

Hypertension and Different Levels of Body Mass Index and Cardiorespiratory Fitness Amongst Adolescents

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Abstract

Background: Hypertension is an increasingly common problem in adolescents; amongst the associated factors, physical inactivity and obesity are increasing the risk of developing cardiovascular diseases.

Objective: To verify whether there is an association between higher blood pressure levels amongst adolescents with the relationship between different levels of body mass index (BMI) and cardiorespiratory fitness (CRF).

Method: Cross-sectional study consisting of 860 adolescents. Higher blood pressure (BP) was considered as borderline and hypertension as the classification. BMI was categorized as low-normal weight and overweight-obesity. The CRF was assessed by a nine-minute run/walk test and classified into low or appropriate levels (less and more favorable to health, respectively). Later, BMI and CRF were grouped into one categorical variable: (I) low/normal weight and appropriate CRF levels; (II) low/normal weight and low CRF levels; (III) overweight/obesity and appropriate CRF levels; and (IV) overweight/obesity and low CRF levels. Data were analyzed using Poisson regression, through the prevalence ratio (PR) and 95% confidence intervals (CI). The p-values of $p < 0.05$ were considered significant.

Results: Adolescents with overweight/obesity and low CRF levels had a 22% higher BP prevalence. Moreover, children with overweight/obesity, but with appropriate CRF levels, have a 15% higher BP prevalence.

Conclusion: Adolescents with overweight/obesity had a higher prevalence of BP, regardless of CRF levels. It is suggested that maintaining normal BMI is a protective factor for less favorable BP.

Keywords: Hypertension; Blood Pressure, Adolescent, Cardiorespiratory Fitness; Obesity; Exercise; Exercise Therapy; Body Mass Index.

Introduction

Obesity and hypertension have become a public health problem worldwide and are now present in both children and adolescents.¹ Amongst adolescents, the higher levels of blood pressure (BP) is associated with sex, obesity, family history of hypertension,² and waist/height ratio.³ These also tend to increase with age, body mass, height, and body mass index (BMI).⁴

The prevalence of prehypertension amongst overweight individuals suggests the need for the early

clinical detection of BP changes, as well as possible intervention in this condition, by making changes in lifestyle, particularly in body weight control.⁵ The association between excess body mass and hypertension highlights the urgent need to implement strategies to prevent cardiovascular disease on a large scale,^{6,7} continuously and over the long term.⁸

In a survey of English schoolchildren, Ogunleye et al.,⁹ found that cardiorespiratory fitness (CRF) attenuates the association between BMI and BP levels; however, amongst obese students, this attenuation was

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not as relevant as amongst normal weight students. Previous findings demonstrated that CRF can reduce the risk of hypertension in children and adolescents when associated with a favorable nutritional status, but it is not yet known whether good CRF is able to attenuate the chances of high BP in individuals with excess body mass.^{10,11} From this perspective, there is still a gap in the literature concerning the concurrent relationship between excess weight and CRF levels with hypertension.

Therefore, it could be easily postulated that the identification of potential protection parameters against the development of hypertension among youth populations would present great importance to decide what should be the focus in preventions and health promotion strategies. The present study aims to verify whether there is an association between higher BP levels amongst adolescents with the relationship between different levels of BMI and CRF.

Method

This was a cross-sectional study using a sample comprised of 860 adolescents (480 girls), aged from 10 to 17 years. All participants were randomly selected from 18 public and private schools of Santa Cruz do Sul, RS, Brazil. The sample was selected by conglomerates, encompassing all municipality regions (center, north, south, east, and west) from urban and rural areas. This study is part of a larger research called "Schoolchildren's Health - Phase II" developed at the University of Santa Cruz do Sul (UNISC). It was approved by the UNISC Committee of Ethics in Research with Human Subjects, logged under protocol number 3044/11. The study included all students whose parents or guardians signed the informed consent form.

The program G*Power 3.1 (Heinrich-Heine University - Düsseldorf, Germany) was used for the sample size estimator, using the Poisson regression as a statistical test (dependent variable as dichotomous) and the test procedure described by Demidenko,¹² with variance correction. The following parameters were established: a power of the test ($1 - \beta$) = 0.95, a significance level of $\alpha = 0.05$, an effect size – $\text{Exp}(\beta_1)$ of 1.15, and a base rate $\text{exp}(\beta_0)$ of 0.70. The sample size was estimated at 784 schoolchildren.

The evaluation of BP levels was performed early in the morning by trained health professionals using a stethoscope and sphygmomanometer, in a quiet room, with participants resting for five minutes in a sitting position, with their backs resting on the chair and their feet resting on the floor. The systolic (SBP) and diastolic (DBP) blood pressure were later classified following criteria established in the VI Brazilian Guidelines on Hypertension,¹³ considering sex, age, and height. The BP level was considered highly altered when SBP and/or DBP were classified as borderline or hypertensive.

The BMI was calculated to assess the adolescent's body composition and classified by the cutoff points established by the Centers for Disease Control and Prevention/National Center for Health Statistics,¹⁴ considering sex and age. Low weight ($<p5$), normal weight ($\geq p5$ and $<p85$), overweight ($p\geq 85$ and $<p95$), and obesity ($\geq p95$) were considered. Subsequently, data were dichotomized as low weight/normal weight or overweight/obesity. The CRF level was assessed using the nine-minute run/walk test, described by *Projeto Esporte Brasil (PROESP-BR)*¹⁵, which was validated for use with this population.¹⁶ Data were obtained in meters performed with subsequent classification into appropriate or low CRF levels, as established by the PROESP-BR cutoff points for the Brazilian children and youth population, considering sex and age. Subsequently, the measures of BMI and CRF were unified into a single categorical variable and classified as (I) low/normal weight and appropriate CRF levels; (II) low/normal weight and low CRF levels; (III) overweight/obesity and appropriate CRF levels; or (IV) overweight/obesity and low CRF levels.

Statistical Analysis

The Statistical Package for the Social Sciences (SPSS), software version 23.0 (IBM, Armonk, NY, USA), was used for statistical analysis. Descriptive statistics were used to characterize the sample, using the frequency and percentage values. The association between the outcome variable (higher BP levels) and the BMI/CRF relationship was tested using Poisson regressions and expressed as prevalence ratio (PR) values and 95% confidence intervals (CI), with adjustment for the biological gender variable. Values of $p < 0.05$ were considered significant in all analyses.

Results

Table 1 shows the descriptive characteristics of the subjects. There was a high prevalence of overweight and obese adolescents (24.8%) and low CRF levels (53.7%), and 19.4% had high BP levels (borderline and hypertension).

Figure 1 presents the percentage of BP levels amongst adolescents with different BMI/CRF relationship classifications. Adolescents with low/normal weight had a lower percentage of higher BP, regardless of the CRF levels (appropriate: 14.6%; low: 15.7%). By contrast, the percentage was higher amongst overweight/obese adolescents: 29.3% for those with appropriate CRF levels and 34.1% for those with low CRF levels.

The regression models demonstrated that adolescents with overweight/obesity and low levels of CRF had

a 22% higher prevalence of higher BP. Students with overweight/obesity and appropriate CRF levels also presented a higher prevalence (15%) of less favorable BP levels (Table 2).

When SBP and DBP were analyzed separately (Table 3), similar findings to those presented in Table 2 were observed. However, the prevalence of alteration was slightly higher for SBP amongst those students with overweight/obesity, regardless of the CRF level.

Discussion

The present study aimed to assess the association between levels of BP and BMI/CRF of schoolchildren. Previous studies assessed the association of BP with obesity and CRF indicators separately. In a systematic review, Corrêa Neto and Palma¹⁷ stated that there is not

Table 1 – Descriptive characteristics of the subjects. Santa Cruz do Sul, RS, 2011-2012

	n (%)
BMI	
Low weight/normal weight	647 (75.2)
Overweight/Obesity	213 (24.8)
CRF	
Appropriate levels	398 (46.3)
Low levels	462 (53.7)
BMI/CRF	
Low/normal weight and appropriate CRF levels	323 (37.6)
Low/normal weight and low CRF levels	324 (37.7)
Overweight/obesity and appropriate CRF levels	75 (8.7)
Overweight/obesity and low CRF levels	138 (16.0)
Blood pressure	
Normal	693 (80.6)
Borderline and hypertension	167 (19.4)
Systolic blood pressure	
Normal	707 (82.2)
Borderline and hypertension	153 (17.8)
Diastolic blood pressure	
Normal	699 (81.3)
Borderline and hypertension	161 (18.7)

BMI: body mass index; CRF: cardiorespiratory fitness;

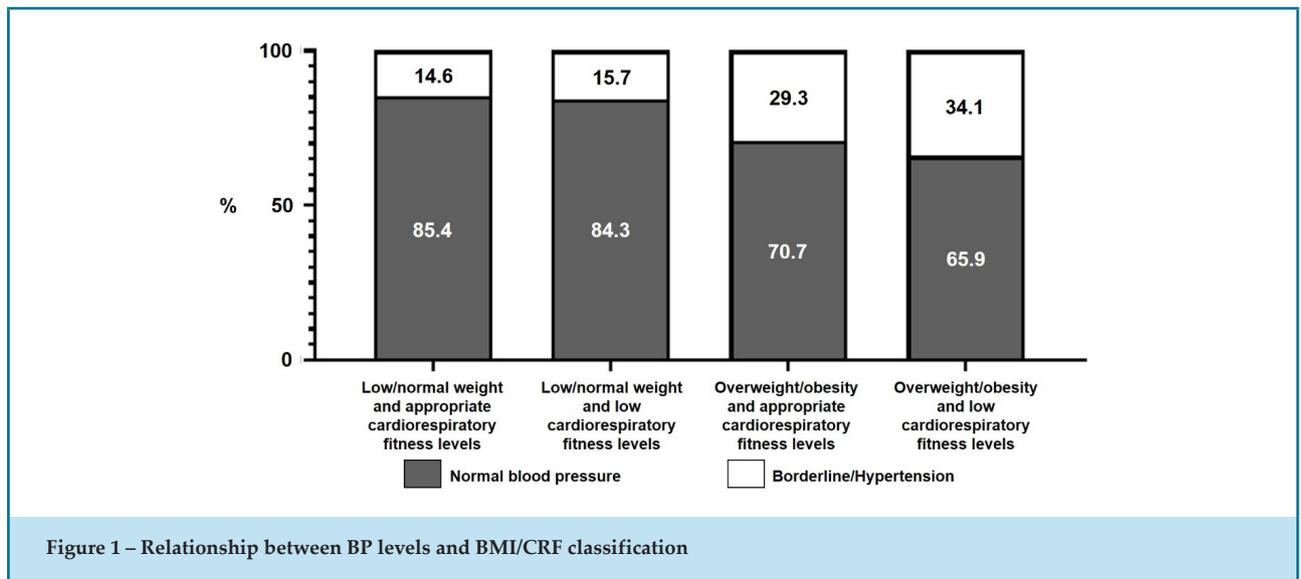


Table 2 – Association between less favorable blood pressure levels and different levels of BMI/CRF in adolescents (n=860)

	Borderline and hypertension	
	PR (95% CI)	<i>p</i>
Low/normal weight and appropriate CRF levels	1	
Low/normal weight and low CRF levels	1.02 (0.97 to 1.08)	0.433
Overweight/obesity and appropriate CRF levels	1.15 (1.03 to 1.28)	0.015
Overweight/obesity and low CRF levels	1.22 (1.11 to 1.33)	<0.001

BMI: body mass index; CRF: cardiorespiratory fitness; PR: prevalence ratio; 95% CI: 95% confidence interval; Poisson regression considering two categories for outcome variable (normal blood pressure versus higher blood pressure); analyses adjusted for sex.

Table 3 – Association between SBP and DBP, and different levels of BMI/CRF in adolescents (n=860)

	Higher SBP		Higher DBP	
	PR (95% CI)	<i>p</i>	PR (95% CI)	<i>p</i>
Low/normal weight and appropriate CRF levels	1		1	
Low/normal weight and low CRF levels	1.03 (0.98 to 1.09)	0.245	1.03 (0.97 to 1.08)	0.370
Overweight/obesity and appropriate CRF levels	1.16 (1.04 to 1.29)	0.008	1.13 (1.02 to 1.26)	0.022
Overweight/obesity and low CRF levels	1.23 (1.12 to 1.34)	<0.001	1.19 (1.09 to 1.29)	<0.001

SBP: systolic blood pressure; DBP: diastolic blood pressure; BMI: body mass index; CRF: cardiorespiratory fitness; PR: prevalence ratio; CI: 95% confidence interval; Poisson regression considering two categories for outcome variable (normal blood pressure versus higher blood pressure); analyses adjusted for sex.

always a well-defined link between higher BP levels and physical inactivity/obesity, which demonstrates a need for greater considerations on the subject. Corrêa-Neto et al.,¹⁸ identified an association between hypertension and obesity in a study with adolescents in Rio de Janeiro, Brazil, but the authors did not consider physical inactivity.

The data presented in the current study suggest that normal BMI is an important protective factor against increased BP, regardless of CRF levels. These findings run in line with the results obtained in a study with children and adolescents, which demonstrated that thinner boys and girls with lower CRF levels have a better cardiometabolic risk profile compared to their peers who are obese and who present appropriate CRF levels. Moreover, Wang et al.,¹⁹ showed that children and adolescents with excess weight and low CRF also present a higher cardiometabolic risk. These results emphasize the importance of maintaining adequate weight to prevent the development of cardiometabolic risk during childhood and youth.^{20,21}

Accordingly, Pozuelo-Carrascosa et al.,²² observed higher BP levels in children with excess weight and low CRF levels in the provinces of Ciudad Real and Cuenca, Spain. Díez-Fernández et al.,²³ also found that BP was worse amongst overweight students and better amongst those with higher CRF levels. Both aforementioned studies demonstrated BMI as a mediator in the association between CRF and BP. Fernandes et al.,²⁴ also suggest that the association between CRF and BP is mediated by body composition. Additionally, Müller et al.,²⁵ identified body weight as an independent determinant of SBP, whereas CRF did not show an association with SBP. These findings demonstrate the importance of maintaining a healthy weight for the prevention of high levels of BP.²⁶ Therefore, as suggested by the present and previous studies, excess weight should be considered when looking at preventing hypertension development among youth, especially for Brazilian children and adolescents, which has an estimation of a quarter presenting excess weight.²⁷

By contrast, Yang et al.,²⁸ highlight better levels of CRF associated with normal BP levels. Obese students with low CRF levels present a higher prevalence of

hypertension (OR: 3.98; 95% CI: 2.92 to 5.41) compared to obese students with better CRF levels (OR: 1.75; 95% CI: 1.10 to 2.79), which suggests that CRF may attenuate the relationship between obesity and less favorable BP levels.⁹ This positive influence of CRF on BP was also demonstrated by Burgos et al.,²⁹ Students with better CRF had better SBP and DBP results. The authors also observed a gradual increase in the number of students with normal BP as the CRF level increased. Additionally, Ruiz et al.,³⁰ showed that markers of total and central adiposity were associated with BP only in children with low levels of CRF, which also demonstrates that more favorable CRF levels can attenuate the association between body fat and BP in children. Lastly, Silva et al.,³¹ exposed that children and adolescents with low CRF levels, with or without the presence of central adiposity, demonstrated a higher cardiometabolic risk than individuals with better CRF levels and normal central adiposity. These findings suggest that low CRF levels can increase BP, regardless of BMI, and it should be considered when targeting BP levels. Therefore, physical activity should be promoted as much as preventing excess weight, especially at higher intensities.³²

The current study has strengths, such as the fact that it presents a representative sample of adolescents from Santa Cruz do Sul. Moreover, to the best of our knowledge, few studies, especially in Brazil, have assessed the association of excess weight and CRF with hypertension in schoolchildren. However, we also highlight some limitations, mainly concerning the methodological design, which cannot establish a causal relationship between the variables. Although the municipality of the study was from German colonization and the sample had a higher percentage of Caucasian students,³³ ethnic aspects were not included in the analyzed models, nor was pubertal status.

Conclusion

Overweight and obese adolescents, regardless of CRF levels, have a higher prevalence of altered BP. It is also suggested that maintaining adequate body mass may well be better in preventing BP changes than improving CRF levels in adolescents would be.

Author contributions

Conception and design of the research: Bertollo C, Burgos LT, Reuter CP. Acquisition of data: Bertollo C, Barbian CD, Schneiders LB, Silveira JFC, Burgos LT, Reuter CP. Analysis and interpretation of the data: Bertollo C, Barbian CD, Schneiders LB, Silveira JFC, Vogt BD, Mello ED, Burgos LT, Hobkirk JP, Reuter CP. Statistical analysis: Schneiders LB, Silveira JFC, Reuter CP. Obtaining financing: Barbian CD, Schneiders LB, Silveira JFC. Writing of the manuscript: Bertollo C, Barbian CD, Schneiders LB, Silveira JFC, Vogt BD, Mello ED, Burgos LT, Hobkirk JP, Reuter CP. Critical revision of the manuscript for intellectual content: Bertollo C, Barbian CD, Schneiders LB, Silveira JFC, Vogt BD, Mello ED, Burgos LT, Hobkirk JP, Reuter CP. Supervision / as the major investigator: Burgos LT, Reuter CP.

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Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

This study is not associated with any thesis or dissertation work.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of the Unisc under the protocol number 3044/11. All the procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013. Informed consent was obtained from all participants included in the study.

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