



# Relationship between different rates of physical activity and adiposity predictors in male and female adolescents

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## ABSTRACT

**Objectives:** To determinate the relationship between different rates of physical activity and adiposity predictors in male and female adolescents. **Methods:** One hundred and eleven children (57 boys and 54 girls) with average age of  $11.62 \pm 0.72$  were measured. As adiposity predictors, the BMI, the body fat percentage, and the waist/hip relation were measured. For the physical activity rates, the total energy expenditure (TEE), the habitual physical activity level (HPAL), the physical activity level (PAL) and the activity energy expenditure (AEE) were calculated through the Bouchard questionnaire and the basal metabolic rate (BMR) was determined through the Schofield-HW equation. **Results:** The sample presented significant difference between genders for age, body fat percentage, waist/hip relation and habitual physical activity level (HPAL), PAL, BMR with  $p < 0.05$ . For boys the TEE, PAL, BMR, AEE were significantly correlated with BMI ( $r = 0.86$ ;  $r = 0.70$ ;  $r = 0.91$ ;  $r = 0.78$ ) and body fat % ( $r = 0.78$ ;  $r = 0.61$ ;  $r = 0.90$ ;  $r = 0.70$ ) with  $p < 0.01$  respectively, but the TEE, BMR, and AEE presented significant correlation with the waist/hip relation ( $r = 0.28$ ;  $r = 0.45$  and  $r = 0.28$ ) with  $p < 0.05$ . For girls the TEE, PAL, BMR, and AEE were significantly correlated with BMI ( $r = 0.86$ ;  $r = 0.82$ ;  $r = 0.78$ ;  $r = 0.85$ ), and the fat % was significant with TEE, PAL, BMR, habitual physical activity level (HPAL) and AEE ( $r = 0.73$ ;  $r = -0.29$ ;  $r = 0.66$ ;  $r = 0.74$ ;  $r = 0.70$ ) with  $p < 0.05$ . **Conclusion:** The different rates of physical activity demonstrated a significant correlation with the adiposity predictors, except for the waist/hip relation in girls. The body mass demonstrated a significance relationship with the increase on the energy expenditure as a function of the higher energy requirement in order to move the body.

## INTRODUCTION

In urban communities, the fast evolution of the life-style has induced to some sociocultural changes that may be affecting the habitual physical activity level (HPAL) of children and adolescents. The constant increase on the incidence of diseases such as heart diseases, hypertension, diabetes, osteoporosis and obesity and its relation with the reduced practice of physical exercises show the necessity of studies conducted with the objective of knowing the amount of exercise recommended in order to reduce the harmful risks to the health of children and adolescents<sup>(1-4)</sup>.

According to Haskell and Kiernan<sup>(5)</sup>, physical activity is considered as any body movement produced through the contraction of

**Key words:** Energy expenditure. Physical activity. Adiposity. Adolescence.

the skeletal musculature. Nahas<sup>(6)</sup> takes the definition of Haskell and Kiernan<sup>(5)</sup> and adds that this movement generates energy expenditure above rest levels.

Thus, the total daily energy expenditure (TEE) may be considered as the sum of three components: the rest energy expenditure, the thermic effect of food and the activity energy expenditure, frequently presented as values relative to the body weight<sup>(7,8)</sup>. The basal metabolic rate (BMR) or the rest energy expenditure corresponds to the highest amount of energy expended by our body, except for expenses in high-intensity aerobic competitions, and it is defined as the amount of energy required in order to maintain the normal physiological processes during rest<sup>(7,9)</sup>.

The alteration on this rest state induces to an energy demand known as activity energy expenditure (AEE) and represents the energy expended depending on the amount of physical activity developed and on the body mass<sup>(10)</sup>. The AEE is obtained through the difference between the total daily energy expenditure and the basal metabolic rate [TEE-BMR]<sup>(11-13)</sup>. On the other hand, the physical activity level (PAL) is a mean through which one obtains information on the relative difference of physical activities by dividing the total daily energy expenditure by the basal metabolic rate [TEE/BMR]<sup>(11,13-15)</sup>.

The estimation of the daily energy expenditure during a period of 24 hours considering inactivity periods and light, moderate and intense activities represents the values known as habitual physical activity level (HPAL)<sup>(16)</sup>.

Several studies present these energy expenditure indicatives associated with the amount of physical activity performed and its relation with the development of degenerative chronic diseases among them the obesity in children and adolescents<sup>(13,17-20)</sup>.

Katzmarzyk *et al.*<sup>(17)</sup> verified the relation between physical activity, physical performance and risk factors for cardiologic diseases and the results indicated that physical activity and physical performance are respectively responsible for 5% to 20% and 11% to 30% on the variation of cardiac risk factors such as blood lipid rate and accumulation of adipose tissue in young people aged 9-18 years.

In this context, Boreham and Riddoch<sup>(21)</sup> suggest four reasons of concern on the prevailing increase of the obesity in children: the first one is because obesity is a risk factor for the development of diseases such as diabetes, hypertension and arteriosclerosis. The second reason considers the tendency for obese children to become obese adults. The third reason: adults who were obese children present increased risks of morbidity and mortality in the adulthood. Fourth: overweighted adolescents may undergo social and economic discriminations from their friends and schoolmates.

One emphasizes that with the increase on the obesity epidemics worldwide, the ability of identifying individually, the sooner as possible, the risk ages and the obesity development factors is particularly important for the development of prevention strategies<sup>(22)</sup>.

The use of adiposity predictors such as the body mass index (BMI), the waist/hip relation (WHR) and the body fat percentage

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Received in 11/3/05. 2<sup>nd</sup> version received in 19/5/05. Approved in 31/5/05.

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have been widely accepted in literature with the objective of employing these indicatives in the obesity prevention, which has been characterized as multifactor disease with contribution of elements such as diet, physical activity, genetics and other factors<sup>(13,17,18,23-25)</sup>.

Despite the advances on this area, the literature does not present in a clear way, which would be the relation between physical activity indicatives and the obesity predictors for boys and girls. How the responses of these indicatives in relation to the increase on the body mass will be? Is the increase on these indicatives associated with body energetic expenditure? Therefore, the objective of this study is to analyze the correlation between physical activity indicatives and the body adiposity predictors in adolescents from both genders.

## MATERIAL AND METHODS

### Sample

The intentional sample was initially composed of 187 individuals with ages ranging from 10.5 to 12.9 years, once this age range, besides the several biological alterations, is characterized by evident behavioral alterations and less dependence on the parents.

Only 111 adolescents (57 male and 54 female) were included in the study because they returned the questionnaires all filled out, and all adolescents attended to public schools of the central region of Curitiba – PR.

The consent term for their participation was sent to their parents, who were informed on all procedures to be adopted and were free to interrupt their participation anytime. The project was approved by the Ethics Research Committee of the Biologic Sciences Sector – Paraná Federal University.

### Instruments and procedures

#### Daily physical activity level

The physical activity level was evaluated using a daily energy expenditure recall developed by Bouchard<sup>(16)</sup>. This method consists of a card composed of three weekly days (Monday, Tuesday and Saturday), where the child's daily activities were recorded each 15 minutes and it was possible estimating the daily energy expenditure through body weight (kcal/kg/day) as well as the habitual physical activity level (HPAL) through the average of the three days selected.

The questionnaire presents reproducibility in children older than 10 years of age ( $r = 0.91$ )<sup>(26)</sup>. Guedes<sup>(27)</sup> in study with sample composed of Brazilian adolescents indicated correlation of  $r = 0.74$  and  $r = 0.79$ , corroborating evidences that self-recall instruments may produce information in relation to the habitual physical activity level in adolescents with acceptable reproducibility. The recall questionnaire was answered by the adolescent and filled as an interview with the aid of the appraiser, who stimulated the individual to recall the activities developed during the day before. Through values found, the TEE, AEE, PAL and HPAL could be calculated.

For the estimation of the basal metabolic rate, the Schofield-HW formula<sup>(14)</sup> developed for children aged 3-18 years was used.

- For boys, the BMR =  $(16.25 \times \text{body mass}) + (1.372 \times \text{height}) + 515.5$

- For girls, the BMR =  $(8.365 \times \text{body mass}) + (4.65 \times \text{height}) + 200$

#### Body mass index (BMI)

With the objective of calculating the BMI, the body mass and stature were measured. For the body mass, a digital scale (*Filizola*) with resolution of 100 grams was used and all individuals were measured in standing position, barefoot and wearing only trunks and t-shirt. For the stature, a flexible tape measure with measure scale of 0.1 cm was used and vertically fixed on the wall, where the adolescents were evaluated barefoot, in standing position and

with heels together against the wall, measuring the longest distance between the plantar region and the vertex using a right angle for support in the vertex<sup>(29)</sup>. With these measures, the BMI = body mass/stature<sup>(2)</sup> was calculated.

#### Body fat percentage

In order to estimate the body fat percentage, the triceps and calf skinfolds were measured using a scientific compass label *Cescorf*. The triceps skinfold was localized in the medial part between the acromion and the olecranon in the posterior part of the extended arm. The calf skinfold was localized in the point of highest circumference with knee inflected at 90 degrees. The measurements were conducted three times and the average between all measurements was adopted<sup>(28)</sup>. The Slaughter<sup>(29)</sup> equation, which takes into consideration both the gender and the sexual maturation stage, was used to estimate the body fat percentage.

Thus, for the calculation of the body fat percentage, the participants evaluated themselves according to maturational classification of Tanner (1962)<sup>(30)</sup>. This method includes the identification of the current development stage of the secondary sexual characteristics of the pubic hair as suggested by Martin *et al.*<sup>(31)</sup> and Bojikian *et al.*<sup>(32)</sup>, who identified the efficiency of the pubic pilosity self-evaluation on the genital development evaluation and a satisfactory agreement with the medical evaluation of 0.61 and 0.53 for both males and females, respectively<sup>(31,32)</sup>.

#### Waist/hip relation (WHR)

A flexible tape measure with measure scale of 0.1 cm was used. The individual remained in standing position and was told to keep normal respiration. The waist circumference was determined in such way that the appraiser surrounded the tape measure horizontally at the omphalion point level. The hip measurement was conducted in the same way but at the trochanteric point<sup>(29)</sup>. The WHR was calculated as the waist/hip relation.

#### Statistical treatment

The descriptive statistics (average and standard deviation) was used for the characterization of the sample and for the comparison between genders; the t-Student test for independent samples was used. For the determination of the relation degree between the variables investigated, the Pearson correlation was used. The significance level adopted was 0.05.

## RESULTS

The results of the t-test indicated significant differences between boys and girls for the body fat percentage ( $t = 105.28$  (1.109)  $p < 0.001$ ), waist/hip relation (WHR) ( $t = 100.52$  (1.109)  $p < 0.001$ ), HPAL ( $t = 100.83$  (1.109)  $p < 0.001$ ), PAL ( $t = 3.99$  (1.109)  $p < 0.05$ ) and BMR ( $t = 105.55$  (1.109)  $p < 0.0001$ ) as verified in table 1. All individuals of this sample were found between stages 2 and 3 of sexual maturation, being classified as pubescent<sup>(30)</sup>.

TABLE 1  
Average and standard deviation for the variables investigated

	Total (n = 111)	Male (57)	Female (54)
Decimal age	11.62 ± 0.72	11.84 ± 0.81	11.39 ± 0.52
Body mass (kg)	42.57 ± 11.98	42.65 ± 13.49	42.49 ± 10.27
Stature (cm)	148.90 ± 8.53	148.91 ± 9.66	148.89 ± 7.23
BMI	18.97 ± 4.06	18.89 ± 4.1	19.06 ± 4.05
Body fat %	19.60 ± 8.85	17.43 ± 9.4**	21.85 ± 7.70
WHR	0.79 ± 0.05	0.82 ± 0.04	0.77 ± 0.05†
TEE (kcal/day)	1,736.89 ± 510.09	1,792.69 ± 587.75	1,675.40 ± 405.09
HPAL (kcal/kg/day)	40.67 ± 3.98	41.66 ± 4.24**	39.57 ± 3.38
PAL (TEE/BMR)	1.27 ± 0.21	1.23 ± 0.20	1.32 ± 0.21*
BMR (kcal/kg)	1,325.35 ± 211.80	1,397.53 ± 256.22†	1,247.82 ± 107.34
AEE (TEE-BMR)	398.75 ± 341.63	373.06 ± 370.65	427.06 ± 307.82

\*  $p < 0.05$ ; \*\*  $p < 0.001$ ; †  $p < 0.0001$ .

The results of the correlation between physical activity indicators (PAI) and the adiposity indicators (AI) are presented in table 2. Significant associations between the following variables were observed: body mass index (BMI), body fat percentage and waist/hip relation (WHR) with TEE, PAL, BMR and AEE in male and female adolescents, except for the WHR for female adolescents.

**TABLE 2**  
Pearson correlation coefficients for physical activity and adiposity indicators

PAI \ AI	Male			Female		
	BMI	Fat %	WHR	BMI	Fat %	WHR
TEE	0.86**	0.78**	0.28*	0.86**	0.73**	0.02
HPAL	-0.09	-0.12	0.09	-0.16	-0.29*	0.12
PAL	0.70**	0.61**	0.26	0.82**	0.66**	0.08
BMR	0.91**	0.90**	0.45**	0.78**	0.74**	-0.12
AEE	0.78**	0.70**	0.28*	0.85**	0.70**	0.08

\*  $p < 0.05$ ; \*\*  $p < 0.001$ .

## DISCUSSION

Analyzing results presented in table 1, one observes that the body mass, stature and BMI variables were not different between genders, what is not in agreement with literature, which establishes lower values for boys when compared with girls<sup>(33)</sup>; however, recent researches have demonstrated a considerable increase on the BMI in Brazilian male adolescents while the BMI presents stability among female adolescents<sup>(34)</sup>. In relation to the body fat percentage, girls ( $21.85 \pm 7.7$ ) demonstrated values significantly higher than boys ( $17.43 \pm 9.4$ ). This difference may be explained by the fact that girls present the beginning of the maturational process before boys and at the pubescent stage, the sexual differences generated by maturation provide fat accumulation in the adipocytes in girls and gain of muscular mass in boys<sup>(35,36)</sup>, or even due to the fact that the equation used for the estimation of the fat percentage, although widely employed in Brazilian studies<sup>(37)</sup>, may present variation because it had been developed based on another population.

Considering the waist/hip relation, boys ( $0.82 \pm 0.04$ ) presented values significantly higher than girls ( $0.77 \pm 0.05$ ). The discrepancies of results between genders may be related to two factors: a) during the adolescence stretch, the growth rates accelerate unequally in relation to the chronological age; b) there is a differentiated body fat distribution of boys in relation to girls<sup>(36)</sup>.

The TEE variable of this sample presented no significant differences between genders ( $1792.69 \pm 587.75$  for boys and  $1675.40 \pm 405.09$  for girls), corroborating with other studies<sup>(13,38)</sup>. However, Roemmich<sup>(23)</sup> and Bratteby<sup>(15)</sup> in studies performed with pre-pubescent and pubescent children through the doubly labeled water method found significant differences between genders, where pubescent boys obtained TEE higher than girls, the authors attributed this fact to the high interaction presented by the maturational variable and due to the fact that boys were more engaged into high-intensity physical activities than girls in their daily lives.

In relation to the energy expenditure relative values, in the HPAL, this difference was significant, demonstrating that boys were more engaged into physical activities than girls ( $41.66 \pm 4.24$  and  $39.57 \pm 3.38$  kcal/kg/day) with value of  $p < 0.001$ ; however, when this variable is analyzed as absolute values, the amount of energy expended (TEE) (kcal/day) apparently demonstrated similar values for both genders. Melanson<sup>(39)</sup> suggests that this aspect may be related with the maturational stage of the male metabolic system that would induce to a different utilization of the energetic substrates partly generated through the high glycolytic capacity of men in comparison to women.

For the PAL, the difference was significant between genders, with girls presenting higher values; however, values of 1.23 and 1.32 for boys and girls, respectively, are similar to values found by Treuth<sup>(11)</sup>, being considered as low physical activity values. Boreham<sup>(21)</sup> presents results favorable to important health gains with PAL values of 1.7 with participation in moderate activities and that active boys may present values above 1.9.

Several authors found results similar to those presented by Boreham<sup>(21)</sup>, and most of them presented results higher for boys when compared to girls<sup>(3,13,38)</sup>, fact not corroborated in our study, probably due to the fact that the boys from our sample adopted sedentary life habits or for not being engaged in extracurricular physical activities<sup>(40)</sup>.

Adolescents with high PAL, stimulated to participate in sportive practices may reach values between 2.6 and 3.4<sup>(3)</sup>. On the other hand, low physical activity levels are associated with high body fat percentages and tendency to develop degenerative diseases<sup>(13)</sup>.

The significance found in the basal metabolic rate (BMR) in behalf of boys may be explained due to the amount of mass of organs (brain, liver, heart, kidney) that corresponds to two thirds of the basal energetic metabolism, even if the total mass of the organs in relation to body is below 6%, the size of the organs in men is slightly higher than in girls, thus elevating the male energetic demand in the BMR<sup>(19)</sup>.

The energy expenditure with physical activities (AEE) presented no significant differences between genders ( $373.06 \pm 370.65$  for boys and  $427.06 \pm 307.82$  for girls), reinforcing findings from other studies; however, girls from this sample are apparently more involved into physical activities than boys, unlike data presented in several other studies where boys presented tendency to get involved into physical activities and girls tended to adopt sedentary life-style<sup>(13,20,23)</sup>. In relation to the physical activity indicators, the results presented in this study come to reinforce the finding of Twisk<sup>(1)</sup> that the amount of physical activity in the general population is decreasing, and that this occurs from the childhood to adolescence and remains until the adult life.

Through the analysis of table 2, one identifies that the TEE, PAL, BMR and the AEE provide strong correlation with the body mass index (BMI), body fat percentage and waist/hip relation (WHR) in adolescents in this age range, except for the female WHR that was not significant. These results are in agreement with Bracco<sup>(20)</sup>, who identified that a higher body size generates a necessity of a higher amount of energy for its maintenance or even for its dislocation and that overweighted children expend higher amounts of energy in order to perform physical activities than their non-obese pairs; however, the time spent with physical activities is shorter in obese children.

However, for this sample of adolescents, the HPAL presented no correlation with none of the adiposity predictors among male adolescents, and only the body fat percentage was significant in girls ( $r = -0.292$ ). However, the negative correlation presented for the BMI and the body fat % leads us to believe that the higher is the HPAL of adolescents, the lower the values found for these predictors will be.

Moore<sup>(41)</sup> in his longitudinal study identified that children with high average habitual physical activity levels presented consistently lower BMI gains and sum of skinfolds, indicating that high physical activity levels during childhood lead to low body fat acquisition during the beginning of the adolescence. Although many people believe that the reduction on the energy expenditure or physical activity is a risk factor for the excessive fat gain during growth in children and adolescents, other factors may be associated such as nourishment and the individual genetic characteristics.

Unlike many studies, Johnson<sup>(42)</sup> identified, in study performed with 115 children aged 5-11 years, that the fat body mass is a factor that influences the increase on adiposity and that the aerobic fitness measured through the oxygen maximum volume ( $\dot{V}O_{2max}$ )



in treadmill was inversely related with adiposity in childhood. When the increase on the fat tissue was adjusted by the  $\dot{V}O_{2max}$ , it was identified that the increase of 0.1 l/min on the  $\dot{V}O_{2max}$  could result in a decrease of 0.81 kg of fat per free of fat mass; however, the BMR, the TEE and the AEE did not seem to be predictors for the alteration on the fat tissue indicatives.

A possible reason for the lack of clearness in relation to the association between adiposity among adolescents and the energy expenditure may be the positive energetic balance required for one to have an accumulation of this energy as fat. Bar-or<sup>(43)</sup> exemplifies with the following: for an individual to gain 4 kg of fat during one year, he will need a daily energy excess equivalent to approximately 80 kcal, what represents a slice of bread or 10 minutes of a basketball game.

The overall gain with the practice of physical activity is the only element that reflects the loss of fat tissue; factors such as sexual maturation and diet appear as elements that influence on the overweight and obesity development<sup>(43)</sup>, but these relations were not objective of our study; however, the literature presents the negative energetic demand generated by physical activity and its association with hypocaloric diets that may bring significant reductions on the amount of body fat<sup>(44)</sup>.

One concludes that the use of indicatives of physical activity levels (PAL), total daily energy expenditure (TEE), activity energy expenditure (AEE) and basal energetic expenditure or basal metabolic rate (BMR) present strong correlation with BMI and body fat % in male and female adolescents, once the habitual physical activity level (HPAL) only presents significance for female adolescents in relation to the body fat percentage and that an elevation on this indicative may influence the reduction on the amount of fat tissue in girls.

The possible negative relation presented by the HPAL apparently leads us to the need of further studies in order to better understand this indicative and its health implications both in children and adolescents. Special attention must be given in relation to the interpretation of the results of this study, once the simple alteration on the amount of muscular mass or fat tissue are factors that influence the energy expenditure in all indicatives used, as demonstrated by the BMI and body fat % variables.

New studies on the possible factors that could influence the energy expenditure and its relation with adiposity are required in order to elucidate the possible unbalance between energetic demands with movement and the factors that stimulate the loss of fat tissue.

The results of the present study come to emphasize that the use of these physical activity indicatives in the follow-up and monitoring of the obesity development risks is satisfactory and thus provide a better health condition, facilitating the continuous and adequate maintenance of the body mass or body fat in relation to physical activities<sup>(2,13,23)</sup>.

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*All the authors declared there is not any potential conflict of interests regarding this article.*

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