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# Impact of physical growth, body adiposity and lifestyle on muscular strength and cardiorespiratory fitness of adolescents

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A B S T R A C T

*Objective:* To investigate the impact of physical growth, body adiposity and lifestyle on cardiorespiratory fitness and muscle strength of pubescent and post-pubescent adolescents.
*Methods:* Cross-sectional study with 1132 adolescents (14–19 years) in Brazil. Aerobic fitness was measured using the modified Canadian Aerobic Fitness Test. Muscle strength was assessed using manual dynamometer. Maturational stages were defined through the Tanner criteria.
*Results:* Boys at pubertal maturation stage showed higher $VO_2$max values than those at the post-pubertal stage when the influence of body adiposity and lifestyle was disregarded. Girls at pubertal maturation stage showed higher $VO_2$max values than those in the post-pubertal stage when the influence of age was disregarded. For muscle strength, no significant differences were found.
*Conclusions:* The variables that influence the association between $VO_2$max and maturational stage are different for boys and girls.



## 1. Introduction

Health-related physical fitness is an important health status indicator, especially during childhood and adolescence (Ruiz et al., 2010). Cardiorespiratory fitness is one of the components of physical fitness. It is defined as the ability of the circulatory and respiratory systems to supply oxygen to muscles during physical exercise of moderate to high intensity and involve large muscle groups for long periods of time (Rowland, 1996). Inadequate cardiorespiratory fitness levels are associated with metabolic syndrome, increased cardiovascular risk and functional inability to perform daily activities (Mota et al., 2002).

Some biological characteristics such as sexual maturity and some behavioral characteristics such as level of physical activity and sedentary lifestyle are factors that influence levels of cardiorespiratory fitness in adolescents (Minatto et al., 2016; Bacil et al., 2015). With the onset of puberty, numerous bodily changes occur such as increased body fat, especially in females, which interferes with the aerobic performance of adolescents (Minatto et al., 2016). In addition, during adolescence, there is a decline in physical activities, particularly high-intensity activities and an increase in the predominance of activities that involve little physical exertion, resulting in lower levels of aerobic fitness (Bacil et al., 2015). Low levels of aerobic fitness are more evident in female adolescents, not physically active and with excess body fat (Huotari et al., 2010).

Another important component of physical fitness is muscle strength, defined as the maximum amount of power or tension that can be generated by a muscle or a muscle group (Powers et al., 2000). Low levels of power are associated with reduced muscle mass and increased risk for cardiovascular disease in adulthood (Steene-Johannessen et al., 2009). Studies have shown that adolescents with low levels of muscle strength are more likely to become adults with low levels of muscle strength, a fact that denotes a concern with levels of muscle power since pediatric age (Ortega et al., 2012). Moreover, during adolescence, muscle strength is affected by biological maturation. The increase in the production of anabolic hormones that occurs during puberty affects muscle hypertrophy and levels of muscle strength. Handgrip strength is the sum of the strength of the flexor muscles against the palmar (Mathiowetz et al., 1985). This kind of strength was used to evaluate hand function and also reflects general health and level of physical activity of the individual, being a low-cost tool to predict overall strength (Hansen et al., 2013; Leong et al., 2015). Low handgrip strength levels was associated with increased health

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recovery time after illness or surgery, malnutrition, type II diabetes, cardiovascular complications and overall mortality (Leong et al., 2015; Montalcini et al., 2013).

Although the relationship between cardiorespiratory fitness and muscle strength with sexual maturation has been explored in adolescents (Ortega et al., 2007; Silva et al., 2016), there is a gap in the literature about considering in the same analytical model, variables related to physical growth, body adiposity and lifestyle simultaneously and verifying which of them more heavily influences aerobic fitness and muscle strength in adolescents. Therefore, the aim of this study was to investigate the impact of physical growth, body adiposity and lifestyle on cardiorespiratory fitness and handgrip strength of pubescent and post-pubescent adolescents.

## 2. Material and methods

### 2.1. Design

This cross-sectional study was approved by the Ethics Committee on Human Research of the Federal University of Santa Catarina (CAAE Protocol: 33210414.3.0000.0121).

### 2.2. Population and sample

The study population consisted of 5182 high school students aged 14–19 years students from public schools of São José, Santa Catarina, southern Brazil, distributed in 11 eligible schools and 170 high-school classes. The sampling process was determined in two stages: 1) stratified by public high-schools ($n = 11$); 2) clusters of classes considering school shift and school grade ($n = 170$ classes). In stage two, all high-school students who were present in the classroom on the days of data collection were invited to participate in the study. The probabilistic sample consisted of 1132 students. Details on estimates for sample size calculation and the entire sampling process (inclusion, exclusion criteria, and eligibility) can be found in literature (Silva et al., 2016).

Data collection occurred at the school environment in the second half of 2014 during the months of August to November. The research team was composed of undergraduate and graduate students previously familiar and trained to administer the questionnaire and physical assessments. Cada participante foi informado igualmente sobre os procedimentos da pesquisa. Each participant was equally informed about the research procedures.

### 2.3. Dependent variables

Aerobic fitness was measured using the modified Canadian Aerobic Fitness Test - mCAFT (Canadian Society for Exercise Physiology, 2003), validated in comparison with indirect calorimetry in individuals aged 15–69 years (Weller et al., 1992), and with sufficient discriminatory power to detect high blood pressure among young Brazilians (Silva et al., 2016). Adolescents had to complete one or more stages of three minutes each (up and down two steps of 20.3 cm each) in cadences established according to sex and age. The test was finished when participant reached 85% of maximum heart rate (recommended by formula 220 - age), (Canadian Society for Exercise Physiology, 2003), which was measured by Polar® frequency meter model H7 Bluetooth. Oxygen consumption and the aerobic fitness reference values were determined by the Canadian battery (Canadian Society for Exercise Physiology, 2003). The aerobic fitness score equation is: *Score = 10 [17.2 + (1.29 x Oxygen consumption) - (0.09 x weight in kg) - (0.18 x age in years)*. To transform this score into $VO_2$max ($ml.kg^{-1}.min^{-1}$), the value was divided by 10 (Silva et al., 2016).

Muscle strength was evaluated using Saehan® manual dynamometer, which has validation concurrent with Jamar® dynamometer (Reis and Arantes, 2011) ($r = 0.976$) and intra-rater reliability ($r = 0.985$) (Reis and Arantes, 2011). During evaluation, adolescent remained standing with arms outstretched at body sides, with equipment not touching the thigh. The equipment was located between the distal phalanges and hand palm; subsequently, the adolescent was requested to perform maximal inspiration and expiration and then the highest pressure as possible with hand in the equipment (Canadian Society for Exercise Physiology, 2003). The test was performed in both hands alternately twice, and the best result in kilograms of each hand was recorded and summed to yield total power.

### 2.4. Independent variables

Anthropometric measurements (height, body weight, triceps and subscapular skinfolds) were performed by a single evaluator with level-one certification of the International Society for the Advancement of Kinanthropometry. Standardizations adopted were according to literature (Marfell-Jones et al., 2006). Height was collected by Sanny® stadiometer with tripod (São Paulo, Brazil) and body mass with G-Tech® digital scale (Zhongshan, China). Skinfolds (triceps and subscapular) were collected using Cescorf® adipometer (Porto Alegre, Brazil).

Time sitting (sedentary lifestyle) was analyzed by screen time. Six distinct questions were asked, which checked the amount of hours spent in front of television, computer and video games on weekdays and weekends. Screen time was calculated by the sum of hours spent in front of the screen on weekdays (calculated by multiplying hours and minutes by five) and weekends (calculated by multiplying hours and minutes by two), resulting in full screen time. The daily average hours was verified by the sum of hours in the seven days of the week, divided by the total days of the week (seven days) for three types of screen (television, computer and video game) (Bar-On et al., 2001).

The level of physical activity was investigated through the question: “During the past seven days, on how many days were you physically active for at least 60 min a day?” Such questioning is used in literature with appropriate validation (Guedes and Lopes, 2010). Adolescents responded one of the options ranging from one to seven days a week. From the chosen option, the number of days in the week that the adolescent answered was multiplied by 60 (minutes), which allowed finding how many minutes per week the adolescent performed physical activity (Word Health Organization, 2013).

Sexual maturation was assessed according to criteria proposed by Tanner (1962), validated and reproducible in the Brazilian population (Matsudo and Matsudo, 1994). Boards containing photos of the five stages of maturational development were shown to adolescents, who were requested to carefully observe every photo and to mark on the questionnaire the one that most resembled his genital organ size for boys and size of breasts for girls. Adolescents were individually guided by assessors of the same sex on the purpose and importance of this evaluation. Only few adolescents were in the pre-pubertal stage (2.0%), which were excluded from the analysis. So, from this variable, adolescents were classified into pubertal and post-pubertal, stages 1, 2 and 3 being classified as pubescent and stages 4 and 5 as post-pubescent.

### 2.5. Statistical analysis

For data analysis, normality was initially tested by means of kurtosis and skewness values, with data showing normal distribution. Descriptive statistics with mean and standard error values was used. To compare the sample according to gender, the *t*-test for

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