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Higher cardiorespiratory and muscular fitness in males could not be attributed to physical activity, sports practice or sedentary behavior in young people

Maior aptidão cardiorrespiratória e muscular em meninos não pode ser atribuída à atividade física, prática esportiva ou comportamento sedentário em jovens

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Abstract – The purpose of the present study was to analyze if the association between sex with cardiorespiratory and muscular fitness is independent of physical activity, sports practice and sedentary behavior in young people. A cross-sectional study involving 729 participants aged 10 to 17 years. Physical activity, sports practice and sedentary behavior were assessed through a questionnaire. Cardiorespiratory fitness was measured using 20m shuttle run test and were analyzed: VO_2max, number of laps and health-related criteria. Muscular fitness was assessed with 90° push-up test and number of repetition and health-related criteria was analyzed. Multiple linear regression was used to estimate β coeficients and Poisson regression estimated prevalence ratios (PR). Male sex was associated to higher cardiorespiratory fitness (VO_2max β = 9.04 to 9.77, Laps PR=1.67 to 1.80, health-related criteria PR=2.03 to 2.09) and the same occurred with muscular fitness (repetitions PR=2.81 to 3.01, health-related criteria PR=1.91 to 2.09). Similarly, the stratification of the sample according to physical activity, sports practice and sedentary behavior did not change the associations between sex with cardiorespiratory (VO_2max β=8.07 to 10.00, Laps PR=1.49 to 1.85, health-related criteria PR=1.64 to 2.27) and muscular fitness (repetitions PR=2.24 to 3.22, health-related criteria PR=1.76 to 2.06). These data suggest that higher cardiorespiratory and muscular fitness in males could not be attributed to physical activity, sports practice or sedentary behavior in young people.

Key words:Adolescent; Motor activity; Muscle strength; Physical fitness; Sex.

Resumo – *O objetivo do presente estudo foi analisar se a associação entre o sexo e a aptidão cardiorrespiratória e muscular é independente da atividade física, prática esportiva e comportamento sedentário em jovens. Estudo transversal envolvendo 729 participantes com idade de 10 a 17 anos. A atividade física, prática esportiva e o comportamento sedentário foram analisados por meio de um questionário. A aptidão cardiorrespiratória foi medida pelo teste de vai e vem de 20m e foram analisados: VO_2max, número de voltas e o critério de saúde. A aptidão muscular foi obtida pelo teste de flexão de cotovelos de 90° e foram analisados o número de repetições e o critério de saúde. A regressão linear múltipla foi utilizada para estimar os coeficientes β e a regressão de Poisson estimou a razão de prevalência (RP). O sexo masculino se associou com a maior aptidão cardiorrespiratória nas análises brutas e ajustadas (VO_2max β = 9.04 a 9.77, voltas RP=1.67 a 1.80, critério de saúde RP=2.03 a 2.09) e o mesmo ocorreu com a aptidão muscular (repetições RP=2.81 a 3.01, critério de saúde RP=1.91 a 2.09). A estratificação da amostra de acordo com a atividade física, prática esportiva e comportamento sedentário não alterou as associações entre aptidão cardiorrespiratória (VO_2max β=8.07 a 10.00, voltas RP=1.49 a 1.85, critério de saúde RP=1.64 a 2.27) e muscular (repetições RP=2.24 a 3.22, critério de saúde RP=1.76 a 2.06). Os resultados sugerem que a maior aptidão cardiorrespiratória e muscular em meninos não pode ser atribuída à atividade física, prática esportiva ou comportamento sedentário em jovens.*

Palavras-chave: *Adolescente; Aptidão física; Atividade motora; Força muscular; Sexo.*

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INTRODUCTION

Cardiorespiratory and muscular fitness are components of physical fitness that are considered powerful markers of health in young people[1]. Specifically, it is well described that cardiorespiratory fitness is associated with lower adiposity levels, and better cardiovascular and mental health, while muscular fitness is associated with both cardiovascular and skeletal health[1].

There is a consensus in the literature that male young people have higher cardiorespiratory and muscular fitness compared to females[2-5] due to differences in lean mass[6-8] that become remarkable during puberty[9].In addiction to physical characteristics, behavioral aspects, such as physical activity, sports practice, and sedentary behavior have been associated with higher cardiorespiratory[10,11] and muscular fitness[12,13] in children and adolescents. Analyzing characteristics according to sex it is noted that girls perform less physical activity[11,14], and sports practice[11,15] and present higher sedentary behavior[11,16] compared to boys. For this reason, a considerable number of researchers have attributed the lower cardiorespiratory and muscular fitness presented by girls, in addition to lean mass, to these behavioral characteristics[3,4,11,17-20].

Despite the large number of studies describing the sociodemographic or behavioral and physiological variables associated with physical fitness, as well as normative values, there are limited information about the impact of physical activity, sports practice, and sedentary behavior on the association between sex and cardiorespiratory and muscular fitness in young people. The lack of information available prevents the understanding of whether behavioral variables contribute to sex differences in physical fitness in children and adolescents. Thus, the aim of the present study was to analyze if the association between sex and cardiorespiratory and muscular fitness is independent of physical activity, sports practice, and sedentary behavior in young people.

METODOLOGICAL PROCEDURES

Study sample and procedures

A cross-sectional study was conducted in a representative sample of students from state schools in the city of Londrina, Parana, Brazil, in 2012. The sample selection was probabilistic, stratified by sex, age (10-17 years) and area of the city, carried out in two stages. One school from each region (north, south, east, west, and center) was selected and in each school data were collected proportionally to the number of students in the respective region, using full classrooms. The inclusion criteria were: being enrolled in selected state schools, aged between 10 and 17 years, agreeing to participate voluntarily in the study, providing informed consent, and not having any physical, metabolic or neurological injury that impeded the execution of study procedures.

The sample size required to conduct the study was calculated using the following parameters: population size of 55,475 students, a 30% prevalence of achieving health-related criteria for cardiorespiratory and muscular fitness, sample error of 5%, confidence interval of 95%, and design effect = 2. The minimum number of participants required was 642 students. Since the study is part of a larger project, data collection was carried out with 965 students; however only participants who performed all study procedures were included in the study sample. The final sample was composed of 729 students.

The study was approved by the Ethics Committee for Research Involving Human Beings of the State University of Londrina, protocol 312/2011, according to Resolution 196/96 of the Brazilian National Health Council. The Informed written consent was obtained from the parents or guardians of participants who agreed to participate in the study. All procedures were carried out at the school where the participants were enrolled. The questionnaire and anthropometric measurements were performed in the classroom and the cardiorespiratory and muscular fitness tests were performed on a sports field at each school. Data collection was conducted by six researchers previously trained to perform all study procedures in a standardized manner and under the supervision of the research coordinator.

Outcomes

The outcomes of the study were cardiorespiratory and muscular fitness. Cardiorespiratory fitness was assessed by the multistage 20m shuttle run test according to previously described procedures[21], and three cardiorespiratory fitness indicators were analyzed: maximum oxygen uptake (VO_{2max}) estimated using equation proposed by Leger et al. [21], number of laps completed in the shuttle run test, and the health-related criteria for cardiorespiratory fitness proposed by *FITNESSGRAM*[22]. Muscular fitness was measured by the 90° push-up test and two variables were analyzed: the number of repetitions performed in the test and the health-related criteria[22]. Type, coding and unit measure of outcome variables are presented in box 1.

Independent variables

The independent variables of the study were sex, age, body mass index (BMI), physical activity, sports practice, and sedentary behavior. Height and weight were measured and BMI was calculated according to the formula: weight(kg)/height(m)^2. Physical activity was assessed through the Baecke Questionnaire of Habitual Physical Activity that presents acceptable validity and reproducibility in Brazilian adolescents[23]. The questionnaire evaluates physical activity in school, sport and exercise, and leisure time activities. Results are expressed as a score. Sports practice was analyzed by the following question: "*In leisure time activities do you practice sports?*", with response options: "*never; rarely; sometimes; frequently and always*"[23]. Sedentary behavior was assessed by the following question: "*How many hours on average do you watch TV, play video games, or use the computer,*" with the response options "*<1 hour per day, 1 hour per day, 2 hours per day, 3 hours per day, 4 hours per day, and 5 or more hours per day*". Type, coding, and unit measure of independent variables are presented in box 1.

Box 1. Type, coding, and unit measure of the study variables.

Variable	Type	Coding or unit measure
Sex	Dichotomous	1 = female, 2 = male
Age	Continuous	years
Body mass Index	Continuous	(Kg/m^2)
$VO_{2max.}$	Continuous	$ml/kg/min^{-1}$
Laps[a]	Discrete	Number of completed laps
Repetitions (n)[b]	Discrete	Number of completed repetitions
Cardiorespiratory fitness (%)	Dichotomous	0 = does not meet the FITNESSGRAM criteria; 1 = meets the FITNESSGRAM criteria.
Muscular fitness (%)	Dichotomous	0 = does not meet the FITNESSGRAM criteria; 1 = meets the FITNESSGRAM criteria.
Physical activity	Continuous	Score
Active	Dichotomous	≥ 80th percentile of physical activity score.
Sports practice (%)	Dichotomous	According to question answer: 1 = Sports practice frequently or always 0 = sometimes, rarely and never.
Sedentary behavior (%)	Dichotomous	According to question answer: 0 = >2h/day and 1 = ≤2h/day[24]
Overweight (%)	Dichotomous	BMI > 25 kg/m^2 at age 18[25]

a = Laps in 20m shuttle run test; b = Repetitions in 90° push-up test.

Statistical analysis

Descriptive statistics was performed using absolute and relative frequencies for categorical variables, mean and standard deviation for continuous variables, and median and interquartile range for count variables. Sample characteristics according to sex were compared using the Student t test for independent samples (continuous variable), Mann Whitney U test (discrete variables), and Chi-squared test (categorical variables). Multivariate linear regression was used to analyze the association between sex and cardiorespiratory fitness for the continuous outcome (VO_{2max}) and coefficients (β), and 95% confidence intervals (CI95%) were estimated. Poisson regression was used to estimate the prevalence ratio (PR) and CI95% of count outcomes (laps in shuttle run test and repetitions in the 90° push-up test) and dichotomous outcomes (cardiorespiratory and muscular fitness health-related criteria). To analyze the effects of physical activity, sports practice, and sedentary behavior on the association of sex with cardiorespiratory and muscular fitness, the analyzes were performed in two ways: 1-) Analysis of the independent variables effects by inserting the variables in different adjusted models considering the whole sample; 2-) Stratified analysis according to physical activity, sports practice, and sedentary behavior. In all analyzes complex sampling was considered using the command "svy" of the statistical package STATA 13.0. The statistical significance was set at 5%.

RESULTS

Of the 965 young people who agreed to participate in the study, 24.5%

(n=236) were excluded due to incomplete information of questionnaires or refusal to perform any study procedure. Higher proportion of girls (60.4%) compared to boys (39.6%) was found on missing group while no differences were found across age and region of the city.

Sample characteristics according to sex are presented in Table 1. Age, BMI and prevalence of overweight were similar between sexes. Males presented significantly higher values of physical activity score, VO_{2max}, laps completed in the 20m shuttle run test and number of repetitions in the push-up test. Furthermore, a higher prevalence of achieving the health-related criteria for cardiorespiratory and muscular fitness, being physically active, sports practice, and sedentary behavior ≤2h/week were found in males.

Table 1. Sample characteristics according to studied variables. Londrina, Paraná, Brazil, 2012.

	Male (n=359)	Female (n=370)	Total (n=729)
Age (years)	13.9 (2.66)	14.2 (2.58)	14.1 (2.62)
BMI (Kg/m^2)	20.3 (3.86)	20.5 (3.96)	20.4 (3.91)
VO_{2max} ($ml/kg/min^{-1}$)	47.6 (5.61) [a]	37.9 (4.57)	42.7 (7.04)
Laps[1]	36.0 (25.0-49.0) [b]	19.0 (14.0-27.0)	26.0 (17.0-38.0)
Repetitions[2]	11.0 (5.0-19.0) [b]	2.0 (0.0-6.0)	6.0 (1.0-13.0)
Physical activity (score)	7.93 (1.61)[b]	6.71 (1.45)	7.31 (1.65)
Overweight (%)	79.9 (75.0-83.6)	80.3 (75.9-84.0)	80.1 (76.9-82.7)
Sedentary behavior[3] (%)	42.4 (37.3-47.5) [c]	31.3 (26.3-35.6)	36.7 (33.4-40.4)
Sports practice (%)	51.0 (45.8-56.1) [c]	20.8 (16.7-24.9)	35.7 (32.2-39.2)
Cardiorespiratory fitness[4] (%)	85.8 (81.8-89.0) [c]	40.8 (35.6-45.6)	63.0 (59.4-66.3)
Muscular fitness[4] (%)	47.6 (42.2-52.5) [c]	22.4 (18.4-26.9)	34.8 (31.3-38.2)
Physically active (%)	46.4 (0.41-0.51) [c]	18.6 (15.0-22.9)	32.3 (28.9-35.7)

BMI = Body mass index; Age, BMI, physical activity score and VO2max are presented as mean (standard deviation) while laps and repetitions are expressed as median (interquartile range). Overweight, sedentary behavior, sports practice, and cardiorespiratory and muscular fitness are expressed as relative frequency (confidence interval). 1 = Laps in 20m shuttle run test; 2 = Repetitions in push-up test; 3 = ≤2h/week; 4 = FITNESSGRAM health-related criteria; a = p<0.05 vs. female in Student t test for independent samples; b = p<0.05 vs. female in Mann Whitney U test; c = p<0.05 vs. female in chi-squared test.

Table 2 presents the results of the association between sex and cardiorespiratory and muscular fitness in the whole sample in four models adjusted for independent variables (age, BMI, physical activity, sports practice, and sedentary behavior). In all models analyzed the male sex demonstrated a positive association with VO_{2max} (β = 9.04 to 9.77), number of laps in the 20m shuttle run test (PR = 1.67 to 1.80), number of repetitions in the push-up test (PR = 2.81 to 3.01), and achieving the health-related criteria for cardiorespiratory (PR = 2.03 to 2.09) and muscular fitness (PR = 1.91 to 2.09).

Table 3 presents the results of the association between sex and cardiorespiratory fitness in a stratified sample according to physical activity, sports practice, and sedentary behavior. The positive associations between the male sex and VO_{2max} (β= 8.07 to 10.00), number of laps in the 20m shuttle run test (PR=1.49 to 1.85), number of repetitions in the push-up test (PR=2.24 to 3.22), and achieving the health-related criteria for cardiorespiratory (PR=1.64-2.27) and muscular fitness (PR=1.76 to 2.06) found in the whole sample remained significant regardless of stratification according to the independent variables.

Table 2. Association between sex and cardiorespiratory and muscular fitness. Londrina, Paraná, Brazil, 2012.

	Category reference: Female				
Outcomes	Model 1	Model 2	Model 3	Model 4	Diff
VO_{2max} (ml/kg/min^{-1})[a]	9.77 (9.25-10.28)	9.31 (8.78-9.85)	9.32 (8.78-9.86)	9.04 (8.48-9.60)	-7.47
Laps[b]	1.80 (1.64-1.98)	1.70 (1.55-1.86)	1.70 (1.56-1.85)	1.67 (1.52-1.84)	-7.22
Repetitions[b]	3.01 (2.42-3.75)	2.84 (2.28-3.54)	2.83 (2.25-3.57)	2.81 (2.18-3.62)	-6.64
Cardiorespiratory HC[b]	2.09 (1.86-2.36)	2.04 (1.80-2.32)	2.03 (1.82-2.26)	2.06 (1.80-2.34)	-2.87
Muscular HC[b]	2.09 (1.45-3.02)	1.93 (1.36-2.73)	1.91 (1.35-2.70)	1.92 (1.31-2.83)	-8.61

HC = Health-related criteria; Model 1: Adjusted for age and BMI; Model 2: Adjusted for age, BMI, and physical activity; Model 3: Adjusted for age, BMI, physical activity, and sports practice; Model 4: Adjusted for age, BMI, physical activity, sports practice, and sedentary behavior. Diff = Percentage difference between highest and lowest coefficients. a = β value of multiple linear regression; b = Prevalence ratio of Poisson regression.

Table 3. Association between sex and cardiorespiratory and muscular fitness according to physical activity, sports practice, and sedentary behavior. Londrina, Paraná, Brazil, 2012.

	Category reference: Female		
	Sports practice		
	Non practice (n=469)	Practice (n=260)	Diff (%)
VO_{2max} (ml/kg/min^{-1})[a]	9.48 (8.85-10.11)	8.91 (7.95-9.87)	-6.0
Laps[b]	1.75 (1.65-1.87)	1.60 (1.08-1.13)	-8.5
Repetitions[b]	2.95 (2.25-3.86)	2.45 (1.15-1.27)	-16.9
Cardiorespiratory HC[b]	1.98 (1.76-2.23)	2.27 (1.55-3.33)	14.6
Muscular HC[b]	1.88 (1.24-2.83)	1.87 (1.34-2.61)	-0.5
	Sedentary Behavior		
	>2h/week (n=477)	≤2h/week (n=262)	
VO_{2max} (ml/kg/min^{-1})[a]	9.13 (8.38-10.23)	10.00 (9.36-10.63)	9.5
Laps [b]	1.85 (1.67-2.05)	1.71 (1.54-1.91)	-5.9
Repetition[b]	3.22 (2.44-4.25)	2.47 (1.78-3.43)	-23.2
Cardiorespiratory HC[b]	2.27 (1.90-2.73)	1.76 (1.40-2.21)	-22.4
Muscular HC[b]	2.06 (1.34-3.16)	1.76 (1.26-2.47)	-14.5
	Physical activity		
	Inactive (n=494)	Active (n=235)	
VO_{2max} (ml/kg/min^{-1})[a]	9.32 (8.67-9.97)	8.07 (7.01-9.14)	-13.4
Laps[b]	1.71 (1.55-1.90)	1.49 (1.17-1.89)	-12.8
Repetition[b]	2.90 (2.17-3.88)	2.24 (1.64-3.07)	-22.7
Cardiorespiratory HC[b]	1.64 (1.53-1.76)	1.78 (1.15-2.74)	8.5
Muscular HC[b]	1.91 (1.10-3.29)	1.77 (1.12-2.79)	-7.3

HC = Health-related criteria; Values expressed as coefficients and confidence interval of 95% of respective regression models; a = β value of multiple linear regression; b = Prevalence ratio of Poisson regression. Diff (%) = Percentage difference between coefficients. All analyzes were adjusted for age and BMI.

DISCUSSION

The results showed that the male sex is positively associated with cardiorespiratory and muscular fitness in young people. The novelty of the present study was that the association between sex and cardiorespiratory and muscular fitness in young people is independent of physical activity, sports practice, and sedentary behavior.

The higher cardiorespiratory and muscular fitness presented by boys, independently of the unit measure used, is consistent with a large number of previously conducted studies[2-5]. Likewise, the behavioral characteristics corroborate those described in the literature[11,14-16], with girls presenting a higher prevalence of physical inactivity, non sports practice, and sedentary behavior compared to boys. Although the higher physical fitness in boys is often attributed in part to behavioral characteristics[3,4,11,17-20], these affirmations are based on assumptions that the greater engagement of boys in physical activity, sports practice, and less sedentary behavior could result in higher physical fitness compared to girls. Armstrong, Tomkinson and Ekelund[26] described that although boys are more active than girls, the pattern of physical activity presented by both rarely reaches the duration and intensity sufficient to increase peak VO_2. A study published later[27] showed that boys perform on average 83.5 and girls 67.4 min/day of moderate to vigorous physical activity, values greater than the 52 and 51 min/day of moderate to vigorous physical activity recommended to achieve the health-related criteria for cardiorespiratory fitness in boys and girls respectively[28].

In fact, physical activity, sports practice, and less sedentary behavior are associated with physical fitness in young people[10-13] and both girls and boys with these characteristics presented higher physical fitness compared to their peers[13,15,19]. Nevertheless, the results of this study showed that physical activity, sports practice, and sedentary behavior did not eliminate the associations found, indicating that the higher cardiorespiratory and muscular fitness of boys cannot be attributed to existing behavioral differences between the sexes in youth. Besides not eliminating the effect of sex on physical fitness, it also cannot be affirmed that behavioral characteristics mediate the relationship between sex and physical fitness. One of the conditions for establishing a mediation is that the regression coefficient for the relationship between the independent variable (sex) and the dependent variable (cardiorespiratory and muscular fitness) must be reduced or eliminated, in case of a perfect mediation, when the mediator variable (behavioral characteristics) is inserted in the regression model. In the present study, the coefficients analyzed changed from 2.87 to 8.61% when the variables physical activity, sports practice and, sedentary behavior were included in the model (Table 2). By analyzing the stratified sample, regression coefficients changed from 0.5 to 23.2% (Table 3), and in any variable analyzed the effect of sex on cardiorespiratory and muscular fitness was eliminated.

Although not investigated in the present study, the differences in body composition of boys and girls are determinants of cardiorespiratory and muscular fitness in young people. The higher lean mass of boys is related to a higher concentration of hemoglobin, which facilitates the transport and use of oxygen during exercise, increasing venous return and consequently maximum stroke volume. These characteristics result in higher peak oxygen uptake in boys compared to girls[6]. With regard to muscular strength, despite the influence of neuromuscular and biomechanical factors in young people being poorly understood[29], lean mass is associated with higher muscular strength production[7,8,29]. Boys presented higher muscular strength per unit of body size, particularly in the upper limbs and trunk[7], and after adolescence girls have only 50% of the upper limb muscle size of boys[30]. These are relevant characteristics as in the present study the push-up 90º test was used, which requires strength of upper limbs and trunk. Moreover, during adolescence there is an increase in lean body mass in both boys and girls, however the growth spurt is more pronounced in boys. On the other hand, there is a marked increase in fat mass in female young people[9]. For this reason the differences in cardiorespiratory and muscular fitness between sexes becomes more pronounced after puberty[2,3,5].

The main recommendation for future studies is the inclusion of lean mass variable on analysis. It could largely explain the association between sex and physical fitness of young people and enables to scale cardiorespiratory and muscular fitness by the lean mass. Moreover, it could describe whether behavioral variables can change the effect of sex on physical fitness when values are corrected by lean mass. However, it's important to state that the absent of lean mass is a common limitation in epidemiological studies[2,3,5,11,17,20] due to the impracticality of collecting this variable accurately in large samples.

CONCLUSIONS

It was concluded that the relationship between sex and cardiorespiratory and muscular fitness is independent of physical activity, sports practice, and sedentary behavior in young people. It is suggested that future studies use a longitudinal design and include, in addition to behavioral variables, other physical and physiological variables in order to identify which determine the differences in physical fitness between the sexes during childhood and adolescence.

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