among young athletes presented both excess weight[7] and low body weight[3]. Such changes are often associated with the sport modality practiced and the inadequate food profile, either due to food excess or deprivation[7].

Currently, a global diet modification is observed, with a tendency to increase the intake of hypercaloric foods, rich in fats and sugars, and with low nutritional content[8], and this seems to occur also among physically active individuals, frequently characterized by high caloric intake and poor quality of food choices, especially among adolescents[7].

In view of this, the present study aimed to relate the body composition and the energy balance of student athletes.

METHODS

Cross-sectional and analytical study, with sampling performed by convenience. A total of 134 young athletes (77 males and 57 females) of the city of Aracaju, SE, comprising 44 judokas, 44 swimmers, 22 tennis players, 11 practitioners of artistic gymnastics and 13 of rhythmic gymnasts participated in this study. The inclusion criteria adopted were age between 10 and 18 years, being federated according to their modality and participating in competitions. Adolescents whose training frequency was inferior to three times a week and those who then had an injury or were in a recent recovery process were excluded.

Data collection took place between the years 2010 and 2012. The individuals who composed the sample were recruited from the respective sports federations and were later contacted at their training sites. In all, six gyms were visited, two judo, one swimming, one tennis and two artistic and rhythmic gymnastics facilities. The parents or guardians of the research participants signed the Informed Consent Form.

All data collections and measurements were performed following standardized procedures. Interviews occurred in the gymnasiums of each modality and the anthropometric evaluation was performed before the training. Afterwards, a semiquantitative, adapted food frequency questionnaire[9] (FFQ) was used to estimate the caloric intake, which was followed by the calculation of the energy balance (EB).

For calculation of the estimated energy requirement (EER), the study adopted the equation proposed by the Institute of Medicine[10], which uses the variables of age, body mass, height and physical activity level (PAL) to estimate the total energy expenditure, added to extra energy for deposition, since they are adolescents.

The PAL was estimated from the adolescents' occupational and sports activities. These data were recorded on a table that contained the days of the week and described, from the report of the adolescents or those in charge, the activities performed during the day. With that aim, the reference values of the Institute of Medicine[10] were also used.

The total energy intake (TEI) of the diet was estimated from the application of the FFQ. Frequency categories were transformed into daily consumption frequencies and data were analyzed using the software Virtual Nutri Plus®.

With the values of the TEI and the EER, it was possible to calculate the energy balance (EB) of the athletes by subtracting the TEI from the EER of a day of training. EB values up to ± 10% of the EER ($-10\% \leq EB \leq +10\%$) were considered in equilibrium[11].

Body mass, height, relaxed arm circumference (AC), triceps skinfold thickness (TST) and subscapular skinfold thickness (SST) were measured for body composition assessment. Both the perimeter of the arm and the skinfolds were measured on the right side of the participants. In adolescents aged 18 years, the abdominal skinfold thickness (AST) was also measured. Skinfolds were measured in triplicate, and the mean value was always used. From the results, the body mass index (BMI), body fat percentage (BFP) and mid-upper arm circumference (MAC) were obtained.

The anthropometric measurements (weight, height and arm circumference) were conducted according to recommended techniques[12]. A portable stadiometer, Alturexata®, was used to measure height and the weight was measured by using a Lider® digital scale. The BMI was classified according to data from the World Health Organization[13].

As for the skinfold measurement, a Lange® adipometer was used. For calculation of the BFP, the following equation was used for children and adolescents between six and seventeen years: ($BFP = 1.35 (TST + SST) - 0.012 (TST + SST)^2 - C$)[12], where "C" corresponds to the constant used depending on age, sex and race. For 18-year-old adolescents, the following equation was used: ($BFP = (457 \div D) - 412.4$)[14], where "D" corresponds to body density ($D = 1.1030 - [0.000815 (X3) + 0.00000084 (X3^2)]$), where X3 is the sum of TST, SST and AST.

Due to the physiological and morphological changes that occur during puberty, the adolescents were separated into two groups according to the age range, following the recommendation of the Institute of Medicine[10], for data analysis.

The descriptive statistics included the calculation of means, standard deviation, medians and interquartile range. Data were tabulated and analyzed in software SPSS version 20.0. The normality of the sample was verified by the Kolmogorov-Smirnov test. Student's t-test for independent samples was used in the comparison of continuous data between sexes. The correlations between age and BFP, age and MAC, and BFP and energy balance were performed with use of Pearson's correlation coefficient. Values of $p \leq 0.05$ were considered significant.

The study was carried out with human beings and was approved by the Research Ethics Committee of the Federal University of Sergipe CAAE no. 0032.0107.000-10.

RESULTS

Of 134 young people participating in the research, 57.5% (n=77) were males. The mean age found in the group was 13.46 ± 2.31 years. As for the nutritional status, 72.4% (n=97) were eutrophic, 1.5% (n=2) were underweight and 26.1% (n=35) were overweight.

Table I summarizes the averages of the anthropometric variables of the individuals participating in the study, sectioned according to sex and age range.

When comparing the sexes in the same age range, it was observed that, in relation to female adolescents, the male adolescents had a higher body mass index ($p=0.008$, among those younger than 14 years, and $p=0.002$ among individuals aged 14 years or more), and larger height ($p=0.016$, for those under 14 years of age, and $p<0.001$ for individuals aged 14 years or over). Regarding MAC and BFP, individuals younger than 14 years did not differ among themselves; only those aged 14 years or older did so. Among the group aged 14 years or more, the male gender presented more muscle mass content, while the female sex had higher body fat percentages.

On the other hand, when comparing age groups within the same sex, all anthropometric variables had higher values for the older ones, except for the BFP among the boys.

Figure 1 shows the correlation analysis between the variables age and BFP, and between age and MAC, in each sex. Muscle mass was significantly higher with advancing age for both sexes ($p<0.001$).

When analyzing the correlation between energy balance and BFP, a weak positive correlation was observed in the female sex; in the male sex, however, these data differed and showed an inverse relation (Figure 2).

Table I - Anthropometric characteristics of student athletes according to sex and age group. Aracaju, Sergipe, 2012.

Variables	Male (n=77)		Female (n=57)	
	<14 years (n=40)	≥14 years (n=37)	<14 years (n=36)	≥14 years (n=21)
Weight (kg)	47.88 (10.57)[a]	69.03 (17.66)[a.b]	41.21 (8.92)	55.95 (12.76)[b]
Height (m)	1.54 (0.08)[a]	1.73 (0.07)[a.b]	1.49 (0.08)	1.63 (0.07)[b]
BMI (kg/m^2)	20.10 (3.51)[a]	23.00 (5.12)[b]	18.43 (2.51)	21.02 (3.82)[b]
MAC (cm)	18.50 (1.58)	25.20 (3.18)[a.b]	17.92 (1.84)	19.64 (1.81)[b]
TST (mm)	17.56 (6.97)	15.95 (9.82)	15.57 (6.20)	19.84 (6.32)[b]
SST (mm)	12.37 (5.97)[a]	13.81 (6.90)	9.62 (4.82)	14.61 (8.20)[b]
AST* (mm)	---	10.00 (0.71)	---	30.08 (1.06)
BFP	22.83 (6.00)[b]	19.80 (7.14)	21.88 (6.06)	25.42 (4.88)[a,b]

BMI: Body Mass Index; BFP: Body Fat Percentage; MAC: Mid-upper Arm Circumference; TST: Triceps Skinfold Thickness; SST: Subscapular Skinfold Thickness; AST: Abdominal Skinfold Thickness. *Performed only with athletes>18 years old; [a] Significant difference ($p \leq 0.05$) between sexes in the same age group; [b] Significant difference ($p \leq 0.05$) between age groups of the same sex.

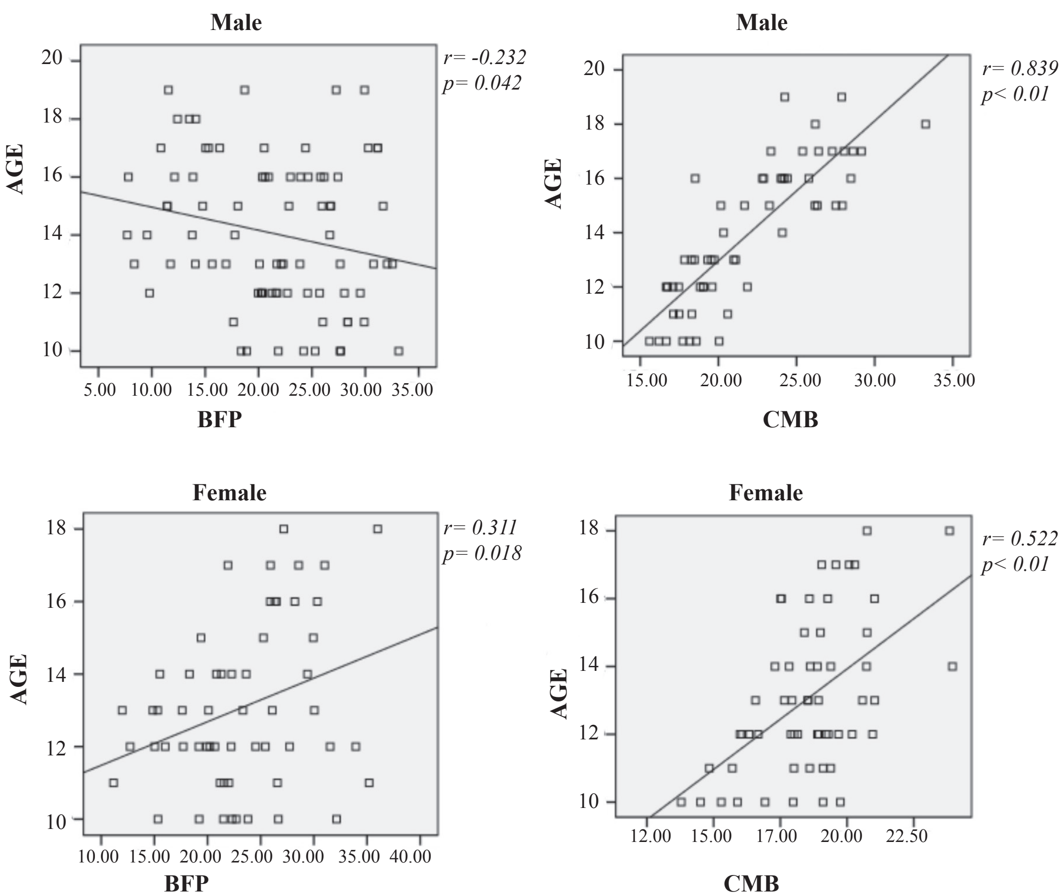

Figure 1 - Correlation between age and fat percentage and between age and mid-upper arm circumference, according to sex, among student athletes. Aracaju, SE, 2012.

r = Pearson's correlation; BFP = Body Fat Percentage; MAC = Mid-upper Arm Circumference

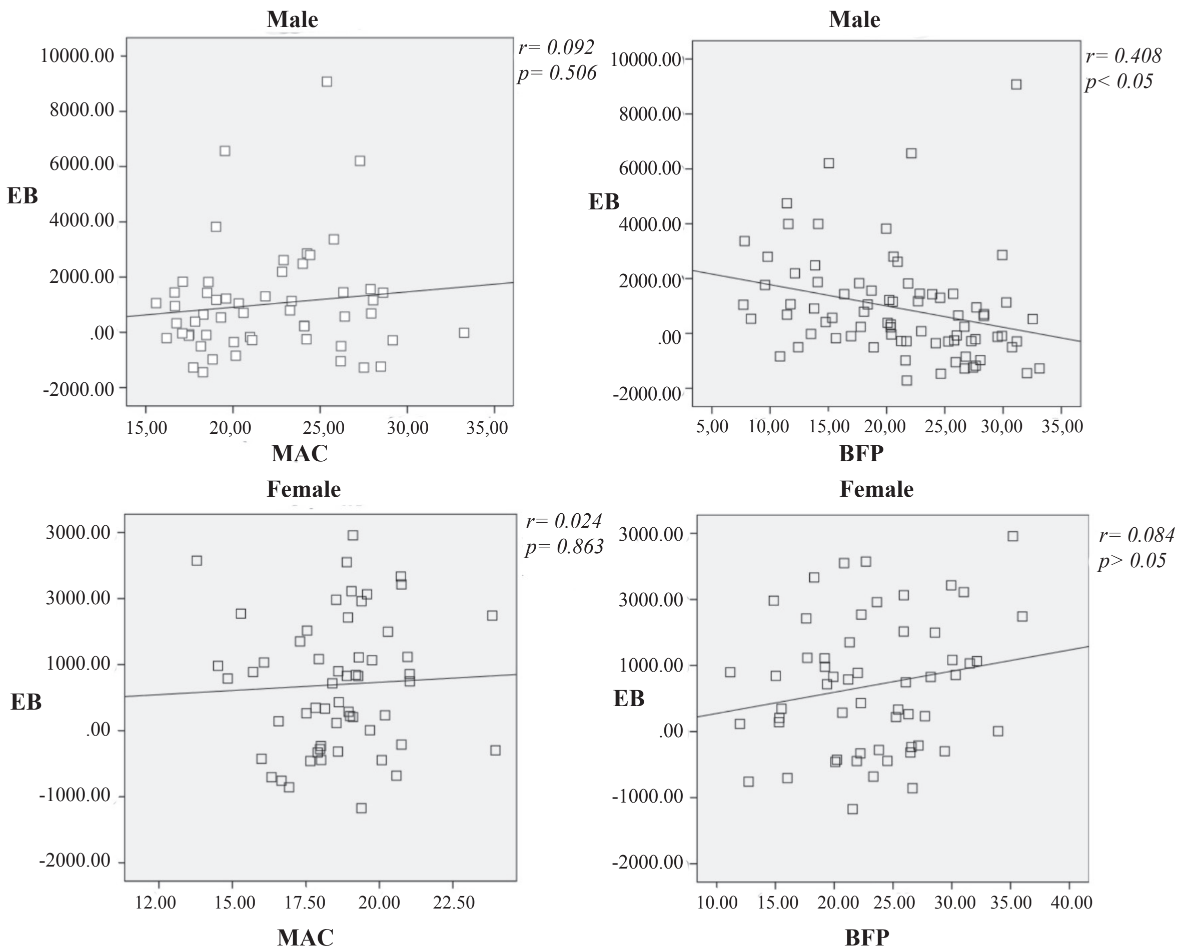

Figure 2 - Correlation between energy balance and mid-upper arm circumference and between energy balance and fat percentage, according to gender, among student athletes. Aracaju, SE, 2012.
r = Pearson's correlation, EB = Energy Balance, MAC = Mid-upper Arm Circumference

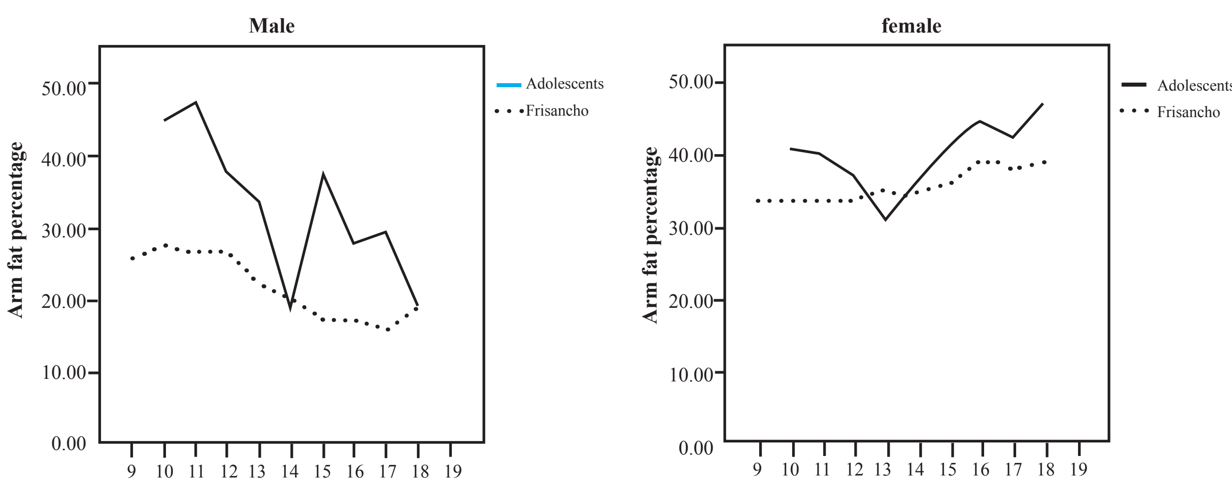

Figure 3 - Arm fat percentage of school athletes compared to the 50th percentile, according to Frisancho[15]. Aracaju, SE, 2012.

Arm fat percentage

Indicate discrepant values.

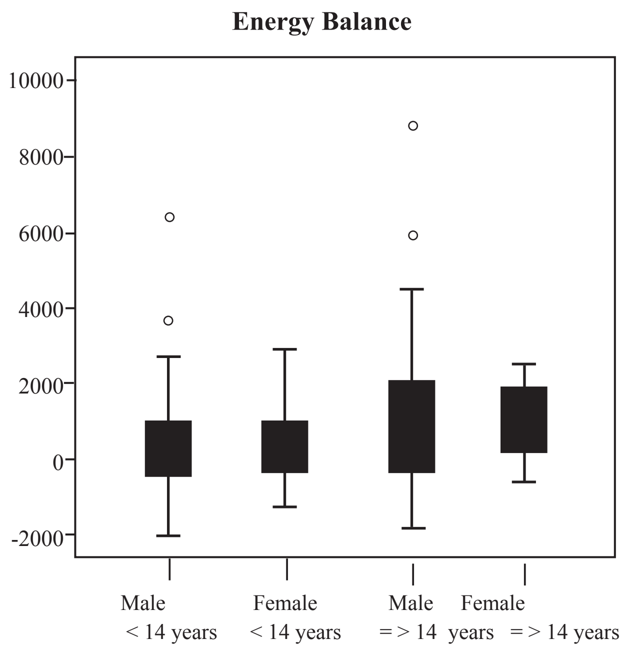

Figura 4 - Energy Balance of the student athletes according to age and sex. Aracaju, SE, 2012.

The values of the athlete's arm fat percentage were compared to the 50th percentile of Frisancho's reference[15] (Figure 3). It is noticed that the adolescents of the study presented values above that reference.

Overall, 51% (n=68) of the adolescents presented high energy balance. This prevalence was identified in 48.05% (n=37) boys and 55.36% (n=31) girls. The dispersion of the energy balance data can be observed in figure 4.

DISCUSSION

In the present study, it was observed that, despite being federated and regular practitioners of physical activity, the athletes presented high fat percentage when compared to adolescents of the same age who were not enrolled in sports activities, whose fat percentage was 16.6% for boys and 19.9% for girls[16].

During adolescence, the adult characteristics of body composition and the distribution of adipose tissue are in development[17]. The modifications that take place in body mass during puberty reflect changes in body composition, either in the proportion of fat mass and fat-free mass. Skinfolds increase after the growth spurt peak, especially among girls, and differences in body composition between the sexes increase throughout puberty[18].

There was no significant difference regarding the variables MAC and BFP in the comparison between sexes in individuals aged less than 14 years in the present study. Researches show that there are no differences in the body composition of prepubertal individuals, since they have not yet undergone the hormonal changes that occur during puberty[19,20].

Differences in body composition become evident with growth, given the hormonal changes that cause increase in adipose tissue among girls and gain of muscle mass in boys[1]. This is possibly due to the fact that the elders have undergone the period of growth and development, or are close to finishing it[20].

When comparing individuals younger and older than or equal to 14 years of age, it was found that the elders had higher muscle mass percentages in both sexes, higher fat percentage in females, and lower adiposity in males. These results differ from those obtained in studies performed with sedentary adolescents in the pre- and post-pubertal periods[21,22]. Those studies found a significant increase in both MAC and BFP among women and a significant increase in MAC and maintenance of the fat percentage in male individuals. These data demonstrate better results concerning the adequacy of body adiposity in male adolescent athletes[21,22].

When evaluating the increase in the abdominal and total body fat percentages among men in the post-pubertal period, it was verified that not practicing physical activity is a fact that positively influences the body fat gain in the adult phase[23]. Other authors have observed that the intense practice of anaerobic exercises during late adolescence is related not only to a lower body fat deposition, but also to a decreased risk for development of cardiovascular diseases[24].

During puberty, for young male athletes, there is an increase in muscle mass associated with a reduction in fat percentage. Nevertheless, these factors may vary according to the modality, the training load practiced and the caloric intake[25].

A more recent study, conducted with non-athlete adolescents, found a significant increase in fat percentage after the pubertal spurt[16]. However, when analyzing male adolescents, whether or not involved in systematized training, it was observed that those who participated in training maintained the body fat percentage after the sexual maturation period, while the adolescents who were not involved in training showed a significant increase in this variable, thus evidencing that the practice of physical activity is a favorable factor for the reduction or maintenance of fat percentage[26].

Even though the boys presented the expected profile in the post-maturation phase, with lower fat percentage when compared to the younger ones, it was observed that the adolescents' adiposity was higher when compared to the fat percentage of sedentary male subjects (16.6%)[16] and athletes (12.70%)[27] with similar age.

For adolescent females, the post-pubertal spurt stage generates lean and fat mass gain. However, young women who practice regular physical exercise generally have lower fat percentage when compared to non-practitioners[25]. The average adiposity of girls aged 14 years or older (25.42%) is very similar to the values found in non-athlete girls (26.0%)[28], possibly due to the eating behavior observed among the adolescents of the present study, with a high energy balance for the major part of them.

In adolescent athletes, the body fat percentage may vary according to the modality practiced. The mean body adiposity found in studies conducted with judokas and female gymnasts were also lower when compared to data of the present study[3,25].

As for the data on energy balance and fat percentage, a weak positive correlation with no significance was observed in this study, for the female sex. For boys, this correlation was significant and negative, which was not expected considering the reports in the literature[11]. On this result, two situations can be considered: the first, higher energy balance between individuals with lower fat percentage; and the second one, lower energy balance among those with higher fat percentage. The first situation may be a reflection of directing the extra energy towards the gain of lean body mass, a process that is highly stimulated during the growth spurt in this sex[18] and also by the physical exercise. However, the observed result reflects the second situation, with a lower energy balance and higher fat percentage, and this may be due to a sub-report of food intake among those with higher body fat percentage[29].

It was observed that both boys and girls presented higher fat percentage when compared to sedentary adolescents and to athletes of similar modalities and ages. Therefore, there is an imbalance between the energy expenditure and the food intake, which is affecting the adolescents' body composition. Thus, it is evident the need for a thorough study regarding the food pattern of these adolescents, assessing to what extent it may negatively influence the body composition of adolescent athletes.

A caloric intake of 70 to 160 Kcal per day above the needs can contribute to the weight gain in children and adolescents. With regard to the adolescents of the present study, sports practice appeared to be insufficient to suit them into a profile of body adiposity adequacy[30].

Most of the studies performed with young athletes present results that show an inadequate dietary pattern and insufficient energy intake, especially when involved in modalities related to a greater control of body mass[31,32]. However, other studies bring different results, such as a positive energy balance identified in the diet of young fighters[33] and in 45% of the sample of adolescent tennis players[11].

Approximately half of the athletes studied take part in modalities that require greater control of body weight; however, it has been documented that individuals who practice modalities divided by weight categories, such as judo, reduce food intake mainly in pre-competition periods. Generally, if not in competition periods, as in the moment when the judokas were assessed, they do not control food intake and may be above the weight category they fight in[34]. Additionally, the fact that the other part of the evaluated youth do not participate in modalities that require a more rigorous weight control can explain the results observed in relation to the energy balance.

As a limitation of the study, we emphasize the use of the FFA as a way of assessing food intake; this instrument seemed not to be sensitive enough to identify the greatest food inadequacies of the individuals.

CONCLUSION

A positive energy balance was found in a majority of the adolescents evaluated and this data was negatively correlated with body composition only in boys. Among female adolescents, however, no correlation was observed between these variables.

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