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# INFLUENCE OF AGE, PERCENTAGE OF FAT, ABDOMINAL ENDURANCE IN CARDIORRESPIRATORY FITNESS OF ADOLESCENT SCHOOLS: A PATH ANALYSIS

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**ABSTRACT**

**Objective:** To investigate the direct and indirect association of variables age, percentage of fat, abdominal muscle endurance and mean arterial pressure with cardiorespiratory fitness (CRF). **Methods:** Adolescent schoolchildren from municipal public schools, aged from 11 to 14 years, from Montes Claros (MG), were researched. Cardiorespiratory fitness was assessed by the six-minute running test, the percentage of fat was assessed by the sum of skin folds, muscle endurance was assessed by sit up test, and systemic blood pressure was represented by mean arterial pressure. Multivariate analysis was performed using path analysis. **Results:** 860 students participated, 52.9% of whom were female. There was a direct negative effect of female age and percentage of fat on cardiorespiratory fitness, in addition to the direct and positive effect of abdominal endurance in both sexes. There was also an indirect effect of the percentage of fat on cardiorespiratory fitness mediated by abdominal endurance. The proportion of direct effect in relation to total effect of fat percentage on cardiorespiratory fitness was 95.4% in girls and 96.7% in boys. **Conclusions:** Considering the effect of age, percentage of fat and muscle endurance on cardiorespiratory fitness, it is suggested to promote actions that encourage practice of physical exercises from earlier ages.



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## INTRODUCTION

Cardiorespiratory fitness (CRF) is the capacity of respiratory and circulatory systems to supply oxygen to muscles during physical exercise of moderate to high intensity and involves large muscle groups for long periods (ACSM, 2014). It is an important component of health-related physical fitness, being considered a relevant indicator of health status (Nogueira *et al*, 2014). A better health condition in general is achieved when individuals develop satisfactory CRF since childhood and adolescence (Ortega *et al*., 2011; Silva *et al*., 2016). These tend to present fewer risk factors for cardiovascular disease, obesity, high blood pressure, dyslipidemia and insulin resistance (Pereira *et al*., 2014; Silva *et al*., 2017; Victo *et al*., 2017). They become more participatory in sports practices, with a greater chance of maintaining them in adulthood (Pate *et al*., 2006), and present more satisfaction with social relationships (Werneck *et al*., 2018). Satisfactory levels of CRF are also associated with better cognitive skills (Hillman *et al*., 2008; Chaddocl *et al*., 2012), to brain plasticity (Hillman *et al*., 2008) and improved memory (Moore *et al*., 2013), resulting in better academic performance (Scudder *et al*., 2014; Sardinha *et al*., 2016). Low CRF in children and adolescents is an observed reality on international scene (Ortega *et al*., 2011; Agostinis Sobrinho *et al*., 2015; Ramírez-Vélez *et al*., 2017) and nationally (Minatto *et al*., 2015; Pelegrini *et al*., 2017; Gonçalves *et al*., 2018) and it is associated with age, sex, body adiposity (Victo *et al*., 2017; Pelegrini *et al*., 2017), with high levels of systemic blood pressure (Senh *et al*., 2019). Muscular endurance also shows a contribution to good health conditioning in this age group (Davoli *et al*., 2018). To improve CRF levels, it is necessary for adolescents to increase their levels of physical activity and choose those that involve the greatest physical effort (Pereira *et al*., 2016). Given the evidence of benefits that CRF adds to health of adolescents and cognitive performance, in addition to the scarcity of studies that assess factors which are directly and indirectly related to the CRF of adolescent students nationwide, especially in northern region of Minas Gerais, there is a need for studies that investigate the theme and carry out multivariate evaluation, through path analysis. In this context, the present study aimed to investigate the direct and indirect association of the variables age, fat percentage, abdominal muscle endurance and mean arterial pressure (MAP) of adolescent students with CRF.

## METHODS

The present cross-sectional stuy is part of the research entitled "School health: nutritional assessment and cardiovascular risk among adolescents in public schools", developed in public schools in the city of Montes Claros, Minas Gerais, Brazil. The population consisted of students enrolled from the sixth to the ninth grade in elementary school, in 2017, when there were a total of 9,162 students distributed in 51 municipal schools. The sample size was defined considering the finite population of adolescents, the prevalence of 50% of the studied event, confidence level of 95% and a standard error of 5%. Correction for the design effect was adopted, adopting *deff*= 2. An increase of 10% was established to compensate for possible non-responses and losses. The participation of at least 844 adolescents was estimated. The selection of sample was of probabilistic type by clusters in two stages. In the first stage, schools were drawn by probability proportional to the sample size. In the second stage, classes were selected by simple random sampling and all students in the selected classes were evaluated. It was used as inclusion criteria being a regularly enrolled student in the educational institution and in the selected class and being in the age group of 11 to 14 years old. Those with physical limitations and/or pain that prevented them from carrying out physical assessment tests were excluded, according to information provided by the school, parents or the adolescentes themselves. Students who did not show up at school on the days of anthropometric measurements and physical assessment tests were considered losses. Anthropometric measurements were taken prior to the performance of abdominal muscle endurance tests and the CRF. Weight was measured on a portable, electronic, digital scale, from brand Omron (HBF514C, Tokyo, Japan), with a capacity of up to 150Kg and a sensitivity of 1,000g. The students were weighed with the school uniform, positioned with their arms relaxed at their sides. It was requested to remove shoes, earrings, rings, watches and other objects they were carrying. Height was assessed using a portable stadiometer, with a scale from 35.0 to 213.0 cm and precision of 0.1 cm. During the measurement, students were instructed to keep their feet together, centered on the equipment, with their heads, buttocks and heels leaning against the wall in a horizontal plane. The stadiometer ruler was moved to the participant's head and the reading was performed after a normal expiration. From the measurements of weight and height, the body mass index (BMI) was calculated, defined as the relationship between weight in kilograms and height in meters raised to the square expressed in Kg/m². Skinfold measurements were obtained following the protocol proposed by Slaugther *et al*. (1988) andstandardizationby Harrison *et al*. (1988). Two previously trained researchers were responsible for measuring all participants, in order to guarantee the reliability of the results. Tricipital, subscapular and calf skinfolds were evaluated using the AVA NUTRI adipometer series 110501-17. Tricipital fold was measured at posterior part of right arm, over tricipital muscle, at the midpoint between the acromium and the olecranon, clamping the skin and subcutaneous tissue between thumb and forefinger, where the adipometer was applied one centimeter below the fingers that pinched the fold. Subscapular fold was measured just below the lower angle of the right scapula. Skin and subcutaneous tissue were pinched at this location and the fold was angled at 45º from the horizontal plane, going superiorly inward, where the adipometer was placed one centimeter below the fingers that pinched the fold. The calf fold was measured at maximum circumference, in the middle region of the calf, with knee and hips flexed at 90º. The procedure was repeated three times, using the average value of measurements.[25] Using skinfold measurements, the percentage of body fat (% BF) was calculated using the equation by Slaughter *et al*. (1988) (Chart 1).

**Chart 1. Regression equation for calculating percentage (%) of fat for children and adolescents (8-18 years)**

| Sex | Equation |
|---|---|
| General Male | %G = 0.735(TR+ CA) + 1.0 |
| Male if (TR+ SS) is higher than 35 | %G = 0.738 (TR+SS) + 1.6 |
| General Female | %G = 0.610 (TR + CA) + 5.1 |
| Female if (TR+ SS) is higher than 35 | %G = 0.546 (TR + SS) +9.7 |

TR:triceps; SS:subscapular; CA:calf
**Source:** Slaughter *et al*. (1988).

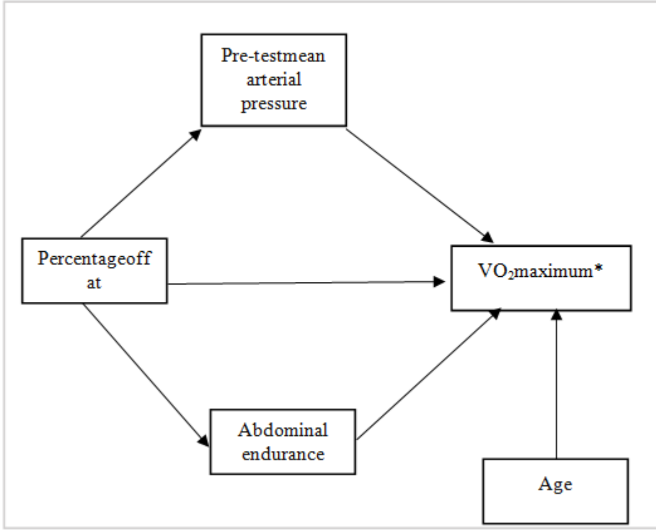
Blood pressure was measured using a calibrated digital sphygmomanometer (Model HEM-CR24®, OMRON®), performed according to the Protocol of the VII Brazilian Guideline on Arterial Hypertension, with the adolescent sitting, with his legs uncrossed, his feet resting on the floor, the dorse against the chair and relaxed, with arm at heart level, supported, with the palm of the hand facing up and clothes without garroting the limb. Two measurements were made, the first one before physical tests and the second after finishing the tests. From the values obtained from systolic blood pressure (SBP) and diastolic blood pressure (DBP), mean arterial pressure (MAP) was calculated, since this represents SBP and DBP in a single variable, from the application of the following formula: PAM = [PAD + (PAS-PAD/3)] (Silva *et al*., 2017). To assess abdominal muscle endurance, the sit up test (number of sit-ups in 1 minute) was performed and for the

CRF, the six-minute running test (6MWT). The protocols established by Projeto Esporte Brasil (PROESP) were followed (Gaya *et al*., 2016). For abdominal endurance test, the student was positioned in dorsal decubitus position on a mat, with knees flexed at 45 degrees and arms crossed over the chest. The evaluator held the student's ankles with hands, fixing them to the ground. A stopwatch was used to record the time of one minute. Upon receiving a signal, the student started flexing their torso until they touched their elbows to their thighs, returning to the starting position, and it was not necessary to touch their head on the mat after each execution. The student should perform the largest number of complete repetitions in one minute and the result was recorded at the end of this time. The 6MWT was used to measure the distance each student was able to travel during this established time. The test was carried out on the school courts with prior marking of their perimeters. The students were divided into groups of four people because it was an adequate amount for the dimensions of the track marked on the court and were informed about the execution of the test. They were instructed to run as long as possible, emphasizing the importance of maintaining a constant running pace, avoiding walks and speed sprints. During the test, students were informed of the passage of time at 2, 4 and 5 minutes. After completing 6 minutes of testing, a beep with a whistle interrupted the race and they remained where they were until the distance covered was recorded, the distance was recorded in meters with a decimal place (Gaya *et al*., 2016). The total distance covered by the students during the 6MWT was used together with the BMI and sex to indirectly estimate the CRF. Thus, the calculation of the maximum oxygen consumption ($VO_{2maximum}$) was performed using the following formula, developed by Bergmann *et al*. (2014):

$VO_{2maximum}$ = 41,946 + 0.022x (6MWT) - 0.875x (BMI) + 2.107x (Sex)

Where 6MWT: meters covered in the test; BMI: kg / $m^2$; female gender = 0 and male gender = 1; unit of measurement expressed per ml/kg/min.

This formula was developed for the prediction of maximum oxygen consumption in adolescents aged from 10 to 14 years, from the 6-minute running/walking test, of demographic and anthropometric variables.The equation was created by a validation group and tested in a cross-validation group and proved to be suitable for this purpose. The best model found was developed by means of multiple linear regression analysis, with a multiple correlation coefficient ($R^2$) of 0.77 and a standard error of estimate of 3.99 ml/kg/min. The result obtained, from the equation, expresses the individual's CRF (Bergmann *et al*., 2014). Collected data were typed in duplicate, organized and analyzed using the statistical software IBM Statistical Package for the Social Sciences (SPSS) for Windows, version 22.0. In data analysis, the categorical variables were described by means of their frequency distributions (absolute and relative) and the numerical variables by mean, standard deviation, minimum and maximum values, asymmetry coefficients (sk) and kurtosis (ku), corrected by design effect (deff). Values of sk> 3 and /or ku> 10 were considered as indicators of violation of the assumption of normality, however, all variables used followed the normal distribution. The missing values were imputed by average. A multivariate theoretical model was developed (Figure 1), based on a review of the scientific literature on factors related to CRF in adolescents. We sought to identify the interrelationships between CRF, considered as the main outcome and the other study variables: age, body fat percentage, abdominal endurance and blood pressure. Then, the multivariate model was adjusted using the path analysis technique.The direct and indirect effects represented by standardized coefficients were estimated, whose statistical significance was assessed by the Critical Ratio (CR) at the level of 5% (Marôco, 2014). Standardized coefficients with values close to 0.10, close to 0.30 and greater than 0.50, were interpreted as small, medium and large effects, respectively, according to Kline's recommendation (2004).




*$VO_2$maximum: maximum oxygen consumption.

**Figure 1. Hypothetical model for the association between age, fat percentage, abdominal endurance and mean arterial pressure with CRF of adolescent students**

In evaluation of fit quality of model, the Bentler comparative fit (CFI), fit adequacy (GFI) and Tucker-Lewis (TLI) indices were used. A good fit was considered when these indices showed values above 0.90. The root mean quadratic error of approximation (RMSEA) was also used, whose values below 0.10 were considered reasonable adjustment indicators and the ratio between the chi-square and the degrees of freedom ($\chi 2$/gl), which indicates an acceptable adjustment for a value less than five (Kline, 2004; Byrne, 2001). Parameter estimation was performed using the maximum likelihood method implemented in IBM SPSS AMOS 20.0 software. Terms of consent and free and informed consent were used, respectively, for the consent of legal guardians and students surveyed. The ethical precautions provided by Resolution 466/2012, of Brazilian National Health Council were observed. The study was approved by the Research Ethics Committee of Universidade Estadual de Montes Claros, approved under opinion number 1,908,982.

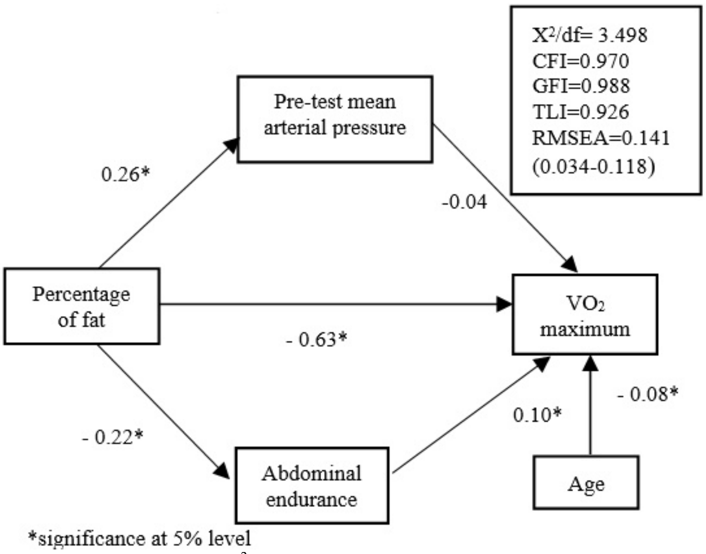
## RESULTS

860 students participated in the research, 52.9% of whom were female. The mean age was 12.6 years (SD = ± 0.94) for females and 12.7 years (SD = ± 0.97) for males. As for education, 63% were in sixth or seventh year. In assessing body composition, the mean BMI was 20.2 kg/m² (SD = ± 4.0) and 19.4 kg/m² (SD = ± 3.5), the percentage of fat was 28,0 (SD = ± 8.1) and 22.9 (SD = ± 13.3) for females and males respectively.

**Table 1. Descriptive measures of sociodemographic and clinical variables, abdominal endurance and CRF by sex of school adolescents. Montes Claros, MG, 2017**

| Variable | n (%) | | | | |
|---|---|---|---|---|---|
| | Female(455) | | Male (405) | Total (860) | |
| Age | | | | | |
| 11 years | 49 (5.7) | | 51 (5.9) | 100 (11.6) | |
| 12 years | 159 (18.5) | | 119 (13.8) | 278 (32.3) | |
| 13 years | 148 (17.2) | | 137 (15.9) | 285 (33.1) | |
| 14 years | 99 (11.5) | | 98 (11.4) | 197 (22.9) | |
| Scholarity | | | | | |
| 6thyear | 115 (13.4) | | 103 (12.0) | 218 (25.3) | |
| 7th year | 166 (19.3) | | 158 (18.4) | 324 (37.7) | |
| 8th year | 127 (14.8) | | 113 (13.1) | 240 (27.9) | |
| 9th year | 47 (5.5) | | 31 (3.6) | 78 (9.1) | |
| Variable | Mean (SD) | Median | Min-Max | Sk | Ku |
| TOTAL | | | | | |
| BMI | 19.8 (3.8) | 18.9 | 12.8 - 37.4 | 1.16 | 1.83 |
| % offat | 25.6 (10.6) | 23.4 | 6.9 - 65.0 | 0.88 | 0.77 |
| Pre-test MAP | 76.8 (9.7) | 76.7 | 47 -123 | 0.56 | 0.95 |
| Abdominal Endurance | 25.2 (9.1) | 25 | 1 – 50 | 0.14 | -0.11 |
| 6MWT | 676.6 (182.4) | 654 | 99 – 1200 | 0.08 | - 0.09 |
| $VO_2$maximum | 40.5 (5.9) | 40.6 | 17.2 - 55.7 | -0.21 | 0.16 |
| FEMALE | | | | | |
| Age | 12.6 (0.94) | 13 | 11 – 14 | -0.05 | -0.93 |
| BMI | 20.2 (4.0) | 19.4 | 12.8 – 37.4 | 1.2 | 1.94 |
| % offat | 28.0 (8.1) | 26.5 | 11.8 – 57.2 | 0.63 | 0.15 |
| Pre-test MAP | 76.9 (9.9) | 76.7 | 53 – 123 | 0.7 | 1.2 |
| Abdominal Endurance | 20.4 (7.2) | 20 | 1 – 43 | 0.13 | 0.54 |
| 6MWT | 626.2 (149.8) | 616 | 192 – 1088 | 0.39 | - 0.10 |
| $VO_2$maximum | 38.05 (5.1) | 38 | 17.2 – 50.5 | - 0.38 | 0.48 |
| MALE | | | | | |
| Age | 12.7 (0.97) | 13 | 11 – 14 | - 0.18 | - 0.97 |
| BMI | 19.4 (3.5) | 18.6 | 12.9 – 32.2 | 1.0 | 0.98 |
| % offat | 22.9 (13.3) | 18.6 | 6.9 – 64.2 | 1.4 | 1.4 |
| Pre-test MAP | 76.7 (9.5) | 76.7 | 47 – 111 | 0.4 | 0.6 |
| Abdominal Endurance | 30.5 (8.1) | 30 | 1 – 50 | - 0.1 | 0.28 |
| 6MWT | 733.3 (198.7) | 720 | 99 – 1200 | - 0.25 | 0.1 |
| $VO_2$maximum | 43.2 (5.5) | 43.2 | 20.4 – 55.7 | - 0.4 | 0.5 |

SD: standard deviation; Min: minimum value; Max: maximum value; Sk: asymmetry; Ku: kurtosis; $VO_2$: maximum oxygen consumption expressed in ml/kg/min; BMI: body mass index; MAP: mean arterial pressure in mmHg; 6MWT: six-minute running test.




$VO_2$maximum: maximum oxygen consumption; $X^2$: Chi-square; df: degrees of freedom; CFI: Bentler's comparative adjustment index; GFI: adjustment adequacy index; TLI: Tucker-Lewis index; RMSEA: root of the mean square error of approximation.
**Source:**Research data, 2017.

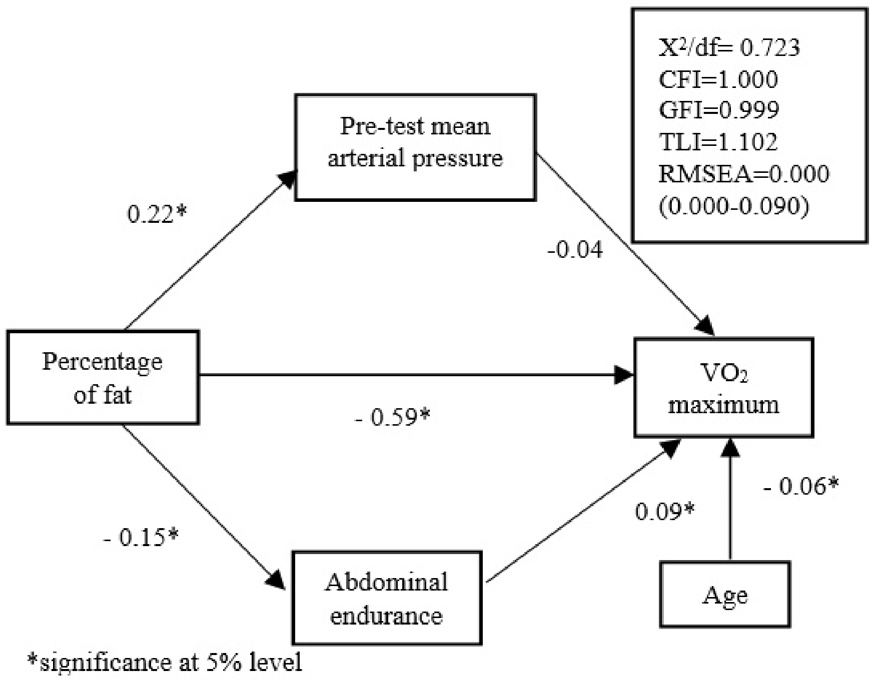
**Figure 2. Adjusted Model for association between age, percentage of fat, abdominal endurance and mean arterial pressure with the CRF of female adolescent students. Montes Claros, MG, 2017 (n=455)**

MAP, measured before the 6MWT, showed values between 47 and 123 mmHg and an average of 76.9 mmHg for females and 76.7 mmHg for males. The abdominal endurance among girls obtained an average of 20.4 (SD = ± 7.2) and among boys, 30.5 (SD = ± 8.1) (Table 1). CRF showed an overall average of 40.5 ml/kg/min (SD = ± 5.9), with 38.05 ml/kg/min (SD = ± 5.1) for females and 43.2 ml/kg/min (SD = ± 5.5) for males, with a minimum value for girls and boys of 17.2 and 20.4, respectively, and a maximum value of 50.55 and 55.7 (Table 1). The variables showed asymmetry and kurtosis values that indicate normal distribution (asymmetry coefficients (sk) <3 and kurtosis (ku) <7). Figures 2 and 3 present the theoretical model adjusted for each sex, where the standardized structural coefficients estimated for the model components are presented, as well as the results of direct and indirect effects of factors associated with CRF. The adjustment indices were considered acceptable, presenting the following values for female sex: $X^2$/df=3.498; CFI=0.970; GFI=0.988; TLI=0.926; RMSEA=0.141 (CI90% 0.034 - 0.118), and for males: $X^2$/df=0.723; CFI=1.0; GFI=0.999; TLI=1.102; RMSEA=0.000 (CI90% 0.00 - 0.090). It was found that the age of girls (β = - 0.08; p = 0.016) and boys (β = - 0.06; p = 0.155) had a direct and negative effect on $VO_2$ maximum, with male age as not statistically significant. The fat percentage of girls (β = - 0.63; p <0.001) and boys (β = - 0.59; p <0.001) has a direct and negative effect, statistically significant on $VO_2$ maximum, with a higher coefficient for female sex. The abdominal endurance of girls (β = 0.10; p = 0.005) and boys (β = 0.09; p = 0.019) have a direct, positive and statistically significant effect on $VO_2$ maximum. MAP had a direct and negative effect on $VO_2$ maximum (β = - 0.04 for both sexes), however no statistical significance was found (p = 0.295 for girls and p = 0.377 for boys) (Figures 2 and 3).

Magnitude of direct and indirect effects are shown in Table 2. There was a negative and statistically significant indirect effect of percentage of fat on $VO_2$ maximum mediated by abdominal endurance in both sexes of β = - 0.02 for girls and β = - 0.01 for boys, and for MAP of β = - 0.01 in girls and β = - 0.009 in boys. The total indirect effect of percentage of fat via abdominal endurance and via MAP on $VO_2$ maximum had a negative influence of β = - 0.03 for girls and β = - 0.02 for boys. There was a total effect of β = - 0.66 and β = - 0.61 for females and males respectively. The proportion of the direct effect in relation to the total effect of fat percentage on $VO_2$ maximum was 95.4% in girls and 96.7% in boys (not mediated by other variables).

# DISCUSSION

This study verified direct and indirect relationships of variables age, fat percentage, abdominal endurance , pretest MAP on the CRF of adolescent students.




$VO_2$maximum: maximum oxygen consumption; $X^2$: Chi-square; df: degrees of freedom; CFI: Bentler's comparative adjustment index; GFI: adjustment adequacy index; TLI: Tucker-Lewis index; RMSEA: root of the mean square error of approximation.
**Source:**Research data, 2017.

**Figure 3. Adjusted Model for association between age, percentage of fat, abdominal endurance and mean arterial pressure with the CRF of male adolescent students. Montes Claros, MG, 2017 (n=405)**

**Table 2. Magnitude of direct, indirect and total effects among factors that influence the CRF ($VO_2$ maximum) of adolescent students. Montes Claros, MG, 2017**

| Independetvariable | Direct / Indirect Effects | Dependent | Effect coefficients | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Direct | | Indirect | | | | Total | |
| | | | | | | | Total Indirect Effect | | | |
| | | | F | M | F | M | F | M | F | M |
| Age | Direct | | - 0.08* | - 0.06 | - | - | - | | - 0.08* | - 0.06 |
| Percentage offat | Direct | | - 0.63* | - 0.59* | - | - | (-0.02)+ (-0.01)= -0.03 | (-0.01) + (-0.009)= -0.02 | -0.66 | -0.61 |
| | Via Abdominal Endurance | | - | - | - 0.22x0,10 = - 0.02* | - 0.15 x0.09 = - 0.01* | | | | |
| | Via MAP | $VO_2$ | - | - | 0,26x(-0,04) = - 0,01 | 0,22 x(-0,04)= - 0,009 | | | | |
| MAP | Direct | | - 0.04 | - 0.04 | - | - | | | - 0.04 | - 0.04 |
| Abdominal Endurance | Direct | | 0.10* | 0.09* | - | - | | | 0.10* | 0.09* |

*p value< 0.05. M= male; F= female; MAP: mean arterial pressure

In literature, there are still few investigations that simultaneously evaluate direct and indirect effects of these variables on CRF in this population. The average values of CRF among adolescents in this study are similar to those of study HELENA (The Healthy Life Style in Europe by Nutrition in Adolescence), carried out with adolescents from 10 European cities, in which the $VO_2$ maximum values of participants presented an overall average 40.6 ml/kg/min, averages of 37.1 ml/kg/min for females and 44.3 ml/kg/min for males (Ortega *et al*., 2011). This similarity was also found in female students in northern Portugal (Agostinis Sobrinho *et al*., 2015) and, in national scenario, in male and female students in Londrina, Paraná (Werneck *et al*., 2018). Higher means were found in adolescent students, of both sexes, in Ilhabela, São Paulo (Victo *et al*., 2017). Male students in the present study had higher CRF averages compared to girls, which was demonstrated in previous studies (AgostinisSobrinho *et al*., 2015; Bergmann *et al*., 2014; Smouter *et al*., 2019). It must be considered that the differences found can be attributed to ethnicity, demographic variation, socio-cultural factors, different methodological criteria for assessment of $VO_2$ maximum and different cutoff points established according to each type of test used to assess the CRF. Regarding direct and indirect effects on CRF, age had a direct negative effect, with a statistically significant association only for females. In a study conducted with students in Vitória, Espírito Santo, lower $VO_2$ maximum values were observed with age progression (Rodrigues *et al*., 2006). The association of age with CRF was observed in a study carried out with students between six and 18 years old in the same city of the present study (Guedes *et al*., 2012) and among students aged from 10 to 17 years in Uruguaiana in Rio Grande do Sul (Pereira *et al*., 2016). In an investigation carried out with students between 11 and 18 years of age in Ilhabela, São Paulo, it was found that age influenced CRF. However, in the analysis separated by sex, female did not remain significant (Victo *et al*., 2017).

Previous studies have shown that female adolescents with older ages were more likely to not meet the recommendations for CRF (Silva *et al*., 2016; Pereira *et al*., 2016). The decrease in CRF with increasing age in females may be associated with a higher prevalence of physical inactivity in this population (Ceschini *et al*., 2009), including a lower frequency in physical education classes (Santos *et al*., 2019). There is evidence that male students generally demonstrate a highly positive attitude towards physical activity, being considered more active during childhood and adolescence in relation to females (Hardman *et al*, 2013). Abdominal muscle endurance presented a positive and direct effect statistically significant on CRF in both sexes. Exercises to strengthen abdominal muscles involve hip flexor muscles, especially the psoas and iliac muscles, contributing to the stability of the lumbar spine, pelvis and hips. Individuals with such musculature strengthened, achieve better performance in physical exercises (Avedisian *et al*., 2005; Andersson *et al*., 1997; Silva *et al*., 2018), providing better performance in abdominal muscle endurance test. Previous studies have observed that adolescents have presented abdominal endurance below the expected values for their age (Nogueira *et al*., 2014; Davoli *et al*., 2018; Lima *et al*., 2017). Percentage of fat presented, in both sexes, a direct and negative influence on CRF and was the most prominent effect in relation to other variables in this model. A similar result was observed in a research, using a structural equation model with students aged from 10 to 17 years from public schools in Londrina, Paraná, in which it was found that body adiposity negatively influenced the CRF of adolescent students (Werneck *et al*., 2018 ). A study carried out with students aged from 14 to 17 years in the Midwest of Santa Catarina showed that adolescents with body composition classified as a health risk presented more than 65% chance of having inadequate CRF (Pelegrini *et al*., 2017). Adolescents with higher percentage of body fat tend to have greater mobility difficulties, decreased stride frequency and less stability during walking and/or running (Chan *et al*., 2009; Adams *et al*., 2013), which can contribute for worst performances in aerobic tests that require such efforts and consequently result in low levels of CRF. Among the male and female adolescents surveyed, the indirect effect of body fat on CRF was also observed, mediated by abdominal endurance. High body fat percentage represents greater body mass to be displaced during the practice of physical activity and, consequently, hinders the performance and maintenance of physical exercises (Smouter *et al*., 2019; García-Hermoso *et al*., 2019) , necessary for muscle strengthening (Silva *et al*., 2018). A study carried out with adolescents, using a structural equation model, found a direct and negative relation between percentage of fat and practice of physical activity (Werneck *et al*., 2018). Other previous studies have shown statistical association of nutritional status, represented by BMI, with CRF (Victo *et al*., 2017; Pereira *et al*., 2016). Studies have used BMI as a substitute measure for fat and as an indicator of nutritional status, however, in adolescents, the sum of the skin folds has been considered more appropriate (Slaughter *et al*., 1988). No statistical significance was demonstrated in the effect of MAP on CRF, however, it has already been shown in previous studies that there is an inverse relationship between CRF levels and BP values (Senh *et al*., 2019; Park *et al*., 2020). Physiologically, physical activity has repercussions in attenuating sympathetic cardiovascular endothelial responses, leading to a decrease in heart rate, cardiac output and low systemic vascular resistance. Thus, these changes in cardiovascular dynamics can affect blood pressure values (Corrêa Neto *et al*., 2014).

Based on the findings of this research, it is necessary to reflect on the need to act on the modifiable risk factors that interfere in CRF of adolescents. Therefore, measures that favor healthy lifestyle habits are necessary in order to prevent high levels of body fat and low muscle resistance. The action of different sectors is important, with involvement of educational and health institutions, with participation of managers, teachers, health professionals, family members and students. School and Primary Health Care (PHC) are privileged settings for such actions, since adolescents spend most of their time at school and PHC, through the Family Health Strategy, is responsible for health care of this population (Silva *et al*., 2014; Vieira *et al*., 2018).Stimulating improvement of CRF levels can also collaborate to improve attention and behavior in classroom, concentration, cognition, memory and, consequently, improve school performance of this population (Sardinha *et al*., 2016).

As this is a sample of adolescents from public municipal schools, care should be taken to extrapolate the results to other groups of adolescents in different contexts, including same region. A limitation of the present study was the lack of measurement of sexual maturation, since, although the students were in similar age group, different pubertal stages could have been found. Individuals with chronic diseases were not excluded, which may have been an interference factor in the ability to perform CRF test. It is noteworthy that this study used a representative sabmple of the population, obtained in a probabilistic way, reinforcing the associations found. Another strength of this study was the use of multivariate model. It is suggested to carry out new longitudinal studies that allow execution of interventions to improve levels of CRF, with periodic reassessment and systematic applications of physical tests to measure results.

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