RBCDH Brazilian Journal of KINANTHROPOMETRY and Human Performance

DOI: http://dx.doi.org/10.5007/1980-0037.2013v15n4p448

original article

Aerobic fitness and biological and sociodemographic indicators in female school children

Aptidão aeróbia, indicadores sociodemográficos e biológicos em escolares do sexo feminino

Roberto Régis Ribeiro[1,2]
Keila Donassolo Santos[1]
Wellington Roberto Gomes Carvalho[2,3]
Ezequiel Moreira Gonçalves[2,4]
Everton Paulo Roman[1,2]
Giseli Minatto[5]

Abstract – Aerobic fitness is an important health-related fitness component. The objective of this study was to analyze the influence of age, growth, body composition, sexual maturation and socioeconomic status on the aerobic fitness of female school children attending public schools in Cascavel, Paraná, Brazil. A cross-sectional epidemiological study was conducted in 2006 on 1,317 school children aged 8 to 17 years. Body mass, height and triceps and medial calf skinfold thickness were measured and relative body fat (%BF) was calculated. Sexual maturation was self-assessed using a breast development scale (M1 to M5). The questionnaire proposed by the Brazilian Association of Research Companies was used to assess socioeconomic status. Aerobic fitness was estimated by the 20-m shuttle run test. The results were analyzed using two-way ANOVA, Tukey post hoc test, Spearman and Pearson correlation coefficients, and multiple linear regression with 95% confidence intervals. Three variables (age, %BF and socioeconomic status) showed an interaction ($p<0.05$) in the prediction of VO_{2peak}rel ($R^2=0.73$). All independent variables (body mass, height, age, %BF, socioeconomic status, and sexual maturation) were significant predictors ($p<0.05$) of VO_{2pico}abs ($R^2=0.88$). In conclusion, chronological age and sexual maturation were the best predictors of VO_{2peak}abs (positive) and VO_{2peak}rel (negative).

Key words: Adiposity; Physical fitness; Puberty, Social class; Students.

Resumo – *A aptidão aeróbia é considerada um dos mais importantes componentes da aptidão física relacionada à saúde. O objetivo deste estudo foi analisar a influência da idade, das variáveis de crescimento, composição corporal, maturação sexual e do nível econômico (NE) sobre aptidão aeróbia em escolares do sexo feminino de escolas públicas da cidade de Cascavel, PR, Brasil. Estudo epidemiológico transversal realizado com 1.317 escolares de oito a 17 anos de idade no ano de 2006. Foram coletadas as variáveis de massa corporal, estatura, dobras cutâneas do tríceps e panturrilha medial e calculado o percentual de gordura corporal (%GC). A maturação sexual foi autoavaliada por meio da prancha de desenvolvimento de mamas (M1 a M5). O NE foi obtido por um questionário proposto pela Associação Brasileira das Empresas de Pesquisa. O teste de vai-vem de 20 metros foi utilizado para mensurar a aptidão aeróbia. Foram aplicados a Anova two-way, teste post hoc de Tukey, as correlações de Pearson e Spearman e a análise de regressão linear múltipla, com nível de confiança de 95%. Três variáveis (idade, %GC e NE) apresentaram interação ($p<0,05$) na predição do VO_{2pico}rel ($R^2=0,73$) e todas as variáveis independentes (massa corporal, idade, estatura, %G, NE e maturação sexual) foram significativas para predizer o VO_{2pico}abs ($R^2=0,88$). Conclui-se que a idade cronológica e a maturação sexual foram as variáveis que melhor predizem positivamente os valores de VO_{2pico}abs e negativamente os de VO_{2pico}rel.*

Palavras-chave: *Aptidão física; Adiposidade; Classe social; Estudantes; Puberdade.*

1 Faculdade Assis Gurgacz. Cascavel, PR. Brasil.

2 Universidade Estadual de Campinas. Faculdade de Ciências Médicas. Laboratório de Crescimento e Composição Corporal. Campinas, SP. Brasil.

3 Universidade Federal do Maranhão. Centro de Ciências Biológicas e da Saúde. Departamento de Educação Física. São Luis, MA. Brasil.

4 Universidade Estadual de Londrina. Grupo de Estudo e Pesquisa em Nutrição Metabolismo e Exercício. Londrina, PR. Brasil.

5 Universidade Federal de Santa Catarina. Programa de Pós-Graduação em Educação Física. Grupo de Pesquisa em Cineantropometria e Desempenho Humano. Florianópolis, SC. Brasil.

Received: 14 September 2012
Accepted: 22 January 2013

INTRODUCTION

Studies on children and adolescents have emphasized the importance of the assessment and intervention in health-related components of physical fitness[1,2] for the adoption of a healthy lifestyle and the prevention of diseases such as obesity, diabetes and hypertension[3,4]. Cardiorespiratory or aerobic fitness is an important health-related component since it describes the capacity of the cardiovascular and respiratory systems to supply oxygen to muscles during continuous effort[5]. This component shows a strong association with health indicators[6].

Peak oxygen uptake (VO_{2peak}), i.e., the maximal oxygen consumption during an exercise test to exhaustion, has been shown to be the best indicator of aerobic fitness in children and adolescents[7]. This component of physical fitness is influenced by gender, body composition, sexual maturation, age, and socioeconomic status[8-11]. Boys present a higher VO_{2peak} than girls and this difference between genders seems to be related to the higher accumulation of body fat in girls and the increase of lean mass in boys during puberty[8,9]. Investigators have shown a decrease in aerobic fitness with increasing age[11], which is due to the increase of body mass during adolescence[9,10]. In addition, school children (10 to 15 years) of low socioeconomic status exhibit lower levels of aerobic fitness[10].

Within this context, knowledge of factors that influence aerobic fitness in girls during childhood and adolescence contributes to data interpretation and to the establishment of prevention and intervention measures in this group, with benefits during the present and subsequent phases of life. Therefore, the objective of the present study was to evaluate the influence of age, growth variables, body composition, sexual maturation and socioeconomic status on the aerobic fitness of female school children aged 8 to 17 years from public schools in Cascavel, Paraná, Brazil.

METHODOLOGICAL PROCEDURES

This study is part of a larger cross-sectional epidemiological study entitled "Anthropometry, body composition, motor performance and sexual maturation of school children of different socioeconomic classes from the municipality of Cascavel, Paraná". The study was approved by the Ethics Committee on Human Research of Universidade Federal de Santa Catarina (UFSC) (Permit No. 131/2006).

The municipality of Cascavel is located on the Third Plateau in the western region of the State of Paraná, southern Brazil. The municipality has a population of 286,205 inhabitants, 94.02% of them living in the urban area[11].

The target population of the present study consisted of female school children ranging in age from 8 to 17 years and living in the urban area of the municipality. The students attended public schools in Cascavel and were enrolled in the 3rd to 8th grade of elementary school and in the 1st to

3rd year of high school in 2006. According to the report of the Regional Education Center and the City Department of Education (2006), the general population of school children enrolled in elementary and high schools was approximately 34,720 individuals attending 89 municipal and state public schools. Since the target population of the study included only female school children, a gender distribution of 50/50 was assumed, corresponding to 17,360 female students.

The sample was stratified according to educational center and class cluster. Three educational centers were formed based on the distribution of the schools across the different geographic regions of the municipality. The geographic division proposed by the Regional Education Center of Cascavel was used to ensure the representativeness of the sample. The proportion was 35.8% school children in center I, 33.1% in center II, and 31.2% in center III. In the first phase, four schools per center, two municipal and two state schools, were selected by drawing lots. Next, the schools that would participate in the study were chosen by drawing lots based on a list provided by the institutions that contained the students' age. In the second phase, simple random selection of the classes was performed in such a way that the sample was representative of the target population. All adolescent girls aged 8 to 17 years, who were present in the classroom on the day of data collection, were invited to participate in the study.

Since this study was part of a larger project, different sample sizes were calculated. In the present study, an unknown prevalence of the outcome (50%), a tolerable error rate of 5%, 95% confidence interval, and design effect of 2.5 were adopted, thus estimating a sample of 920 school children. An extra 20% were added for possible losses and refusals and the final sample consisted of 1,152 school children. In view of the characteristics of the sampling process that involved all individuals belonging to the clusters, 1,317 school children were included in the sample.

Eligibility criteria were enrollment in a municipal or state public school, presence in the classroom on the day of data collection, and an age of 8 to 17 years. Criteria for exclusion were (a) the lack of written informed consent by the responsible person; (b) refusal to participate in the study, and (c) an incomplete socioeconomic questionnaire.

The chronological age of the students was determined based on the difference between the date of assessment and the date of birth, which was converted into decimal age as described by Ross and Marfell-Jones[12]. Body mass was measured on a bioimpedance scale (Tanita®) to the nearest 0.1 kg, with the subject being barefoot and wearing light clothing. Height was measured with a vertical stadiometer (Seca®) to the nearest 0.1 cm according to the procedures proposed by Gordon *et al.*[13]. Triceps (TSF) and medial calf (MCS) skinfold thickness was measured in the right hemibody to the nearest 1 mm using a Lange skinfold caliper (Cambridge Scientific Industries, Inc.), as described by Harrison *et al.*[14]. Body fat percentage (%BF) was estimated using the equation proposed by Slaughter *et al.*[15] by the sum of TSF and MCS: $\%F = 0.610*(TSF + MCS) + 5.1$.

VO_{2peak} was determined indirectly using the 20-meter shuttle run test proposed by Léger and Boucher[16]. The test consists of running a distance of 20 meters between two lines, accompanying the sound signal that indicates an increase in speed. The initial speed of the test is 8.5 km/h, with progressive increases of 0.5 km/h at intervals of one minute. The test is finished when the subject can no longer follow the pace and the speed of the last completed stage is recorded. VO_{2peak}relative (VO_{2peak}rel) ($mL.kg^{-1}.min^{-1}$) was estimated using the equation: VO_{2peak}rel = 31.025 + 3.238 * V - 3.248 * A + 0.1536 * V * I, where *V* = speed in km/h (in the stage achieved) and *A* = age in years. These results were also transformed into VO_{2peak}absolute (VO_{2peak}abs) ($L.min^{-1}$)[17]. This test has shown good validity (r=0.71) and reproducibility (r=0.89) in children and adolescents[18] and has also been used in test batteries from other countries such as FITNESSGRAM and EUROFIT[19].

Socioeconomic status was defined using the questionnaire and classification of the Brazilian Association of Research Companies (ABEP)[20], which estimates the purchasing power of families and classifies it from high to low into classes A, B, C, D and E. The students were assigned to high (A+B), medium (C+D), and low socioeconomic classes (E).

Sexual maturation was evaluated by self-assessment using the breast stages proposed Marshall and Tanner[21] (M1 to M5). The instructions were provided by a female examiner.

Descriptive statistics including means and standard deviations were used for statistical analysis. Body mass, height, %BF, VO_{2peak}rel and VO_{2peak}abs were compared between ages and sexual maturation stages by two-way analysis of variance (ANOVA), followed by the Tukey multiple comparisons test to identify possible differences. Pearson's simple correlation coefficient was calculated to evaluate the correlation of VO_{2peak}rel and VO_{2peak}abs with age, anthropometric variables and body composition. Spearman's coefficient was used to determine the correlation with socioeconomic status and sexual maturation stage. Next, stepwise multiple linear regression analysis was performed to determine the effects of each independent variable (age, body mass, height, %BF, socioeconomic status, and maturation stage) on the dependent variables (VO_{2peak}rel and VO_{2peak}abs). Dummy variables were used to introduce the qualitative variables socioeconomic status and maturation stage in the multiple linear regression model. The data were stored and analyzed using SPSS® 13.0 for Windows (Statistical Package for the Social Sciences). A level of significance of 5% was adopted for all variables.

RESULTS

A total of 1,317 female school children attending public schools in Cascavel, Paraná, Brazil, were studied. Of these, 27 (2.1%) were 8 years old; 68 (5.2%) were 9 years; 134 (10.2%) were 10 years; 236 (17.9%) were 11 years; 205 (15.6%) were 12 years; 175 (13.3%) were 13 years; 169 (12.8%) were 14 years; 145 (11.0%) were 15 years; 104 (7.9%) were 16 years, and 54 (4.1%) were 17 years. The lowest percentages of school children were 8, 9 and 17 years of age. Among the students included in the study, 1.9% (n=25) belonged to the high socioeconomic class, 41.0% (n=540) to the medium class, and 57.1% (n=752) to the low class.

Table 1 shows the mean and standard deviation of body mass, height %BF, VO_{2peak}rel, and VO_{2peak}abs. Comparison of these parameters to the subsequent age showed a significant increase in body from 11 to 14 years, in height from 10 to 13 years, in %BF only at 12 years, and in VO_{2peak}abs from 11 to 13 years, with a significant reduction at 17 years. Regarding VO_{2peak}rel, significant reductions were observed from 10 to 17 years.

Table 1. Body mass, height, body fat percentage (%BF), peak oxygen uptake relative (VO_{2peak}rel) and absolute (VO_{2peak}abs) according to age. Cascavel, PR, Brazil, 2006.

Age. years (n)	Body mass (kg)	Height (cm)	%BF	VO_{2peak}rel (mL.kg^{-1}.min^{-1})	VO_{2peak}abs (L.min^{-1})
8 (27)	28.6 (4.7)	132.9 (3.7)	22.0 (5.2)	48.1 (2.0)	1.4 (0.2)
9 (68)	30.9 (4.9)	136.0 (5.9)*	24.2 (4.9)	46.5 (1.9)*	1.4 (0.2)
10 (134)	34.9 (6.9)*	142.5 (6.7)*	24.1 (5.6)	44.6 (2.2)*	1.6 (0.3)*
11 (236)	39.5 (8.0)*	147.9 (13.6)*	25.5 (5.9)*	43.3 (2.3)*	1.7 (0.3)*
12 (205)	45.1 (10.0)*	155.1 (6.8)*	27.5 (6.6)	40.8 (2.4)*	1.8 (0.4)*
13 (175)	49.9 (9.9)*	159.5 (6.4)	28.3 (6.2)	39.5 (2.8)*	2.0 (0.4)
14 (169)	51.5 (8.9)	160.5 (6.5)	30.0 (6.3)	37.3 (2.7)*	1.9 (0.3)
15 (145)	54.7 (7.7)	161.7 (5.7)	31.5 (5.9)	35.9 (3.1)*	2.0 (0.3)
16 (104)	54.9 (9.0)	162.4 (5.7)	30.5 (5.9)	33.8 (3.1)*	1.9 (0.3)*
17 (54)	53.1 (7.4)	162.0 (5.0)	29.8 (6.1)	31.8 (2.7)	1.7 (0.2)

Values are reported as the mean (standard deviation);
*$p<0.05 \neq$ compared to the subsequent year.

A significant increase in body mass, height, %BF, VO_{2peak}rel and VO_{2peak}abs was observed when compared to the more advanced maturation stage. No significant differences were found for %BF between M1 and M2 and for height between M4 and M5 (Table 2).

Table 3 shows the correlation of VO_{2peak}rel and VO_{2peak}abs with age, body mass, height, %BF, maturation stage, and socioeconomic status. For VO_{2peak}rel, moderate and high negative correlations were observed with all independent variables, except for socioeconomic status which showed a weak positive correlation. VO_{2peak}abs showed moderate and high positive correlations with all independent variables, except for age and socioeconomic status.

Multiple regression analysis revealed a significant interaction of the three independent variables age, %BF and socioeconomic status in predicting VO_{2peak}rel (R^2=0.73), and of all independent variables (body mass, age, height, %BF, socioeconomic status and maturation stage) in predicting VO_{2peak}abs (R^2=0.88). The independent variables explained 73% of the variability in VO_{2peak}rel and 88% of the variability in VO_{2peak}abs. Thus, the models [VO_{2peak}rel = 63.073 + (-1.668 x age) – (0.0126 x %BF) + (0.335 x socioeconomic status) and VO_{2peak}abs = 0.546 + (0.035 x body mass) + (-0.082 x age) + (0.004 x height) + (-0.003 x %BF) + (0.025 x socioeconomic status) + (0.015 x maturation stage)] can be accepted since analysis of variance indicated that these variables significantly reduce the variation in VO_{2peak}rel and VO_{2peak}abs (F=1154.671 and p=0.001)

Table 2. Body mass, height, body fat percentage (%BF), peak oxygen uptake relative (VO_{2peak}rel) and absolute (VO_{2peak}abs) according to sexual maturation stage (M). Cascavel, PR, Brazil, 2006.

Age. years (n)	Body mass (kg)	Height (cm)	%BF	VO_{2peak}rel ($mL.kg^{-1}.min^{-1}$)	VO_{2peak}abs ($L.min^{-1}$)
M1 (113)	30.7 (8.2)*	136.7 (7.7)*	22.7 (5.8)	45.8 (3.1)*	1.4 (0.3)*
M2 (269)	35.7 (6.0)*	145.1 (7.6)*	24.0 (5.2)*	43.7 (2.7)*	1.6 (0.3)*
M3 (277)	43.5 (7.8)*	154.0 (7.2)*	26.6 (5.6)*	41.6 (3.3)*	1.8 (0.3)*
M4 (498)	51.5 (7.9)*	160.5 (6.1)	29.6 (5.7)*	37.4 (3.8)*	1.9 (0.3)*
M5 (160)	58.3 (9.0)	161.7 (5.2)	33.3 (6.5)	35.2 (3.5)	2.1 (0.4)

Values are reported as the mean (standard deviation).
* $p \leq 0.05 \neq$ compared to the more advanced maturation stage.

Table 3. Correlation of peak oxygen uptake relative (VO_{2peak}rel) and absolute (VO_{2peak}abs) with the independent variables age, body mass, height, body fat percentage (%BF), maturation stage, and socioeconomic status. Cascavel, PR, Brazil, 2006.

Independent variable		VO_{2peak}rel ($mL.kg^{-1}.min^{-1}$)		VO_{2peak}abs ($L.min^{-1}$)	
		r	p	r	p
Age (years)	Pearson	- 0.83	<0.001	0.33	<0.001
Body mass (kg)	Pearson	- 0.67	<0.001	0.88	<0.001
Height (cm)	Pearson	- 0.64	<0.001	0.62	<0.001
Body fat (%)	Pearson	-0.46	<0.001	0.66	<0.001
Maturation stage (breast)	Spearman	- 0.72	<0.001	0.54	<0.001
Socioeconomic status (class)	Spearman	0.16	<0.001	0.04	<0.001

The correlation of VO_{2peak}rel and VO_{2peak}abs obtained in the exercise test and the values calculated with the multiple linear regression model showed high correlations for the two variables (VO_{2peak}rel: r=0.84 and p<0.001; VO_{2peak}abs: r=0.94 and p<0.001) (Figure 1).

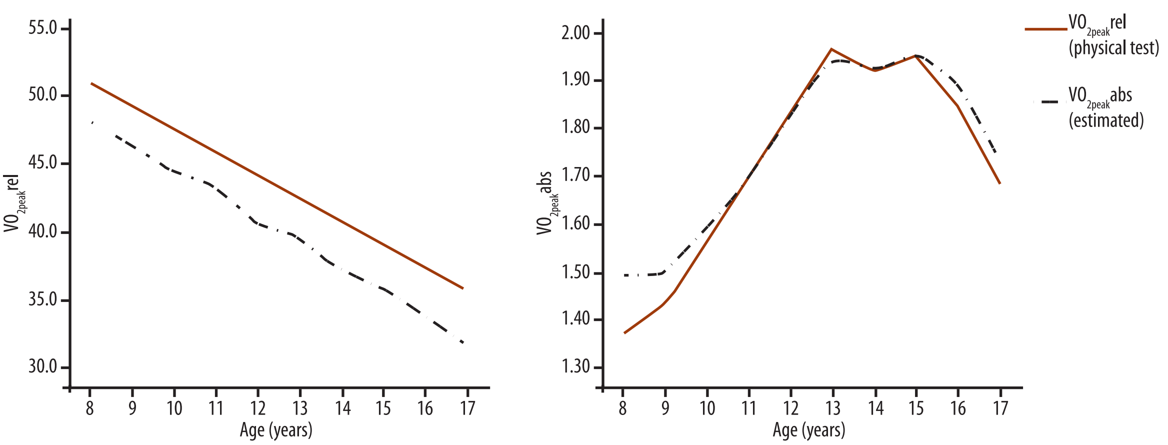

Figure 1. Mean relative (VO_{2peak}rel) and absolute (VO_{2peak}abs) peak oxygen uptake obtained in the exercise test and by multiple regression according to age. Cascavel, PR, Brazil, 2006.

DISCUSSION

In general, the present results showed that in this group of school children body mass, height and VO_{2peak}abs began to increase at about 10 years of age and stabilized from 14 to 17 years, except for VO_{2peak}abs which decreased at 17 years. With respect to maturation stage, body mass, height, VO_{2peak}rel and VO_{2peak}abs also increased gradually when compared to the more advanced stage. For %BF, the differences occurred at 12 years of age when compared to age 13 and between pubertal stages (M2, M3, and M4).

In contrast, VO_{2peak}rel gradually decreased from 10 to 17 years of age and with advancing stage of maturation. Furthermore, VO_{2peak}rel was negatively correlated with all independent variables, except for socioeconomic status, whereas VO_{2peak}abs showed moderate or high positive correlations with all variables, except for age and socioeconomic status. Multiple linear regression analysis revealed that age, %BF and socioeconomic status explained 73% of the variability in VO_{2peak}rel (R^2=0.73), and age, body mass, height, %BF, socioeconomic status and sexual maturation explained 88% of the variability in VO_{2peak}abs (R^2=0.88).

Similarly, studies indicate an almost linear increase of VO_{2peak}abs in girls up to age 13, which tends to stabilize at about 14 years of age[8]. Using the same test for the determination of aerobic fitness, Vasques *et al.*[10] observed a decline in VO_{2peak}rel from 10 to 15 years and concluded that this decrease is mainly a consequence of increasing body mass during this phase. Similar to the present findings, an increase of absolute values and a decrease of relative values have been reported for North American girls aged 8 to 16 years, with the latter being related to the increase in body fat[9]. In the girls studied here, the increase of body fat, which is accompanied by a significant increase of body mass, was more apparent with advancing sexual maturation. In this respect, %BF was negatively correlated with VO_{2peak}rel, in agreement with other studies that used the same test to estimate VO_{2peak}[23,24].

According to Armstrong[5], VO_{2peak} values are conventionally expressed relative to body mass to control for the effect of growth in children and adolescents. However, the use of relative values results in a different scenario than the use of absolute values as demonstrated in the present study. This author also found that VO_{2peak}abs values increase by approximately 80% in girls from 8 to 16 years of age and that VO_{2peak} is correlated with body mass. In the present study, considering mean percentages, the increase of body mass in girls aged 8 to 17 years was approximately 47%, whereas the increase of VO_{2peak}abs was about 32%, a fact leading to a significant reduction of VO_{2peak}rel of approximately 34%.

Studies using regression models have demonstrated a positive effect of maturation stage on VO_{2peak}abs in children and adolescents[7,25]. In addition, this type of model permits to show the effects of age, gender and sexual maturation on VO_{2peak}, irrespective of the body size of boys and girls[25]. In a study using this type of model, a positive and significant effect of maturation stage on VO_{2peak} was observed when this parameter was included in the model[7]. Therefore, like chronological age, sexual maturation has also been recognized as a variable that can explain the results, irrespective of body mass and fat in boys and girls aged 11 to 17 years[7]. Still with respect to sexual maturation, as observed in the present study, other investigators also reported that advanced maturation was accompanied by an increase in VO_{2peak}abs[5]. However, in a study involving young female athletes of different modalities aged 10 to 17 years, analysis of variance and multiple regression analysis revealed no significant effect of sexual maturation on aerobic fitness[26].

As demonstrated in the present investigation and in other studies, aerobic fitness of children and adolescents is influenced by age, growth, body composition and sexual maturation[7,9,23-25]. As a consequence, the understanding of aerobic fitness is compromised if these factors are not taken into account at the time of data interpretation[5]. The use of VO_{2peak} expressed relative to body mass to control for differences and to permit comparison of the results is a widely accepted approach. However, data expressed in this manner should be interpreted with caution since the hypothesis that VO_{2peak}rel increases in direct proportion to body mass has been questioned and inadequate control of this parameter may impair the understanding of aerobic fitness during growth and sexual maturation[5].

One factor that has been little explored, particularly in international studies, and that is relevant because of the major distortions observed in Brazil is socioeconomic status. In the present study, multiple linear regression analysis showed an influence of socioeconomic status on both VO_{2peak}rel and VO_{2peak}abs. A study investigating the influence of socioeconomic status of adolescents from Florianópolis, Santa Catarina, Brazil, reported lower VO_{2peak}rel values in less privileged classes and, consequently, a higher proportion of adolescents who did not meet recommended health criteria[10]. In contrast, a study involving Danish school children found no differences in cardiorespiratory fitness between different socioeconomic classes[27].

The motivation of adolescents to undergo the aerobic fitness test, a variable not investigated here, may have affected the results and is a limitation of the present study. Furthermore, the cross-sectional design of the study does not permit to establish causal relationships between the variables analyzed or to infer an increase or decrease of aerobic fitness as a function of age and sexual maturation stage. It should be noted that sexual maturation was obtained by self-assessment, an approach that may have been influenced by cultural issues. However, according to the literature, this method is reliable to estimate sexual maturation stage[28]. Clinical evaluation by a pediatrician may prevent such errors and permit to obtain more precise results.

The strengths of the study include the representativeness of the population studied, which permits inferences for the population of adolescent school children from Cascavel, Paraná. In addition, the test used for the evaluation of aerobic fitness in school children shows good validity[29]. The equations used for the calculation of VO_{2peak}rel and VO_{2peak}abs should not be applied indiscriminately since the models were based on a general population of female school children from Cascavel (Paraná, Brazil). These results are not intended to replace physical tests, but rather to identify variables that, alone or in combination, reveal variations in VO_{2peak}rel and VO_{2peak}abs during growth and therefore contribute to the understanding of aerobic fitness.

CONCLUSION

The present results showed that age and sexual maturation stage interfered positively and negatively with VO_{2peak}abs and VO_{2peak}rel, respectively. In addition, VO_{2peak}abs was influenced by all variables studied, whereas VO_{2peak}rel was influenced mainly by age, %BF and socioeconomic status. These variables should therefore be taken into account in the analysis of aerobic fitness in female children and adolescents.

ACKNOWLEDGMENTS

The authors thank CAPES for the fellowships granted (WRGC, EMG and GM).

REFERENCES

1. Ronque ERV, Cyrino ES, Dórea VR, Serassuelo Jr H, Galdi EHG, Arruda M. Diagnóstico da aptidão física em escolares de alto nível socioeconômico: avaliação referenciada por critérios de saúde. Rev Bras Med Esporte 2007;13(2):71-6.
2. Dórea V, Ronque ERV, Cyrino ES, Serassuelo Jr H, Gobbo LA, Carvalho FO, et al. Aptidão física relacionada à saúde em escolares de Jequié, BA, Brasil. Rev Bras Med Esporte 2008;14(6):494-9.
3. Ball GDC, Shaibi GQ, Cruz ML, Watkins MP, Weigenberg MJ, Goran MI. Insulin sensitivity, cardiorespiratory fitness, and physical activity in overweight Hispanic youth. Obesity Res 2004;12(1):77-85.
4. Ulbrich AZ, Machado HS, Michelin A, Vasconcelos IQA, Stabelini NA, Mascarenhas LPG, Campos W. Aptidão física em crianças e adolescentes de diferentes estágios maturacionais. Fit Perf J 2007;6(5):277-82.
5. Armstrong N. Aerobic fitness of children and adolescents. J Pediatr 2006;82(6):406-8.
6. Maranhão Neto GA, Lourenço PMC, Farinatti PTV. Equações de predição da aptidão cardiorrespiratória sem testes de exercício e sua aplicabilidade em estudos epidemiológicos: uma revisão sistemática. Cad Saúde Pública 2004;20(5):48-56.
7. Armstrong N, Welsman J. Peak oxygen uptake in relation to growth and maturation in 11 to 17 year-old humans. Eur J Appl Physiol 2001;85(6):546-51.
8. Armstrong N.; Welsman Jr. Developmental of aerobic fitness during childhood and adolescence. Pediatr Exerc Sci 2000;12(5):128-49.
9. McMurray RG, Harrell JS, Bradley CB, Deng S, Bangdiwala SI. Predicted maximal aerobic power in youth is related to age, gender, and ethnicity. Med Sci Sports Exerc 2002;34(1):145-51.
10. Vasques DG, Silva KS, Lopes AS. Aptidão cardiorrespiratória de adolescentes de Florianópolis, SC. Rev Bras Med Esporte 2007;13(6):376-80.
11. Santos DA, Silva AM, Santa-Clara H, Matias CN, Fields DA, Sardinha LB. Determinant factors of cardiorespiratory fitness in Portuguese adolescents of different ethnicities. Rev Bras Cineantropom Desempenho Hum 2011;13(4):243-9.
12. Instituto Brasileiro de Geografia e Estatística/IBGE. Censo Populacional 2010. Available from: <http://www.ibge.gov.br/home/estatistica/populacao/censo2010/populacao_por_municipio.shtm> [2010 Dec 12].

13. Ross WD, Marfell-Jones MJ. Kinanthropometry. In: MacDougall JD, Wenger HA, Green HS, editors. Physiologic Testing of the Elite Canadian Association of Sport Science. Ithaca: Movement Publications, 1982;75-115.
14. Gordon CC, Chumles WC, Roche AF. Stature, recumbent length, and weight. In: Lohman TG, Roche AF, Martorel R, editors. Anthropometric Standardization Reference Manual. Champaign, IL: Human Kinetics,1988; p. 3-8.
15. Harrison GG, Buskirk ER, Carter JEL, Johnston FE, Lohmam,TG, Pollock ML, et al. Skinfold Thickness and Measurement Technique. In: Lohman TG, Roche AF, Martorel R, editors. Anthropometric Standardization Reference Manual. Champaign, IL: Human Kinetics. 1988; p. 55-70.
16. Slaughter MH, Lohman TG, Boileau RA, Hoswill CA, Stillman RJ, Van Loan MD, Bemben DA. Skinfold equations for estimation of body fatness in children and youth. Hum Biol 1988;60(5):709-23.
17. Léger L, Boucher R. An indirect continuous running multistage field test: the Université de Montreal track test. Can J Sports Sci 1980;5(2):77-84.
18. Silva AC, Torres FC. Ergoespirometria em atletas paraolímpicos brasileiros. Rev Bras Med Esporte 2002;8(3):107-16.
19. Léger L, Mercier D, Gadoury C, Lambert J. The multistage 20 meter shuttle run test for aerobic fitness. J Sports Sci 1988;6(2):93-101.
20. Guedes DP, Guedes JERP. Manual prático para avaliação em Educação Física. Manole: Barueri, 2006.
21. Associação Brasileira de Empresas de Pesquisa - ABEP. Dados com base no Levantamento socioeconômico – 2000. Available from: <http://www.abep.org> [2006 Feb 10].
22. Marshall WA, Tanner JM. Variations in the pattern of pubertal changes in girls. Arch Dis Child 1969;44(235):291-303.
23. Bim RH, Nardo Jr N. Aptidão física relacionada à saúde de adolescentes estagiários da Universidade Estadual de Maringá. Acta Sci Health Sci 2005;27(1):77-85.
24. Bodas AR; Leite TM, Carneiro ALG, Gonçalves PO, Silva AJ, Reis VM. A influência da idade e da composição corporal na resistência, flexibilidade e força em crianças e jovens. Fit Perf J 2006;5(3):155-60.
25. Armstrong N, Welsman JR, Nevill AM, Kirby BJ. Modeling growth and maturation changes in peak oxygen uptake in 11–13 yr olds. J Appl Physiol 1999;87(6):2230-36.
26. Böhme MTS. Resistência aeróbia de jovens atletas mulheres com relação à maturação sexual, idade e crescimento. Rev Bras Cineantropom Desempenho Hum 2004;6(2):27-35.
27. Kristensen PL, Wedderkopp N, Moller NC, Andersen LB, Bai CN, Froberg K. Tracking and prevalence of cardiovascular disease risk factors across socio-economic classes: a longitudinal substudy of the European Youth Heart Study. BMC Public Health 2006;27:6-20.
28. Saito MI. Maturação sexual: autoavaliação do adolescente. Pediat 1984;6:111-5.
29. Ruiz JR, Castro-Pinero J, Espana-Romero V, Artero EG, Ortega FB, Cuenca MM, et al. Field-based fitness assessment in young people: the ALPHA health-related fitness test battery for children and adolescents. Br J Sports Med 2011;45(6):518-24.

Corresponding author

Roberto Régis Ribeiro
Rua Pernambuco, 600
Edifício José Smarczewski, Ap. 801.
Centro. CEP: 85810 020 - Cascavel, PR. Brasil
E-mail: robertor@fcm.unicamp.br