

## Relationship between Habitual Physical Activity and high Blood Pressure Among Adolescents In High Socioeconomic Level School: a Confounder-Controlled Analysis

### Relação Entre Atividade Física Habitual e Pressão Arterial Alta Entre Adolescentes de uma Escola de Alto Nível Socioeconômico: uma Análise Controlada por Fatores de Confusão

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#### Abstract

The interplay between habitual physical activity and health outcomes in adolescents might be shaped by diverse social and environmental factors. Moreover, ensuring control over confounding variables is imperative for a more precise determination of the magnitude of these associations. Therefore, the present study aimed to investigate the relationship between habitual physical activity (HPA) and high blood pressure (HBP) among students from high socioeconomic level schools. Utilizing a sample of 120 students in Londrina-PR, aged between nine and 13 years, the study did not find significant associations between different domains of HPA (school-based, active sports/leisure, and free time) and the prevalence of HBP. Surprisingly, total physical activity was associated with a higher risk of HBP, regardless of adjustments for variables such as nutritional status and somatic maturation. This suggests that the relationship between physical activity and cardiovascular health in children may be more complex than mere volume of physical activity, implicating the type and context of activities practiced. The results underscore the importance of considering these factors when assessing the risk of HBP in children from high socioeconomic backgrounds. However, further research is needed to better understand the underlying mechanisms of this paradoxical relationship between physical activity and cardiovascular health in school-aged children.

**Keywords:** Exercise. Hypertension. Schools. Social Class. Population Health.

#### Resumo

*A relação entre a prática habitual de atividades físicas e os desfechos de saúde em adolescentes pode ser influenciada por diversas variáveis sociais e ambientais. Além disso, o controle de variáveis de confusão é fundamental para identificar de forma mais precisa a magnitude dessas relações. Dessa forma, o presente estudo teve como objetivo investigar a relação entre a prática habitual de atividade física (PHAF) e a pressão arterial elevada (PAE) em escolares de alto nível socioeconômico. Utilizando uma amostra de 120 escolares em Londrina-PR, entre nove e 13 anos, o estudo não encontrou associações significativas entre os diferentes domínios da PHAF (na escola, esporte/lazer ativo e tempo livre) e a prevalência de PAE. Surpreendentemente, a prática total de atividades físicas foi associada a um maior risco de PAE, independentemente de ajustes para variáveis como estado nutricional e maturação somática. Isso sugere que a relação entre atividade física e saúde cardiovascular em crianças pode ser mais complexa do que o simples volume de atividade física, implicando o tipo e contexto das atividades praticadas. Os resultados destacam a importância de considerar esses fatores ao avaliar o risco de PAE em crianças de alto nível socioeconômico. No entanto, mais pesquisas são necessárias para entender melhor os mecanismos subjacentes a essa relação paradoxal entre a atividade física e a saúde cardiovascular em escolares.*

**Palavras-chave:** Exercício. Hipertensão. Escola. Classe social. Saúde Populacional.

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#### 1 Introduction

Arterial hypertension is a condition characterized by increased blood pressure in the arteries and currently exhibits high prevalence in the Brazilian population, influencing the genesis of various diseases, particularly vascular diseases<sup>1</sup>, which constitute the leading cause of morbidity and mortality in the Brazilian population<sup>2</sup>, as well as in the vast majority of countries worldwide<sup>3</sup>.

Cardiovascular health in adolescence is an area of growing concern, especially considering the lifestyle habits adopted during this crucial developmental phase<sup>4</sup>. High blood pressure (HBP), one of the main precursors of cardiovascular diseases in adulthood, has been increasingly observed among adolescents, contributing to a series of long-term health

complications<sup>5,6</sup>. While several studies have investigated the relationship between physical activity and blood pressure in adolescents<sup>7-9</sup>, few focus on high socioeconomic populations. This research aims to fill this gap by examining the association between habitual physical activity (HPA) and HBP in adolescents from high socioeconomic backgrounds.

Additionally, this analysis was controlled for intervening factors such as nutritional status, abdominal obesity, and somatic maturation, in order to discern the independent influence of physical activities on blood pressure in this specific demographic. Understanding these relationships is essential to inform intervention strategies and promote cardiovascular health among adolescents from privileged socioeconomic backgrounds, thus contributing to a more comprehensive and

effective approach in preventing cardiovascular diseases from adolescence to adulthood.

Therefore, the aim of the present study was to analyze the association between different domains of HPA (independent variables) and the prevalence of HBP (dependent variable) in high socioeconomic schoolchildren.

## 2 Material and Methods

### 2.1 Sample

The sample comprised students of both sexes, aged between nine and 13 years, enrolled in elementary education in private schools in the municipality of Londrina, Paraná, Brazil. Sample calculation utilized a hypertension prevalence of 12%, according to literature data<sup>10</sup>, with a statistical power of 80% and a tolerable error of 5%. The required simple sample size was established at 100 subjects. Considering that the present study was conducted in a single school representative of the high socioeconomic population of Londrina, Paraná, a compensation adjustment of 20% was adopted, totaling a necessary sample of 120 subjects. Economic status was determined using the “Economic Classification Criteria of Brazil” established in 2019 by the Brazilian Association of Companies and Research (ABEP).

Inclusion criteria included obtaining informed consent from guardians regarding the procedures to which the subjects were subjected. This study was approved by the State University of Londrina Ethics Committee (CAAE No. 0281.0.268.000-07 – Report N° 295/07).

### 2.2 Experimental design

This study is characterized by a cross-sectional design conducted in Londrina, Paraná, a city with approximately 570,000 inhabitants, being the second most populous city in the state. The city has approximately 80,000 students enrolled in elementary education, with about 10% in private schools.

The evaluations began with questionnaires. Subsequently, the subjects were referred for anthropometric measurements evaluation. Blood pressure measurements were then taken.

### 2.3 Dependent variable

#### 2.3.1 Blood pressure

An automatic oscillometric equipment (Omron model HEM 742), previously validated for adolescents, was used for blood pressure evaluation<sup>10</sup>. Subjects were kept seated at rest for 10 minutes before blood pressure assessment. Procedures for blood pressure measurement followed those established in the literature<sup>11</sup>. Classification criteria for subjects as “normotensive” or “hypertensive” were those established by the National High Blood Pressure Education Program<sup>12</sup>.

### 2.4 Independent Variable

#### 2.4.1 Habitual physical activity practice

Habitual physical activity practice was assessed through a questionnaire using an inquiry specifically developed for this purpose<sup>13</sup>, validated for application in Brazilian pediatric populations<sup>14</sup>. This instrument provides a dimensionless score considering the domains of habitual physical activity practice in the school environment, leisure, free time, and total physical activity practice (school + leisure + sports activity outside the school environment).

The dichotomization between those classified as “high” and “low” habitual physical activity practice in all its domains was normative, so that individuals classified in the fourth quartile were considered as “high” habitual physical activity practice, while their peers circumscribed in quartiles one, two, and three were classified as “low” habitual physical activity practice.

### 2.5 Characterization and Control Variables

#### 2.5.1 Anthropometry

Body mass was assessed using an electronic scale with a maximum capacity of 150 kg. Height was measured using a portable stadiometer. Body mass index (BMI) was calculated using body mass divided by the square of height. Cut-off points adopted for nutritional status classification were those recommended by Cole et al.<sup>15</sup>.

#### 2.6 Waist circumference

Waist circumference was determined as the minimum circumference between the iliac crest and the last rib. It was measured using a non-stretchable tape graduated in mm. Cut-off points adopted to characterize “absence” or “presence” of abdominal obesity were those recommended by Taylor et al.<sup>16</sup>.

#### 2.7 Somatic maturation

Leg length and sitting height were assessed using standard techniques<sup>17</sup>. These measurements were used to estimate somatic maturation onset, which denotes the time (in years) from the onset to peak height velocity (PHV)<sup>18</sup>, an important maturation event. PHV is an indicator of somatic maturation (linear growth) and reflects the age of maximum growth rate during adolescence.

### 2.8 Statistical Treatment

Chi-square test with Yates correction (categorical variables) was applied to verify possible associations between blood pressure (dependent variable) and habitual physical activity practice. The magnitude of associations between the dependent variable and other independent variables was analyzed using Poisson regression with robust variance adjustment (prevalence ratio). All analyses were performed in univariate (unadjusted) and multivariate (adjusted for

nutritional status, abdominal obesity, and somatic maturation) models. The significance level established was  $P < 0.05$ . Analyses were conducted using the SPSS software package.

### 3 Results and Discussion

The present study aimed to examine the association among different domains of habitual physical activity practice (HPAF) and the prevalence of high blood pressure (HBP) among high socioeconomic status schoolchildren,

controlling for confounding variables such as nutritional status, abdominal obesity, and somatic maturation. The results of the association analysis between HPAF domains and HBP revealed diverse findings.

Table 1 presents descriptive data related to grade, gender, clinical status, number of cases (N), age, body mass (BM), height, and peak height velocity (PHV) of normotensive and hypertensive individuals, separated by gender.

**Table 1** - General characteristics of the sample

Grade	Gender	Clinical Status	N	Age (years)		BM (kg)		Height (m)		PHV	
				Mean	SD	Mean	SD	Mean	SD	Mean	SD
7	Male	Normotensive	18	12.67	0.33	48.4	8.2	1.60	0.08	-1.72	0.90
		Hypertensive	8	12.72	0.20	49.3	8.5	1.56	0.07	-1.65	0.48
	Female	Normotensive	29	12.44	0.51	47.7	8.2	1.57	0.06	-1.37	0.41
		Hypertensive	3	12.32	0.16	46.0	8.2	1.53	0.06	-1.46	0.05
8	Male	Normotensive	24	13.56	0.42	53.4	7.6	1.67	0.06	-0.59	0.42
		Hypertensive	19	13.39	0.28	58.5	16.1	1.66	0.09	-0.71	0.41
	Female	Normotensive	17	13.40	0.42	54.1	9.2	1.60	0.05	-0.70	0.54
		Hypertensive	8	13.37	0.39	59.2	8.7	1.61	0.06	-0.73	0.43
9	Male	Normotensive	23	14.30	0.35	54.9	5.8	1.68	0.06	0.14	0.57
		Hypertensive	15	14.36	0.29	65.0	10.6	1.72	0.08	0.41	0.54
	Female	Normotensive	26	14.23	0.32	52.8	7.3	1.62	0.04	0.12	0.40
		Hypertensive	11	14.46	0.65	59.8	10.2	1.63	0.05	0.10	0.45

Number of cases = N; body mass = BM; peak height velocity = PHV.

Source: research data.

The results of the association analysis (Table 2) indicate that the prevalence of HBP was similar between the low and high HPA groups in all the analyzed domains. In the school-based HPA category, 69.2% of the individuals classified as “low” HPA had normal blood pressure, while 67.2% of those classified as “high” HPA also fell into this category. The chi-square test did not show statistical significance ( $p = 0.907$ ), suggesting no association between school-based HPA and HBP.

Similarly, in the Sports/Leisure HPA category, the distribution of blood pressure between the groups classified

as “low” and “high” HPA showed no statistically significant difference ( $p = 0.995$ ).

In the Free Time HPA domain, there was a slight numerical difference in the prevalence of HBP between the “low” and “high” HPA groups (75.2% versus 70.3%, respectively). However, the chi-square test did not show statistical significance ( $p = 0.579$ ).

Finally, in the Total HPA analysis, an inverse association trend between HPA and HBP was observed ( $p = 0.066$ ). Individuals classified as “high” HPA showed a higher prevalence of HBP compared to their “low” HPA counterparts.

**Table 2** - Association between blood pressure and habitual physical activity practice

		Blood pressure				Chi-square test		Phi	
		Normal		Elevated		X <sup>2</sup>	P-value	Value	P-value
		N	%	N	%				
HPA_School	Low	92	69.2%	43	67.2%	0.014	0.907	0.014	0.779
	High	41	30.8%	21	32.8%				
	Total	133	100.0%	64	100.0%				
HPA_Sports/Leisure	Low	94	70.7%	46	71.9%	0.000	0.995	-0.012	0.862
	High	39	29.3%	18	28.1%				
	Total	133	100.0%	64	100.0%				
HPA_Free Time	Low	100	75.2%	45	70.3%	0.307	0.579	0.052	0.467
	High	33	24.8%	19	29.7%				
	Total	133	100.0%	64	100.0%				
HPA_Total	Low	105	78.9%	42	65.6%	3.376	0.066	0.143	0.044
	High	28	21.1%	22	34.4%				
	Total	133	100.0%	64	100.0%				

HPA = habitual physical activity practice.

Source: research data.

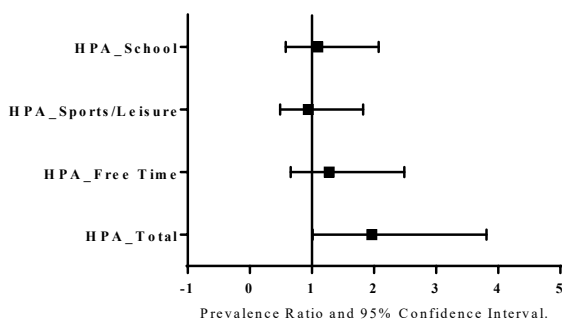
Figure 1 illustrates the data regarding the magnitude of the association between different domains of habitual physical activity practice (HPAF) and the incidence of high blood pressure (HBP) in the univariate model. Logistic regression analysis revealed that there is no statistically significant association between HPAF at school and the occurrence of HBP, with an odds ratio of 1.096 (95% CI: 0.579-2.075), indicating a 1.096 times increase in the odds of HBP for each unit increase in physical activity practice at school, but without statistical significance ( $P = 0.779$ ).

Furthermore, the results of logistic regression analysis did not demonstrate a statistically significant association among HPAF, specifically sports activities and active leisure, and the occurrence of HBP, with an odds ratio of 0.862 (95% CI: 0.487-1.826), suggesting no significant increase in the likelihood of developing HBP among practitioners of these activities compared to non-practitioners ( $P = 0.862$ ).

Similarly, there was no statistically significant association between HPAF in free time and the occurrence of HBP, with an odds ratio of 1.279 (95% CI: 0.658-2.488), and a p-value of 0.468, indicating lack of statistical significance.

On the other hand, the results of logistic regression analysis indicated a statistically significant association between total habitual physical activity practice, considering all domains, and the occurrence of HBP, with an odds ratio of 1.964 (95% CI: 1.012-3.813) and a p-value of 0.046, indicating statistical significance. This suggests that individuals who are more active have 1.964 times higher odds of developing HBP compared to those who are less active.

**Figure 1** – Magnitude of the association between high blood pressure and the different domains of habitual physical activity practice. Univariate Mode.



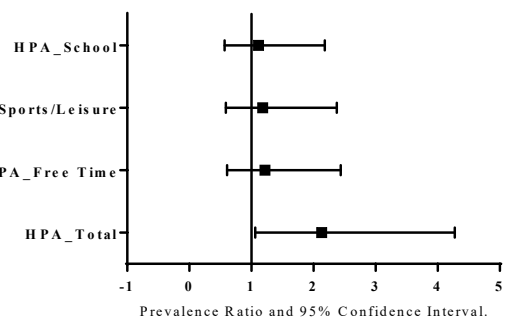
Source: research data.

Figure 2 presents data regarding the magnitude of the association between different domains of habitual physical activity practice (HPAF) and HBP, now in the model adjusted for nutritional status, abdominal obesity, and somatic maturation. The results of logistic regression analysis demonstrated that there is no statistically significant association between HPAF at school and the occurrence of HBP (odds ratio = 1.114; 95% CI = 0.570-2.180;  $P = 0.752$ ), even after adjustment for variables such as nutritional status, abdominal obesity, and somatic maturation.

Similarly, no statistically significant association was found between HPAF in sports and active leisure and the incidence of HBP (odds ratio = 1.182; 95% CI = 0.588-2.374;  $P = 0.639$ ), after adjustment for the mentioned variables. The results also revealed the absence of a statistically significant association between HPAF in free time and the occurrence of HBP (odds ratio = 1.217; 95% CI = 0.607-2.438;  $P = 0.581$ ), even after controlling for confounding variables.

However, the results indicated a statistically significant association between total habitual physical activity practice and the incidence of HBP (odds ratio = 2.131; 95% CI = 1.062-4.275;  $P = 0.033$ ), suggesting that regular physical activity practice is associated with a higher risk of developing HBP, even after adjustment for variables such as nutritional status, abdominal obesity, and somatic maturation. These findings suggest the importance of considering not only the volume but also the type and context of physical activities in assessing the risk of HBP.

**Figure 2** - Magnitude of the association between high blood pressure and the different domains of habitual physical activity practice. Model adjusted for nutritional status, abdominal obesity, and somatic maturation



Source: research data.

In general, the results indicated that the prevalence of HBP was similar between low and high HPAF groups in all the analyzed domains. No statistically significant differences were observed in the prevalence of HBP between groups classified as “low” and “high” HPAF in school, sports/leisure, and free time. The chi-square test did not show statistical significance, suggesting the absence of association between physical activity practice in these domains and the occurrence of HBP. However, when considering total HPAF, a trend of direct association between HPAF and HBP was observed. Individuals classified as “high” HPAF showed a higher prevalence of HBP compared to their “low” HPAF counterparts.

Univariate logistic regression analysis did not reveal a statistically significant association between HPAF in any of the analyzed domains and the occurrence of HBP. However, when considering the model adjusted for confounding variables such as nutritional status, abdominal obesity, and somatic maturation, the results remained consistent, suggesting a lack of association between physical activity

practice and the incidence of HBP among high socioeconomic status schoolchildren.

Surprisingly, when analyzing total HPAF in the adjusted model, a statistically significant association was found between HPAF and the incidence of HBP, indicating a higher risk of developing HBP among the most active individuals, even after controlling for confounding variables.

These results suggest that, although regular physical activity practice is generally associated with cardiovascular health benefits, its relationship with HBP may be complex and influenced by contextual and individual factors<sup>19</sup>. The importance of considering not only the volume but also the type and context of physical activities in assessing the risk of HBP is highlighted, suggesting the need for further research to better understand this relationship in specific populations, such as high socioeconomic status schoolchildren<sup>20</sup>.

Despite the interesting results presented, it is important to acknowledge some limitations of this study. Firstly, the sample composed of high socioeconomic status schoolchildren may limit the generalization of findings to other populations with different socioeconomic contexts<sup>21</sup>. Additionally, the cross-sectional design of the study prevents inference of causality, needing longitudinal research to better elucidate the relationship between HPAF and HBP over time<sup>22</sup>. Another limitation is related to the use of self-reports to assess HPAF, which may lead to memory or social desirability biases<sup>23</sup>. Moreover, variables not considered in this study, such as salt intake, family history of hypertension, and exposure to stress, could influence the results and were not controlled<sup>24</sup>. Lastly, the lack of consideration of other possible determinants of HBP, such as genetic factors, could affect the accuracy of the association estimates between physical activity practice and HBP<sup>25</sup>. These limitations suggest the need for more comprehensive and careful approaches in future investigations on the topic.

#### 4 Conclusion

This study investigated the association between habitual physical activity practice (HPAF) and high blood pressure (HBP) in adolescents of high socioeconomic status, controlled by confusion variables such as nutritional status, abdominal obesity, and somatic maturation. The results obtained did not reveal a significant association between HPAF in different domains, such as at school, active sports/leisure, and free time, and the incidence of HBP. However, when considering total HPAF, there was a statistically significant association with a higher risk of developing HBP, even after adjustment for control variables.

These findings highlight the importance of considering not only the quantity but also the type and context of physical activities when assessing the risk of HBP in adolescents of high socioeconomic status. Additionally, they underscore the need for further investigations to better understand the underlying

mechanisms of this seemingly paradoxical association between physical activity practice and cardiovascular health, especially in socioeconomically privileged populations.

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