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Original Article

ARE THE HABITUAL PRACTICE OF PHYSICAL ACTIVITY, DIETARY HABITS, ANTHROPOMETRIC INDICATORS, AND AUTONOMIC MODULATION ASSOCIATED WITH THE PREVALENCE OF HIGH BLOOD PRESSURE?

PRÁTICA HABITUAL DE ATIVIDADE FÍSICA, HÁBITOS ALIMENTARES, MODULAÇÃO AUTONÔMICA E INDICADORES ANTROPOMÉTRICOS ESTÃO ASSOCIADOS À PREVALÊNCIA DE PRESSÃO ARTERIAL ELEVADA?

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RESUMO
Objetivo: Analisar a associação entre pressão arterial elevada, obesidade geral e abdominal, indicadores de atuação autonômica, prática habitual de atividade física e hábitos alimentares na rede pública de ensino de Londrina/PR. Métodos: Foram avaliados 189 sujeitos (75 masculino e 114 feminino), com idade entre 10 e 17 anos. Foram realizadas avaliações antropométricas, além da pressão arterial de repouso, atuação autonômica, hábitos alimentares e prática habitual de atividade física. O teste qui-quadrado foi aplicado para verificar associações da pressão arterial (variável dependente) com as demais variáveis. Aplicou-se também a regressão de Poisson para identificação da magnitude da associação. Resultados: Obesidade e obesidade abdominal foram associadas à pressão arterial elevada. Indivíduos com obesidade abdominal obtiveram 2,3 vezes mais chance (P=0,002) de apresentarem pressão arterial elevada. Conclusão: Adolescentes com obesidade abdominal possuem aproximadamente duas vezes mais chances de apresentarem pressão arterial elevada, independente dos níveis de obesidade.
Palavras-chave: Estado nutricional, Sistema nervoso autônomo, Atividade motora.

ABSTRACT
Objective: To analyze the prevalence and association between high blood pressure, general and abdominal obesity, indicators of autonomic activity, habitual physical activity, and dietary habits in public schools in Londrina / PR. Methods: 189 subjects were evaluated (75 males and 114 females), 10-17 years. Assessment of habitual physical activity and dietary habits was performed. Anthropometric measurements were performed, in addition to measurement of resting blood pressure and heart rate variability. The chi-square test was used to assess associations between blood pressure (dependent variable) and other variables. Those that were significantly associated were submitted to Poisson regression to identify the magnitude of the association. Results: Individuals with "abdominal obesity" were 2.3 times more likely (P = 0.002) to present high blood pressure. Conclusion: Individuals with abdominal obesity are approximately twice as likely to have high blood pressure, independent of obesity levels, which in turn, are not associated with increased blood pressure.
Keywords: Nutritional status, Autonomic nervous system, Motor activity.

Introduction

Arterial hypertension is highly prevalent in Brazilian adults, increasing the risk of other health complications, such as cardiovascular diseases[1]. Similarly, overweight is ranked as the second most relevant determinant for the development of cardiovascular diseases, being only less relevant than sedentarism[2,3]. Subjects with a high body mass index (BMI) present higher blood pressure and hence an increased risk of arterial hypertension[4]. It is also recognized that physical inactivity is associated with the development of arterial hypertension in adults[5-7] and high blood pressure in adolescents[8]. Additionally, diets rich in processed foods have also been related to high blood pressure in pediatric groups[9].

Taking into account the large amount of scientific evidence, techniques developed to assess functions of the cardiovascular system have great relevance in the promotion of health. Among them, the assessment of the autonomic nervous system is highlighted, due to its significant action on the control of the cardiovascular system[10,11]. The autonomic nervous system can be assessed through the use of heart hate variability (HRV)[10-12].

Few studies have assessed the relationship between HRV and high blood pressure in adolescents, however, they point out that higher blood pressure is related to lower activity of the autonomic system[13,14], suggesting that even in young groups, the adoption of unhealthy habits seems to promote harmful physiological adaptations related to neuronal control.

It is well documented that physical activity[2,3], food habits[9], anthropometric indices[4], and the autonomic nervous system[13,14] are factors that affect blood pressure in isolation. However, when considering blood pressure as the outcome, the assessment of isolated and clustered effects of anthropometric, behavioral, and physiological variables could clarify the actual determinants of high blood pressure in adolescents. The use of appropriate statistical models seems to improve knowledge about covariates in this complex relationship.

Therefore, the aim of the present study was to analyze the association of blood pressure with anthropometric indices, HRV, food habits, and physical activity practice in schoolchildren from Londrina, southern Brazil.

Methods

Sample

The sample was composed of adolescents of both sexes, with ages ranging from 10 to 17 years-old, regularly registered in public elementary schools. The minimum sample size was estimated taking into account a prevalence of 10%[15], statistical power of 80%, and error of 5%. The required sample was 150 subjects. Taking into account the conglomerate sampling, the sample was increased by 20%.

Parents signed a written consent form as the inclusion criteria. The study was approved by the Ethical Research Board of the University (CAAE Nº 0281.0.268.000-07 – Report Nº 295/07).

Anthropometry

All anthropometric measures were taken with the subjects wearing light clothing and no shoes. Body mass was measured using a digital scale with a maximum capacity of 150kg, and height using a portable stadiometer. BMI was estimated dividing body mass by height squared. The cutoffs proposed by Cole et al.[16] were used to identify nutritional status.

Food habits

Food habits were assessed through the use of a questionnaire composed of four questions, in which the adolescents reported the frequency (none; 1-2 days; 3-5 days; seven days) of consumption of several types of foods (vegetables; snacks and beverages; fruits; fried foods) in the week prior to the assessment. The response “6-7 days” was adopted as “high consumption” (categorical variable) for these types of food. The habit of skipping any meal was also assessed.

Physical activity practice

Physical activity practice was assessed using a questionnaire[17] previously validated for the Brazilian pediatric population[18]. The questionnaire generates a score considering the physical activity performed at school, sport practice, leisure-time, and overall physical activity (school, sport, and leisure-time). Adolescents who were ranked in the lowest quartile for physical activity score were classified as "low physical activity practice" (categorical variable).

Waist circumference

Waist circumference was defined as the minimum circumference between the iliac crest and last rib using a metallic tape measure to the nearest millimeter (mm). The cutoffs adopted to identify "absence" or "presence" of abdominal obesity were proposed by Taylor et al.[19].

Blood pressure

Blood pressure was assessed through the use of an automatic device (Omron HEM 742) previously validated for adolescents[20]. Adolescents remained seated for 10 minutes prior to the assessment. The procedures adopted for blood pressure measurement have been previously published[21]. The criteria to classify adolescents as "normotensive" or "hypertensive" were those established by the National High Blood Pressure Education Program[22]. Adolescents ≥95 percentile for systolic and/or diastolic blood pressure were classified as "high blood pressure".

Heart rate variability

HRV was measured using a previously validated heart rate monitor (Polar - RS800CX)[23]. The R-R intervals were recorded by the device for 10 minutes and subsequently uploaded to a computer using the software Polar Precision Performance (release 3.00, Polar Electro Oy), considering only the final five minutes of measurement. Fourier's transformation was performed to quantify the very low, low, and high frequency bands, following the recommendations of the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology[24]. The quantitative analysis "beat-by-beat" was performed using the Poincaré plot. The analyzed variables were RMSSD (time domain), LF, HF, and LF/HF (frequency domain). Adolescents ranked in the lowest quartile for HRV were classified as "low" HRV (RMSSD, LF, HF, and LF/HF).

Experimental design

Initially, the Municipality Department of Education provided a list of all school units in the city and their geographical location. Taking into account the geographical regions (north, south, east, west and downtown), a random process was used to select one school unit per geographical region, totalizing five. The selected school units provided a list of all schoolchildren of the target age and from this students were randomly selected. Following the previously established minimum sample size, 36 adolescents were assessed in each school unit. Only adolescents whose parents/legal guardians signed the written consent form were assessed.

Data collection began with questionnaire filling (food habits and physical activity), followed by anthropometric measures (height, body mass, and waist circumference). Next, the adolescents received guidance and help (if necessary) on how to wear the heart rate monitors used to assess HRV. HRV measures were taken in a quiet room in a supine position and the adolescents were requested not to speak and to avoid movements. After the HRV measures, the adolescents were carefully positioned in the sitting position for blood pressure measures.

Statistical analysis

Initially, the normality assumption (stratified by sex) was assessed using the Kolmogorov-Smirnov's test. Next, the *Mann-Whitney* U test (continuous data) was used to compare the sexes. The Chi-square test (categorical data) assessed the existence of associations of blood pressure (dependent variable) with nutritional status, waist circumference, HRV, food habits, and physical activity (independent variables). Associations with $p<0.200$ were analyzed in the Poisson regression to determine the magnitude of the associations between the dependent and independent variables (prevalence ratio [PR]). Statistically significant associations in the crude model were inserted in the adjusted multivariate model. Numerical variables were presented as median and interquartile range. Significance was set at $P<0.05$. Statistical analysis was performed using the statistical software SPSS version 17.0 and STATA version 8.

Results

The general characteristics of the sample are presented in Table 1. For anthropometric variables, boys were taller than girls (P=0.025). Systolic blood pressure was on average 6 mmHg lower in girls than boys. Boys and girls were similar in age, body mass, BMI, waist circumference, and diastolic blood pressure.

Table 1. General characteristics of the sample (numerical variables). Median and IR.

	Boys (n=72)	IR	Girls (n=117)	IR	*P*	Overall (n=189)	IR
Age (years)	13.00	3	13.00	3	0.301	13.00	3
Body mass (kg)	49.53	19	46.60	17	0.595	46.60	18
Height (cm)	160.00	21	155.00	12	0.025	156.00	15
BMI (kg/m^2)	18.41	5	19.70	5	0.192	19.47	5
WC (cm)	66.00	12	64.00	10	0.075	65.00	10
SBP (mmHg)	120.50	14	114.00	14	<0.001	117.00	16
DBP (mmHg)	75.18	12	72.00	9	0.256	73.00	10

BMI = body mass index; WC = waist circumference; SBP = systolic blood pressure; DBP = diastolic blood pressure; IR = interquartile range.
Source: Authors.

It was detected that one out of six adolescents was classified as overweight, while the obesity rate was around four percent in both sexes. The prevalence of overweight and obesity was higher in girls compared to boys. On the other hand, boys presented a higher prevalence

of abdominal obesity and high blood pressure than girls (Table 2).

Table 2. Prevalence of nutritional status, abdominal obesity, and blood pressure in schoolchildren from Londrina, Parana State, Brazil.

		Boys	Girls	Overall
	Categories	n (%)	n (%)	n (%)
Nutritional status				
	Eutrophic	58 (80.6)	92 (78.6)	150 (79.4)
	Overweight	12 (16.7)	20 (17.1)	32 (16.9)
	Obesity	2 (2.8)	5 (4.3)	7 (3.7)
WC				
	Normal	62 (86.1)	108 (92.3)	170 (89.9)
	Abdominal obesity	10 (13.9)	9 (7.7)	19 (10.1)
SBP				
	Normal	53 (73.6)	97 (82.9)	150 (79.4)
	Elevated	19 (26.4)	20 (17.1)	39 (20.6)
DBP				
	Normal	59 (81.9)	103 (88.0)	162 (85.7)
	Elevated	13 (18.1)	14 (12.0)	27 (14.3)
BP				
	Normal	48 (66.7)	88 (75.2)	136 (72.0)
	Elevated	24 (33.3)	29 (24.8)	53 (28.0)

WC = waist circumference; SBP = systolic blood pressure; DBP = diastolic blood pressure; BP = blood pressure.
Source: Authors.

Table 3 presents the results of the chi-square test, which tested the association of blood pressure with anthropometric indices (BMI and waist circumference), HRV indices (RMSSD, LF, HF, and LF/HF), food habits (fried foods, vegetables, snacks/beverages, fruits, skipping meals, and knowledge about food habits), and physical activity (school, sport, leisure-time, and overall).

Table 3. Association of blood pressure with anthropometric indices, heart rate variability, food habits and physical activity.

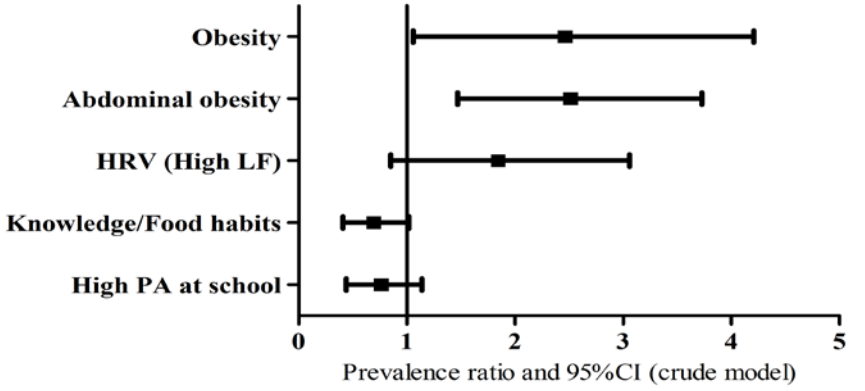
Anthropometric indices		Normal (*n* - %)	Elevated (*n* - %)	χ^2	*P*
NS	Eutrophic/overweight	133 (73.1)	49 (26.9)	3.051	0.098
	Obesity	3 (42.9)	4 (57.1)		
WC	Normal	128 (75.3)	42 (24.7)	9.329	0.002
	Abdominal obesity	8 (42.1)	11 (57.9)		
HRV indices					
RMSSD	Low	33 (70.2)	14 (29.8)	0.094	0.759
	High	103 (72.5)	39 (27.5)		
LF	Low	38 (80.9)	9 (19.1)	2.452	0.117
	High	98 (69.0)	44 (31.0)		
HF	Low	34 (69.4)	15 (30.6)	0.217	0.642
	High	102 (72.9)	38 (27.1)		
LF/HF	Low	36 (76.6)	11 (23.4)	0.667	0.414
	High	100 (70.4)	42 (29.6)		
Food habits					
Fried foods	Low	107 (70.9)	44 (29.1)	0.448	0.503
	High	29 (76.3)	9 (23.7)		
Vegetables	Low	103 (70.1)	44 (29.9)	1.171	0.279
	High	33 (78.6)	9 (21.4)		
Sna/Beve	Low	114 (73.1)	42 (26.9)	0.555	0.456
	High	22 (66.7)	11 (33.3)		
Fruits	Low	117 (72.7)	44 (27.3)	0.274	0.601
	High	19 (67.9)	9 (32.1)		
Skip meal	Low	51 (65.4)	27 (34.6)	0.010	0.920
	High	45 (66.2)	23 (33.8)		
FH/Know	Low	42 (63.6)	24 (36.4)	3.480	0.062
	High	94 (76.4)	29 (23.6)		
PA					
School	Low	35 (64.8)	19 (35.2)	1.912	0.167
	High	101 (74.8)	34 (25.2)		
Sport	Low	38 (77.6)	11 (22.4)	1.026	0.311
	High	98 (70.0)	42 (30.0)		
Leisure	Low	43 (69.4)	19 (30.6)	0.310	0.578
	High	93 (73.2)	34 (26.8)		
Overall	Low	34 (70.8)	14 (29.2)	0.040	0.841
	High	102 (72.3)	39 (27.7)		

NS= nutritional status; WC= waist circumference; HRV= heart rate variability; RMSSD= root mean square of the successive differences; LF= low frequency; HF= high frequency; Sna/Beve= snacks and beverages; FH/Know= knowledge on food habits; PA= physical activity.
Source: Authors.

For the anthropometric indices, abdominal obesity was associated with high blood pressure, while HRV, food habits, and physical activity were not.

In the crude model (Figure 1), values of PR and the 95% confidence interval (95%CI) are presented for the association of high blood pressure with anthropometric indices (BMI and waist circumference), HRV (LF), food habits (knowledge about food habits), and physical activity (performed at school). Obese adolescents were twice as likely to present high blood

pressure compared with normal weight individuals (PR=2.12[95%CI=1.06-4.21]). In the association with "waist circumference", the chance of adolescents with abdominal obesity having high blood pressure was 134% higher than non-abdominally obese adolescents (PR=2.34[95%CI=1.47-3.73]). There were no significant associations with the other independent variables.



Note:
HRV= heart rate variability; LF= low frequency; PA= physical activity

Figure 1. Crude model of the association of high blood pressure (dependent variable) with anthropometric indices, HRV, food habits, and physical activity.
Source: Authors.

In the adjusted model (Figure 2), for anthropometric indices (BMI and waist circumference) the association between "nutritional status" and "high blood pressure" was no longer significant (PR=0.97[95%CI=0.44-2.18]). The association between "waist circumference" and "high blood pressure" remained significant, in which abdominally obese adolescents were 136% more likely to present high blood pressure (PR=2.36[95%CI=1.37-4.07]).

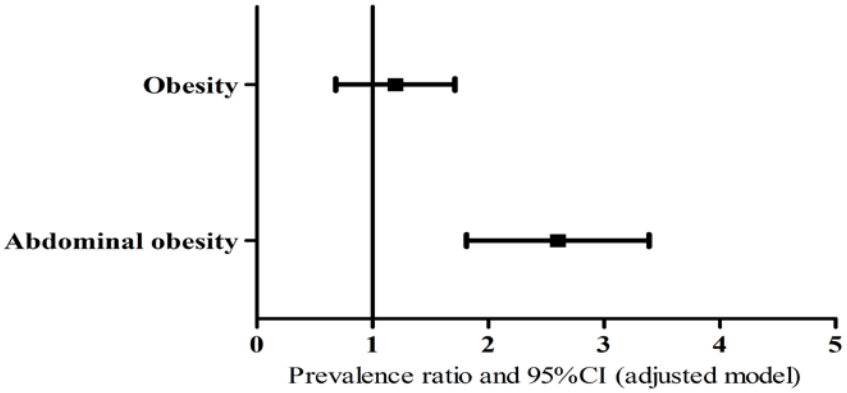


Figure 2. Adjusted model of the association between high blood pressure (dependent variable) and anthropometric variables.
Source: Authors.

Discussion

The present study analyzed the prevalence of high blood pressure and its associations with anthropometric indices, HRV, food habits, and physical activity in schoolchildren from

public schools aged from 10-17 years in the city of Londrina. The prevalence of high blood pressure observed in this study is higher than observed in previous studies[3,25,26] carried out in the same city. The increase of 16% in the prevalence of high blood pressure over the last five years is concerning, while the prevalence of high blood pressure shows a significant increase of around 10%, even when compared to the prevalence in older high school students [27].

The prevalence of overweight was similar to previous studies involving Brazilian students[28,29], and the prevalence of obesity was lower[28,29]. It is noteworthy that the present study does not take into account economic condition, limiting inferences of the finding, since higher economic status is related to higher rates of overweight and obesity[3,30].

Disagreeing with other studies[29,31,32] the present study did not find a significant association between obesity and high blood pressure, however when "overweight" and "obesity" were combined there was an association with "high blood pressure" (P=0.043 – data not shown). Other studies combining "overweight" and "obesity" also found significant associations[26,33]. In the statistical analysis, only the obese adolescents were maintained as evidence shows that "overweight" does not significantly increase the risk of diseases[34-36].

On the other hand, in the crude models, obese adolescents were twice as likely to present high blood pressure. Regarding abdominal obesity, there was an association with high blood pressure and the magnitude observed was similar to that observed for obesity. However, in the adjusted model the association with nutritional status was no longer significant. In this sense, abdominal obesity increased twice the likely risk of high blood pressure. Previous studies have observed similar associations[25,37,38], suggesting that increased abdominal fatness constitutes a risk factor for the development of cardiovascular complications. The risk for health related to abdominal fatness is higher than overall fatness[38-40], which is concerning due to the increase in the waist circumference of adolescents in recent years[41].

The association between abdominal fatness and high blood pressure, even without clear pathways so far, seems to be supported by imbalances in insulin sensitivity, with compensatory hyperinsulinemia[42,43]. Due to excessive insulin secretion, blood pressure increases, since insulin secretion stimulates sodium and hence water retention, leading to higher sympathetic activity[44]. Abdominal fatness is also related to higher blood concentration of fat-free-acids, leading to body fatness accumulation and lower sensitivity of the liver and skeletal tissues to insulin action[45,46].

There was no association between high blood pressure and HRV indices. The absence of association could be supported by the low number of obese adolescents in the sample. Previous studies identified an association between autonomic modulation and obesity in children[10,47,48]. There are few data about the relationship between blood pressure and HRV in children. In the study conducted by Zhou et al.[14]there was an association between obesity and reduced activity of the vagus nerve, as well as an association between high blood pressure and modifications in vagal and sympathetic activity. The differences between the studies could be attributed to differences in the analyzed sample as well as the methods/classifications used for HRV.

In the present study, physical activity was not related to high blood pressure, agreeing with previous studies involving pediatric groups[31,32]. Recent studies[49,50] have identified that sedentary habits is the main behavioral variable related to the development of cardiovascular risk factors, such as increased blood pressure. Therefore, physical activity and sedentary habits have to be considered as independent variables[51]. In this sense, it is noteworthy to recognize that sedentary behaviors were not assessed in this study.

The association between high blood pressure and food habits was also not significant, similar to other studies[26,31]. It is necessary to highlight the limitations related to the assessment of food habits through the use of the available tools, which usually have low reliability, particularly in children and adolescents. Moreover, our questionnaire assessed only weekly frequency instead of the amount of consumed food.

Obesity seems to be the most relevant condition related to the increase in blood pressure in adolescents, since other variables related to higher blood pressure in previous studies were not significantly related to high blood pressure in our multivariate model.

It is relevant to highlight that blood pressure was assessed in one opportunity in the present study and due to the effects of behavioral, nutritional, and emotional factors on blood pressure control, the inferences for arterial hypertension diagnosis should be avoided. Moreover, only adolescents from public schools were assessed, limiting generalizations to adolescents from private schools. Additionally, the cross-sectional design of the study does not offer support for causality relationships, and future research should take into account other nutritional variables related to the cardiovascular system, such as sodium and caffeine.

The present study did not assess biological maturation of the adolescents, which is a limitation. However, it is important to remember that blood pressure has been not related to sexual maturation when the effects of body mass and height are controlled[52]. Therefore, blood pressure in adolescents should not be determined by sexual maturation stages. Moreover, maturation is not considered in the construction of the percentile values to diagnose high blood pressure in children and adolescents[22].

Conclusions

Abdominally obese adolescents present two times higher odds for high blood pressure, independent of general obesity, which in turn was not related to blood pressure. HRV indices, food habits, and physical activity were not associated with high blood pressure in the analysed schoolchildren.

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