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Cardiorespiratory fitness in children and adolescents

Aptidão cardiorrespiratória em crianças e adolescentes

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Abstract – Cardiorespiratory fitness is an important health status indicator. The purpose of this study was to verify the cardiorespiratory fitness according to age group and gender in children and adolescents from Sergipe, Brazil. It is a cross-sectional study with sample consisting of 195 adolescents of both genders with mean age of 11.75 ± 3.0 years. For the characterization of participants, a questionnaire with age and gender identification designed by researchers was used. Subsequently, participants were submitted to anthropometric evaluation in order to estimate the maturational stage by means of the peak height velocity (PHV). The 20-meter back-and-forth test was used to estimate cardiorespiratory fitness. Two-way ANOVA was applied with sample divided into two groups ("up to 13 years" and "above 13 years"). Polynomial contrast was used to identify the type of tendency for cardiorespiratory fitness, and simple contrast for multiple comparisons. All procedures were performed using SPSS version 22.0 software, considering 5% significance level. In the "over 13 years" group, there was a significant effect on the cardiorespiratory capacity behavior according to "gender" [$F_{(1, 45)}$ = 5.54, p = 0.02, r = 0.33] and "age" [$F_{(4.45)}$ = 3.37, p = 0.02, r = 0.48]. The simple contrast identified increased cardiorespiratory fitness behavior in relation to age groups of 15 and 16 year when compared to the age group of 14 years. It was concluded that gender and age positively influence cardiorespiratory fitness from the maturational reference age in the study group.

Key words: Adolescents; Cardiorespiratory fitness; Child.

Resumo –*Aptidão cardiorrespiratória é um importante indicador da condição de saúde. Objetivou-se verificar a capacidade cardiorrespiratória, conforme grupo etário e sexo, em crianças e adolescentes do Estado de Sergipe. Trata-se de um estudo com delineamento transversal. A amostra foi composta por 195 adolescentes de ambos os sexos com média de idade de 11,75±3,0 anos. Para a caracterização dos participantes, utilizou-se um questionário com dados sociodemográficos. Aplicou-se uma avaliação antropométrica, de forma a estimar o estágio maturacional por meio do pico de velocidade de crescimento (PVC) e o teste de vai-e-vem de 20 metros para a estimativa da capacidade cardiorrespiratória. ANOVA two-way foi aplicada com amostra dividida em dois grupos ("até 13 anos" e "acima de 13 anos"). Foi aplicado contraste polinomial para identificar o tipo de tendência para a aptidão cardiorrespiratória, e contraste simples para comparações múltiplas. Todos os procedimentos adotaram p ≤ 0,05 e utilizaram o software SPSS versão 22.0. No grupo etário "acima dos 13 anos", encontrou-se efeito significativo no comportamento da capacidade cardiorrespiratória conforme "sexo" [$F_{(1, 45)}$ = 5,54, p = 0,02, r=0,33] e "idade" [$F_{(4, 45)}$ = 3,37, p = 0,02, r=0,48]. O contraste polinomial revelou tendência linear para o VO_2 em relação à idade de corte de 13 anos (p=0,04). O contraste simples identificou comportamento crescente da capacidade cardiorrespiratória em relação aos grupos etários de 15 e 16 anos quando comparados ao grupo de 14 anos. Conclui-se que o sexo e a idade influenciam positivamente na capacidade cardiorrespiratória a partir da idade de referência maturacional.*

Palavras-chave: *Adolescente; Aptidão cardiorrespiratória; Criança.*

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INTRODUCTION

Chronological age is considered a development marker, but biological maturation is more accurate, since, during childhood and adolescence, individuals with the same chronological age may differ considerably in the biological maturity stage[1]. Among the several forms of maturational evaluation, age of peak heigh velocity (PHV) considers somatic maturation of the adolescent and is considered an interesting alternative of biological classification[2].

Thus, physical fitness and its components should not be considered without observing the maturation variable, especially because it is a reliable and consistent health marker in childhood and adolescence[3,4].

Among the physical fitness components, it is clear in literature that cardiorespiratory capacity is influenced by age and gender[5], showing that males have higher values when compared to females [6]. During childhood, this difference between genders is small[7]; however, with age advancement, this difference tends to increase[8].

Regarding the population cardiorespiratory fitness behavior, studies indicate that in Brazilian children and adolescents, its mean values have been decreasing in the last decades[5,9], and this decrease is related to increased risk of cardiovascular diseases and metabolic syndrome in adolescents as well as to risk of cardiovascular diseases in adult life, confirming the importance of studying this variable in all age groups[6-8].

Therefore, the study of the cardiorespiratory capacity in children and adolescents is of paramount importance, since it is necessary to formulate health promotion actions to encourage the practice of physical activity, as well as other habits considered healthy[9].

Based on the above, the purpose of the study was to verify the cardiorespiratory capacity behavior according to age group and gender, based on maturational stage differences in children and adolescents in the Northeastern Region of Brazil.

METHODOLOGICAL PROCEDURES

This is a cross-sectional pilot study conducted with children and adolescents enrolled in elementary and high schools of the Public-School System of Aracaju-SE, with the authorization of the Regional Board of Education. Procedures were conducted in accordance with the Declaration of Helsinki and Resolution 510/2016 of the National Health Council, being analyzed and approved by the Ethics Research Committee of the Federal University of Sergipe (protocol No. 2.164.559).

The sample consisted of 195 adolescents of both genders with mean age of 11.75 + 3.0 years selected for convenience. The inclusion criteria adopted were: to be older than seven and under 19 years of age, to be regularly enrolled in the educational institution, to sign the Free and Informed Assent and to have parental consent through the Free and Informed Consent Form.

The following exclusion criterion was adopted: to present some clinical and/or physical incapacity that would compromise the performance of tests and failure to fill out fundamental information such as age and gender in the identification instrument.

For data collection, a questionnaire was used to characterize participants, designed by researchers to identify gender and the age of participants, followed by anthropometric evaluation of body mass, height, trunk-cephalic height and length of lower limbs, all measured according to standardization suggested by the International Society for the Advancement of Kinanthropometry[10], and used for the calculation of the Peak Height Velocity (PHV)[11]. For the characterization of the cardiorespiratory capacity, the 20-meter back-and-forth test was applied, as recommended by Léger & Lambert[12].

For the interpretation of data, the characterization of participants was made with descriptive analysis using mean, standard deviation and confidence interval. For the age distribution of groups, the last point of interaction between PHV and age was used as reference in the male and female groups, which ended up by characterizing the age groups of this study into "up to 13 years" and "above 13 years".

Differences observed between age groups for each variable (gender, age) were analyzed using analysis of variance for independent measurements at two moments (two-way ANOVA). Polynomial contrast was used to identify the trend in cardiorespiratory fitness behavior for age, age group, and simple contrast was used as a strategy for multiple comparisons between ages, taking the baseline for each age group as reference. For all analyses, the effect size was calculated from the eta calculation, considering cutoff points suggested by Cohen[13] as reference. A 5% significance level was adopted. All procedures were performed using SPSS software version 22.0 for Windows.

RESULTS

A total of 206 children and adolescents were observed, nine of whom were excluded because they had not completed their age in the questionnaire and two because they did not appear on the day the test battery was applied. For this study, a sample of 195 children and adolescents were used, of whom approximately half (52.3%) were female.

Table 1 shows the descriptive values for the variables observed in the study, indicating homogeneity of the distribution for variables directly considered in the study.

The age distribution into two groups took into account maturational stage from the Peak Height Velocity, identifying three points of interaction in the distribution at 7, 10 and 13 years (Figure 1). This result coincides with the mean age at which maturational differentiation is indicated in literature[14], being taken as reference for the differentiation of the age groups, as previously presented.

Table 1. Age, peak height velocity and maximal oxygen uptake in children and adolescents from the city of Aracaju, SE, 2017

Variables	Female		Male	
	≤ 13 years	> 13 years	≤ 13 years	> 13 years
N	70	32	70	23
Age (years)				
Mean	10.43	15.50	10.10	15.61
SD	2.00	1.55	1.97	1.03
95% CI	9.95 – 10.91	14.94 – 16.06	9.63 – 10.57	15.16 – 16.06
PHV (years)				
Mean	-3.22	-0.19	-3.66	0.42
SD	1.42	0.88	1.29	0.78
95% CI	-3.55 – -2.88	-0.51 – 0.13	-3.96 – -3.35	0.08 – 0.75
VO_2 (mL/Kg.min)				
Mean	28.91	29.04	28.87	30.38
SD	2.35	1.61	2.77	2.89
95% CI	28.35 – 29.48	28.46 – 29.61	28.21 – 29.53	29.13 – 31.63

Note. SD: standard deviation; 95% CI: 95% confidence interval; PHV: Peak Height Velocity; VO_2: oxygen uptake.

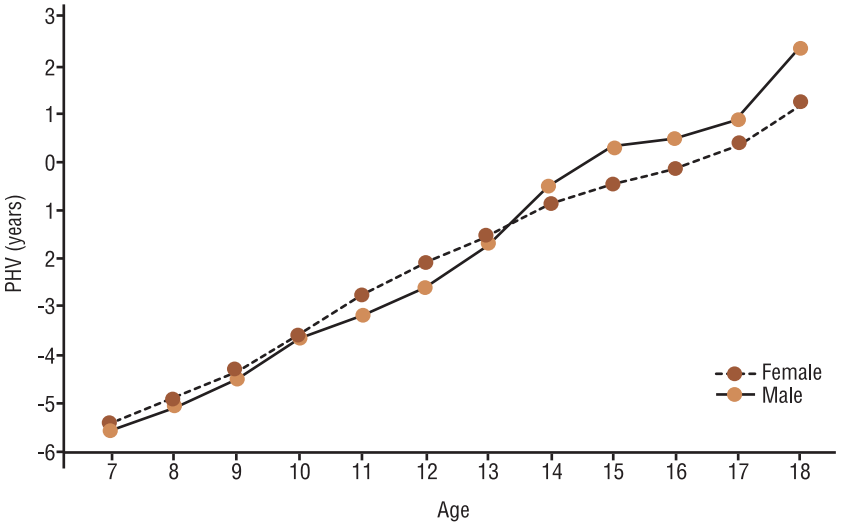

Figure 1. Identification of the Interaction Points between Age and Peak Height Velocity (PHV) in children and adolescents from Aracaju, 2017

Table 2 shows that there was no effect of age, gender and gender * age interaction on the cardiorespiratory capacity in the "up to 13 years" group. On the other hand, for the "above 13 years" group, effects of gender and age were observed on cardiorespiratory capacity.

As can be verified in Figure 2, at the "up to 13 years" moment, there are three points of interaction between groups, pointing to a random behavior for cardiorespiratory capacity when genders were compared.

Still in Figure 2, in the "up to 13 years" group, the polynomial contrast indicates that there is no trend of positive or negative variation for the cardiorespiratory fitness behavior in relation to age. It was also observed in Figure 2, through simple contrast for multiple comparisons, considering baseline as being the seven-year age group, that there is a random behavior of "VO_2", reinforcing that there was no trend in this age group.

Table 2. Cardiorespiratory capacity in children and adolescents by group ("up to 13 years" and "above 13 years"), gender and age, Aracaju, SE, 2017

Age of PHV Interaction	df	Sum of Squares	Mean Square	F	Sig.	Effect Size
up to 13 years						
Gender	1	0.01	0.01	<0.01	0.98	0
Age (years)	6	51.21	8.54	1.35	0.24	0.25
Gender * Age	6	69.37	11.56	1.83	0.10	0.28
Error	126	795.68	6.32	-	-	-
over 13 years						
Gender	1	23.92	23.92	5.54	0.02	0.33
Age (years)	4	58.33	14.58	3.37	0.02	0.48
Gender * Age	4	14.38	3.60	0.83	0.51	0.26
Error	45	194.50	4.32	-	-	-

Note. PHV: peak height velocity; df: Degrees of freedom; F: F statistic value; Sig: value calculated for the significance level.

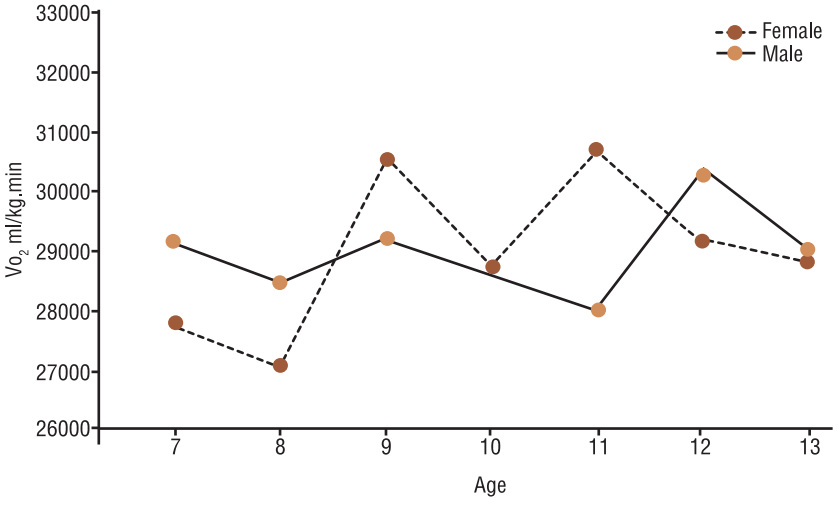

Figure 2. Cardiorespiratory capacity of children and adolescents "up to 13 years", by gender and age of the municipality of Aracaju, SE, 2017.

Figure 3 shows the behavior of the age group "above 13 years", where significant effects of variable "gender" on variable "VO_2" [F (1, 45) = 5.54, p = 0.02] were found. Significant effects of variable "age" on variable "VO_2" [F (4, 45) = 3.37, p = 0.02] were also observed, and there was no significance in the effect of the interaction between variables "gender" and "age" on "VO_2" [F (4, 45) = 0.83, p = 0.51].

The polynomial contrast in the "above 13 years" group (Figure 3), identified that there is a linear positive trend for VO_2 behavior in relation to the "14-year age" group when compared to the other age groups. Using simple contrast for multiple comparisons based on the "14-year age" group, an increased cardiorespiratory capacity behavior was evidenced when compared to the 15-year and 16-year age groups.

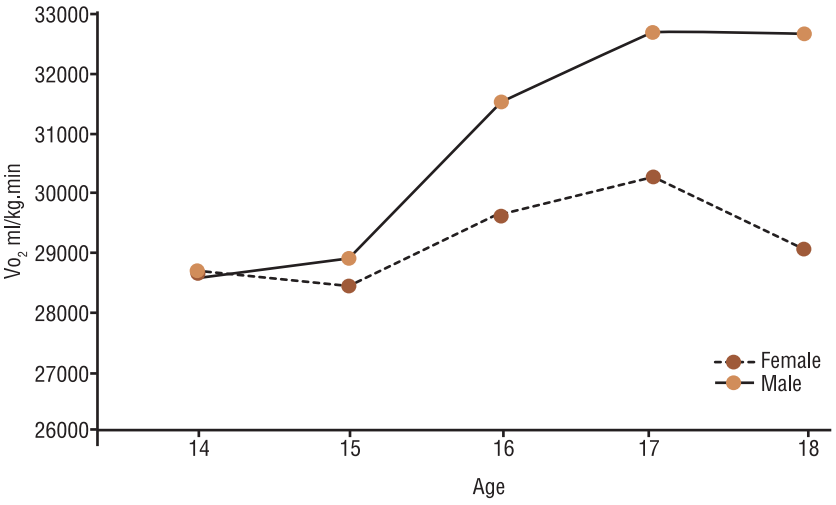

Figure 3. Cardiorespiratory capacity of children and adolescents "above 13 years", by gender and age of the municipality of Aracaju, SE, 2017.

DISCUSSION

This study pointed out that cardiorespiratory capacity has a random behavior up to the age of 13 years in both sexes, indicating that for the "above 13 years" age group, the cardiorespiratory fitness in male adolescents tends to increase. It was also identified that for the "above 13 years" group, the cardiorespiratory capacity was higher in males when compared to the opposite sex.

Considering the general response of cardiorespiratory capacity, the study of Armstrong and Welsman[15] reported that VO_2 relative to body mass in boys aged 11-18 years presents variations, and in girls, there is a progressive decline after that period, which shows that maturation does not influence the VO_2 behavior in both genders.

Silva and Petroski[6] analyzed the cardiorespiratory fitness in children and adolescents during puberty and observed that in males, there is stability in this variable relative to body mass and lean mass, and in females, there is a decline in VO_2 behavior, even with increased maturational stage.

In a study conducted in 10 European countries, results like those obtained in this study with adolescents aged 12-17 years of both genders were presented, where the levels of physical fitness components were higher in boys than in girls, except for flexibility, which also increased with increasing age[16].

The present study shows results like those found by Armstrong and Welsman[15], which showed a random behavior of cardiorespiratory capacity in children and adolescents up to the age of 13 years, presenting a progressive decline of this aptitude in girls from the age of 17 years.

The difference in cardiorespiratory fitness between boys and girls can be explained by the development of muscle mass, cardiorespiratory efficiency and higher levels of physical activity predominant in boys[8,17].

Pereira et al.[18] carried out a study with Portuguese twin siblings of both genders aged 9-20 years and found that the brother-brother pairs

presented better cardiorespiratory performance when compared to the brother-sister and sister-sister pairs and older pairs obtained better results when compared to younger ones.

Another study carried out with 282 adolescents of both genders aged 11-13 years from three schools in southern Brazil (Londrina) found that 56% of boys and 34% of girls had inadequate levels of cardiorespiratory fitness, but boys presented higher VO_2 in relation to girls. A similar result was found by Pelegrini et al. [19] in a study with 601 schoolchildren aged 14-17 years, also in southern Brazil (mid-western state of Santa Catarina), where boys had higher prevalence of inadequate VO_2 (92.6%) when compared to girls (35.5%), but the relative VO_2 was higher in males than in females[20].

Soares et al.[22] carried out a study with 747 schoolchildren aged 9-14 years from Aracaju and found a decreasing tendency of relative VO_2 in relation to maturational stages (pre-pubertal, pubertal and post-pubertal), and in males, the cardiorespiratory capacity was higher in the pre-pubertal stage and presented minimal variation in the other stages, whereas in females, VO_2 presented a more evident variation throughout the three stages. The present study identified a random behavior of VO_2 up to the age of 13 years, demonstrating different findings.

Possibly the difference among these studies and the present study is in the following points: the secular tendency, which can favor changes of patterns over time; the behavior of variables, considering the environmental response and the experience of children and adolescents; the analysis model used, since here the interaction point was used to identify the best differentiation at the positive variation point of the cardiorespiratory capacity.

The main limitation of the present study is the fact that it is not a population-based study, which makes it impossible to transpose the results for the entire region studied, suggesting the conduction of population surveys.

The analysis model used should be considered as an important strength of the present study, since the identification of the point of interaction of the curve as age cutoff point justifies better the age classification in the study group, making clear the maturational characterization according to the study population.

CONCLUSION

For the group analyzed, it was concluded that up to the maturational peak age, there is no trend in the cardiorespiratory fitness behavior in both genders. It was also verified that from this age, males present advantages over females, presenting higher and increasing values.

COMPLIANCE WITH ETHICAL STANDARDS

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Ethical approval

Ethical approval was obtained from the local Human Ethics Research Committee – 2.164.559 - Federal University of Sergipe, and the protocol was written in accordance with the standards set by the Declaration of Helsinki.

Conflict of interest statement

The authors have no conflict of interests to declare.

Author Contributions

Conceived and designed the study: RJSS, NMMS, KROB. Performed data collection: CFSL, KROB, MGDO, JOC. Analyzed data: KROB, MGDO, JOC, RJSS. Contributed with materials / analysis tools: CFSL, NMMS, JOC. Wrote the paper: KROB, JOC, MGDO.

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