Original Article

Adiposity as a Mediator in the Relationship between Vigorous Physical Activity and Blood Pressure in Brazilian Children

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Abstract

Background: **Elevated blood pressure (BP) in childhood is a strong predictor of hypertension and cardiovascular disease in adulthood. Vigorous physical activity (VPA) has been inversely associated with BP; however, the extent to which adiposity mediates this relationship – particularly by sex – remains unclear.**

Objectives: **To examine the association between VPA, adiposity indices, and BP in Brazilian children, and to test the mediating role of adiposity.**

Methods: **This cross-sectional study included 246 children (125 girls) aged 7-10 years. VPA was assessed using triaxial accelerometers. Adiposity markers included body mass index (BMI), tri-ponderal mass index (TMI), waist circumference (WC), and body fat percentage (%BF). Systolic (SBP) and diastolic BP (DBP) were measured. Associations were analyzed using age-adjusted multivariable regression models. Mediation analyses were performed using the PROCESS macro for SPSS. Statistical significance was set at 5%.**

Results: **Adiposity measures were positively associated with BP in both sexes. VPA was inversely associated with SBP only in girls (β = –0.46; 95% CI: –0.74 to –0.18). Adiposity partially mediated the VPA–SBP association in girls (BMI: 25%, TMI: 22%, WC: 23%, %BF: 20%) and in boys (BMI: 12%, TMI: 8%, WC: 9%, %BF: 10%).**

Conclusion: **VPA is inversely associated with BP in girls, with adiposity acting as a partial mediator in both sexes. These findings underscore the importance of high-intensity physical activity during childhood for improving body composition and supporting cardiovascular health.**

Keywords: **Adiposity; Child; Arterial Pressure; Exercise.**

Introduction

Elevated blood pressure (BP) is a major modifiable risk factor for cardiovascular disease and has increasingly been recognized as an important pediatric health concern.[1,2] Although clinical hypertension is relatively uncommon in childhood, BP levels tend to track from early life into adulthood, underscoring the importance of early prevention strategies.[3,4]

BP regulation during childhood is influenced by multiple factors, including family history, birth weight, ethnicity, dietary patterns, and lifestyle behaviors such as physical activity (PA) and sedentary time.[5,6] Among these, excess adiposity and insufficient PA are consistently associated with higher BP. In particular, increased body fat – especially central adiposity – is a strong predictor of early vascular dysfunction and elevated BP in youth.[7] Conversely, regular PA, particularly at moderate-to-vigorous intensity (MVPA), has been associated with improved vascular function, autonomic regulation, and BP control.[8]

The World Health Organization recommends that children accumulate at least 60 minutes of MVPA daily, including vigorous-intensity activity (VPA) at least three

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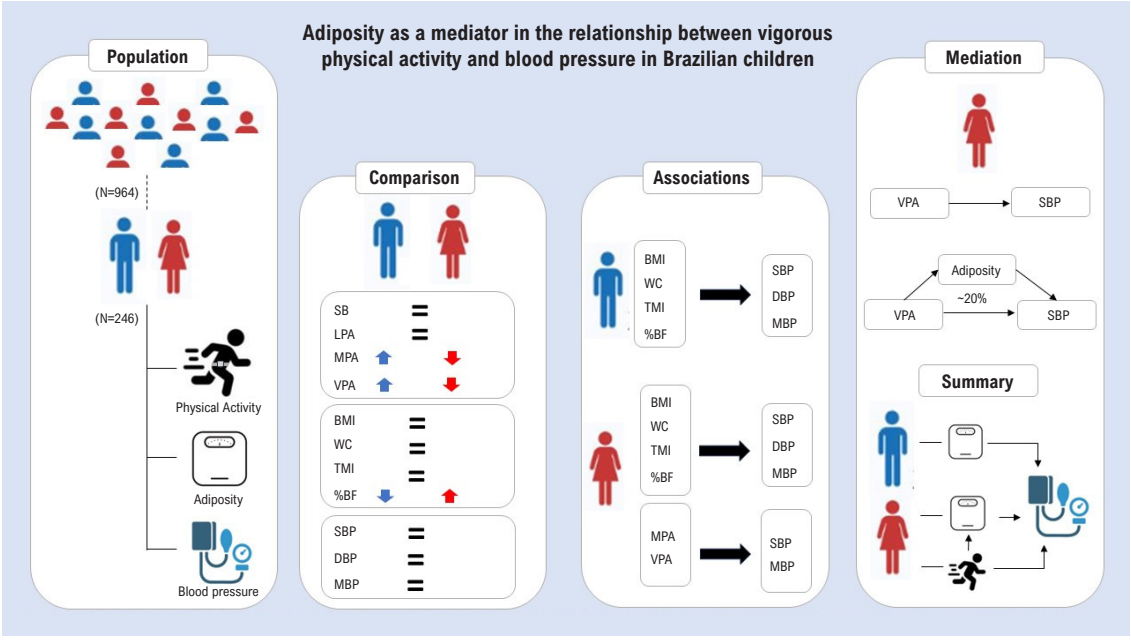
Central Illustration: Adiposity as a Mediator in the Relationship between Vigorous Physical Activity and Blood Pressure in Brazilian Children



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SB: sedentary behavior; LPA: light physical activity; MPA: moderate physical activity; VPA: vigorous physical activity; BMI: body mass index; WC: waist circumference; TMI: tri-ponderal mass index; %BF: body fat percentage; SBP: systolic blood pressure; DBP: diastolic blood pressure; MBP: mean blood pressure.

times per week.[9] However, fewer than 20% of school-aged children worldwide meet this recommendation, raising important public health concerns.[10]

While MVPA is generally linked to cardiovascular benefits in youth,[11] growing evidence suggests that VPA may produce stronger and more consistent effects on cardiometabolic health.[12] Studies have shown that VPA improves adiposity, cardiorespiratory fitness, and metabolic risk profiles in children and adolescents.[13] Nevertheless, evidence regarding the association between VPA and BP remains inconsistent, with observational studies reporting mixed findings.[11-15] In contrast, intervention studies – particularly those involving high-intensity interval training (HIIT) – have demonstrated greater BP reductions than moderate-intensity programs, especially among girls and children with obesity.[16]

These inconsistencies may be explained by methodological differences and by the influence of mediating or moderating factors, such as sex and adiposity. Supporting this hypothesis, Lucena Filho et al.[1] showed that adiposity mediated the association between MVPA and both systolic (SBP) and diastolic BP (DBP) in young children.

Given the limited evidence focusing on VPA and adiposity in BP regulation among younger children, this study aimed to examine the association between VPA, adiposity markers, and BP in Brazilian children aged 7-10 years, and to investigate whether adiposity mediates the relationship between VPA and BP, considering potential sex differences.

Methods

Study design and sample

This study was approved by the Human Research Ethics Committee under protocol CAAE Nº 40415120.4.0000.0104. All parents or legal guardians were fully informed about the study procedures and signed the informed consent form. Likewise, the children received age-appropriate explanations and signed the informed assent form. In addition, the present study complies with the 1964 Declaration of Helsinki and its later amendments, rigorously following the requirements established in Resolution Nº 466/2012 of the Brazilian National Health Council.

This cross-sectional study included a sample of 246 children aged 7-10 years, of both sexes, who participated in the project entitled "Sedentary behavior and physical activity: patterns and correlations with biological, psychosocial, and environmental factors in children aged 7 to 10 years." Inclusion criteria were: (i) enrollment in the municipal public school system; (ii) age between 7

and 10 years, both sexes; and (iii) submission of properly completed and signed informed consent and assent forms. Children were excluded if they (i) had physical limitations or disabilities preventing participation in the assessments; (ii) did not complete the protocols; or (iii) were absent during data collection. The report of the current study is based on the AGReMA statement.[18]

A total of 946 children attending three public schools in different regions of Ivaiporã, Paraná, Brazil, were invited to participate. Of these, 246 children met all inclusion criteria and comprised the final analytical sample. Details of participant selection and exclusions are presented in Figure 1.

Anthropometric assessments

Body mass was measured using a digital scale (Welmy®), recorded to the nearest 0.1 Kg, with participants barefoot and wearing light clothing. Height was assessed using a portable stadiometer (Sanny®), recorded to the nearest 0.1 cm, with participants standing upright, barefoot, with heels together and head positioned in the Frankfurt plane. Both measurements followed standardized procedures described by Gordon, Chumlea, and Roche.[19]

Body mass index (BMI) was calculated by dividing body mass (Kg) by height squared (m^{-2}).[20] Tri-ponderal mass index (TMI) was calculated by dividing body mass (Kg) by height cubed (m^{-3}). Body fat percentage (%BF) was estimated from triceps and subscapular skinfold thickness, measured on the right side of the body using a scientific caliper (Cescorf®), with a resolution of 0.1 mm. Measurements were taken in duplicate, and a third measurement was performed if the difference between the first two exceeded 2 mm. The average of the closest values was used for analysis. The equations proposed by Slaughter et al.,[21] were applied to estimate %BF.

Waist circumference (WC) was measured at the midpoint between the last rib and the iliac crest, using a non-elastic measuring tape (Cescorf®), recorded to the nearest 0.1 cm, with participants standing and at the end of a normal expiration. All measurements were performed by trained evaluators.

Blood pressure measurement

SBP and DBP were assessed using a digital automatic monitor (HBP-1120, Omron®) with an appropriate pediatric cuff. Before measurement, children remained seated in a quiet, private room for 5 minutes. Three BP readings were taken on the right arm at one-minute intervals, and the average of the last two measurements was used for analysis. Mean blood pressure (MBP) was calculated as one-third of SBP plus two-thirds of DBP.

Sedentary behavior and physical activity

Sedentary behavior (SB) and PA were assessed using a triaxial accelerometer (ActiGraph GT9X). Children were instructed to wear the device on the right hip, above the

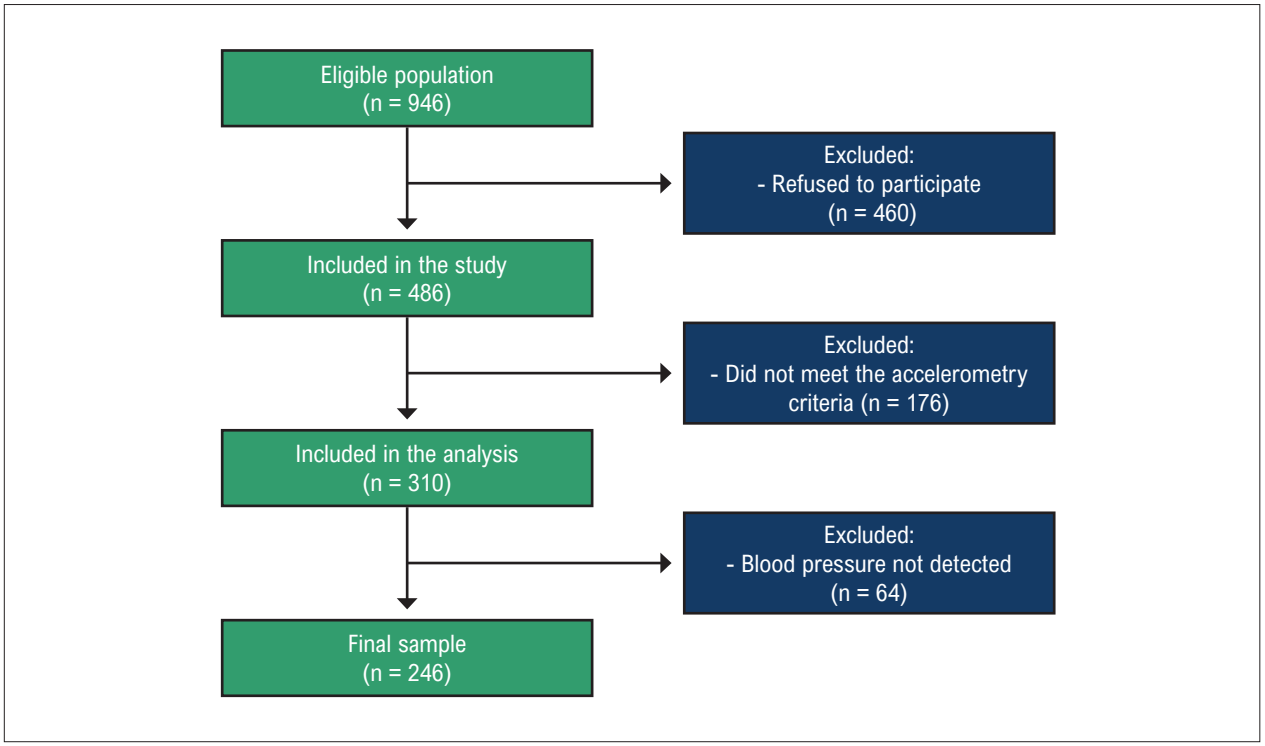

Figure 1 – *Flowchart of participant selection in a cross-sectional study of Brazilian children aged 7-10 years from Ivaiporã, Paraná, Brazil.*

iliac crest, during all waking hours for seven consecutive days, excluding water-based activities (e.g., bathing, swimming), contact sports (e.g., wrestling, judo), and sleep periods. Daily reminders and follow-ups with children and guardians were conducted to ensure proper device use.

Data were included if the device was worn for at least four valid days (including at least one weekend day), with a minimum wear time of eight hours per day. After the monitoring period, data were downloaded and processed using ActiLife software (version 6.13.4). A normal filter and a sampling frequency of 90 Hz were applied,[22] with 15-second epochs. Non-wear time was defined as ≥30 consecutive minutes of zero counts. SB and PA intensities were classified using empirically established cut-points based on counts per minute.[23]

Statistical analysis

Data normality was assessed using the Kolmogorov-Smirnov test, and the assumption of homogeneity of variance was evaluated using Levene's test. Descriptive statistics (median and interquartile range) were used to characterize the sample. To compare adiposity markers, BP, and PA between boys and girls, the Mann–Whitney test was applied. The Spearman correlation coefficient was used to examine associations between adiposity indicators, PA, and BP. Multiple linear regression analyses were conducted to assess the relationships between adiposity indicators, PA, and BP measurements. Regression assumptions – including linearity, normality of residuals, homoscedasticity, and absence of multicollinearity – were verified, and no relevant violations were identified.

Mediation analysis was performed using linear regression models with bootstrapping procedures (5,000 resamples) to estimate 95% confidence intervals (CI) using the bias-corrected and accelerated (BCa) method. This approach considered predictors (PA), mediators (adiposity markers), and outcomes (BP). The mediation analysis followed a structured framework involving four equations: (a) the association between the predictor (VPA, MVPA) and the mediator (BMI, TMI, WC, %BF); (b) the association between the mediator and the outcome (SBP, DBP, MBP); (c) the total effect of the predictor on the outcome, without including the mediator; and (c′) the direct effect of the predictor on the outcome, adjusted for the mediator. An indirect effect was considered statistically significant when the 95% CI did not include zero. The percentage of mediation was calculated as $1 - (c'/c)$. Analyses were adjusted for age and stratified by sex. Data analysis was performed using IBM SPSS Statistics (version 24.0; IBM Corp., Armonk, NY, USA), and mediation analyses were conducted using the PROCESS macro for SPSS.[24] Statistical significance was set at $p \leq 0.05$.

Results

A total of 246 Brazilian children aged 7-10 years, including 125 girls (50.8%), participated in the study. The descriptive characteristics of body adiposity, BP, and PA variables by sex are presented in Table 1. Boys and girls showed similar median age and general anthropometric characteristics. However, girls exhibited significantly higher %BF compared with boys. Regarding PA levels, girls engaged in significantly less MPA, VPA, MVPA, and total PA than boys (Central Illustration).

Table 2 presents the correlations between adiposity markers, PA, and BP measurements (SBP, DBP, MBP) in children stratified by sex. Among boys, inverse correlations were observed between SBP and light physical activity (LPA) and total PA. DBP showed negative correlations with VPA and MVPA. MBP was positively associated with all anthropometric variables and negatively associated with all PA variables. Among girls, SBP was inversely associated with SB and all PA variables except LPA. DBP was positively associated with BMI and WC, and inversely associated with MPA, VPA, and MVPA. Similarly, MBP was positively associated with all anthropometric variables and negatively associated with all PA variables except LPA.

Table 3 presents the associations between anthropometric, body composition, PA, and BP measurements in children, stratified by sex. Among boys, positive associations were observed between all markers of adiposity (BMI, TMI, WC, %BF) and BP variables (SBP, DBP, MBP). Among girls, similar positive associations were found between all adiposity markers and both SBP and MBP, along with negative associations of MPA and VPA with SBP and MBP. However, DBP did not show significant associations with adiposity variables in this group.

The indirect effect was significant, indicating that adiposity markers mediated the association between VPA and BP in boys (Figure 2). BMI, TMI, and WC mediated between 8% and 12% of the association between VPA and BP (SBP, DBP, and MBP) (Central Illustration).

In girls, adiposity markers (BMI, TMI, WC, and %BF) mediated between 20% and 25% of the association between VPA and SBP and MBP (Figure 3). No significant indirect effect was observed for DBP (Central Illustration).

Discussion

This study examined the association between VPA and BP in children, as well as the mediating role of adiposity. Our results revealed a significant association between VPA and SBP only among girls, while adiposity mediated this association in both sexes. These findings highlight adiposity as a potential pathway through which VPA exerts beneficial effects on cardiovascular health during childhood.

Consistent with previous literature, our results reinforce adiposity as a key determinant of elevated BP in pediatric populations.[25] The biological plausibility of this mediation is supported by mechanisms suggesting that excess body fat – particularly visceral adiposity – increases sympathetic activity, insulin resistance, and systemic inflammation, ultimately leading to higher vascular resistance and BP.[26] Our findings align with those of Lucena Filho et al.,[17] who reported a similar mediating role of adiposity in the association between MVPA and BP among children aged 5 to 7 years.

Table 1 – Descriptive characteristics of adiposity, blood pressure, and physical activity in Brazilian children aged 7-10 years from Ivaiporã, Paraná, Brazil according to sex

Variables	Total (n=246) Median (IQR)	Boys (n=121) Median (IQR)	Girls (n=125) Median (IQR)	U	p
Age (years)	9.2 (1.9)	9.1 (1.8)	9.2 (2.0)	7.805	0.664
Height (cm)	137.5 (12.6)	137.2 (11.5)	138.0 (15.5)	7.851	0.605
Body mass (kg)	36.0 (13.1)	36.4 (12.1)	36.0 (13.4)	7.644	0.884
BMI ($kg \cdot m^{-2}$)	18.7 (5.1)	18.9 (5.4)	18.6 (4.5)	7.579	0.976
TMI ($kg \cdot m^{-3}$)	13.5 (3.2)	13.8 (3.6)	13.3 (2.9)	7.465	0.861
WC (cm)	61.5 (10.6)	63.0 (12.0)	61.0 (10.6)	6.987	0.302
%BF	27.7 (10.1)	25.1 (14.2)	29.0 (7.9)	9.536	**<0.001**
SBP (mmHg)	108.0 (12.0)	108.0 (12.0)	109.0 (12.0)	7.500	0.911
DBP (mmHg)	62.0 (10.0)	62.0 (9.0)	62.0 (12.0)	7.616	0.924
MBP (mmHg)	77.5 (11.0)	77.3 (10.2)	77.6 (11.2)	7.530	0.954
SB (h/day)	8.1 (1.9)	8.1 (2.0)	8.2 (1.8)	8.000	0.433
LPA (min/day)	251.3 (67.0)	253.3 (63.3)	248.3 (69.0)	6.836	0.193
MPA (min/day)	25.7 (17.0)	29.2 (17.8)	22.3 (14.4)	5.661	**0.001**
VPA (min/day)	8.5 (8.3)	9.6 (10.2)	7.2 (6.8)	6.082	**0.008**
MVPA (min/day)	35.1 (25.9)	38.3 (28.9)	30.6 (22.8)	5.695	**0.001**
Total PA (min/day)	291.2 (78.6)	298.1 (79.8)	287.0 (79.4)	6.446	0.045

BMI: Body mass index; TMI: tri-ponderal mass index; WC: waist circumference; %BF: body fat percentage; SBP: systolic blood pressure; DBP: diastolic blood pressure; MBP: mean blood pressure; SB: sedentary behavior; LPA: light physical activity; MPA: moderate physical activity; VPA: vigorous physical activity; MVPA: Moderate-to-vigorous physical activity: IQR: Interquartile range; Total PA: Total physical activity; U: Mann-Whitney U statistic; P: p-value ($p \leq 0.05$); Bold values indicate statistical significance.

While MVPA is widely recommended, growing evidence suggests that VPA may confer superior vascular benefits.[27] Meta-analyses and pooled cohort studies have shown that VPA elicits greater improvements in cardiorespiratory fitness and cardiometabolic risk.[14] Moreover, VPA has been associated with more pronounced reductions in adiposity,[15] a particularly harmful fat depot linked to early vascular dysfunction.[28] Our findings suggest that reductions in adiposity may be a key mechanism through which VPA contributes to lower SBP in both sexes and, to a lesser extent, lower DBP in boys.

Importantly, the mediation effect was only partial, indicating that additional physiological pathways are likely involved. VPA may improve BP independently of adiposity by enhancing parasympathetic tone, improving vascular compliance, reducing arterial stiffness, and lowering inflammatory and oxidative stress markers.[29,30] In addition, regular VPA may promote vascular remodeling and improve insulin sensitivity, further contributing to hemodynamic regulation.[31-33] These mechanisms warrant further exploration in longitudinal and interventional research.

Sex-specific factors may also influence the VPA and BP relationship. Girls generally have higher %BF and enter puberty earlier than boys, which can affect hormonal balance and fat distribution.[34] In addition, girls typically spend less time engaged in higher-intensity activities, such as MPA and VPA, compared to boys.[8] In our study, VPA was significantly associated with SBP only in girls. These findings add to the growing body of evidence suggesting that interventions designed to increase VPA in this subgroup may be particularly important for early cardiovascular disease prevention.[15]

From a public health perspective, our findings highlight the need to go beyond general PA promotion and actively encourage higher-intensity physical activities in school-aged children. Strategies that integrate VPA into school routines, recreational play, and organized sports may be especially beneficial. This is particularly urgent given that less than 10% of girls globally meet current MVPA guidelines,[10] with even fewer engaging in sufficient VPA.

Our study has several strengths, including the use of objective PA measurements, a focus on a specific and developmentally relevant age group, and the application of mediation analysis to explore underlying mechanisms. Despite the strengths of this study, some limitations should be considered when interpreting the

Table 2 – Correlations between adiposity markers, physical activity, and blood pressure according to sex in Brazilian children aged 7-10 years from Ivaiporã, Paraná, Brazil

Variables	SBP (mmHg)		DBP (mmHg)		MBP (mmHg)	
	rho	p	rho	p	rho	p
Boys (n=121)						
BMI (kg·m^{-2})	0.325	**<0.001**	0.306	**0.001**	0.343	<0.001
TMI (kg·m^{-3})	0.233	**0.010**	0.266	**0.003**	0.274	0.002
WC (cm)	0.331	**<0.001**	0.300	**0.001**	0.346	<0.001
%BF	0.368	**<0.001**	0.285	**0.002**	0.349	<0.001
SB (h/day)	0.120	0.188	0.094	0.307	0.113	0.216
LPA (min/day)	-0.209	**0.022**	-0.096	0.293	-0.165	0.071
MPA (min/day)	-0.161	0.078	-0.178	**0.050**	-0.197	0.031
VPA (min/day)	-0.151	0.098	-0.204	**0.025**	-0.206	0.023
MVPA (min/day)	-0.168	0.066	-0.208	**0.022**	-0.219	0.016
Total PA (min/day)	-0.240	**0.008**	-0.154	0.091	-0.217	0.017
Girls (n=125)						
BMI (kg·m^{-2})	0.433	**<0.001**	0.207	**0.020**	0.329	**<0.001**
TMI (kg·m^{-3})	0.323	**<0.001**	0.112	0.214	0.216	**0.015**
WC (cm)	0.405	**<0.001**	0.199	**0.026**	0.315	**<0.001**
%BF	0.300	**0.001**	0.140	0.120	0.225	**0.012**
SB (h/day)	0.175	0.051	0.121	0.179	0.156	0.082
LPA (min/day)	-0.129	0.152	-0.137	0.127	-0.150	0.094
MPA (min/day)	-0.314	**<0.001**	-0.196	**0.029**	-0.254	**0.004**
VPA (min/day)	-0.349	**<0.001**	-0.225	**0.012**	-0.291	**0.001**
MVPA (min/day)	-0.346	**<0.001**	-0.213	**0.017**	-0.279	**0.002**
Total PA (min/day)	-0.178	**0.047**	-0.159	0.076	-0.182	**0.043**

SBP: systolic blood pressure; DBP: diastolic blood pressure; MBP: mean blood pressure; BMI: body mass index; TMI: triponderal mass index; WC: waist circumference; %BF: body fat percentage; SB: sedentary Behavior; LPA: light physical activity; MPA: moderate physical activity; VPA: vigorous physical activity; MVPA: moderate-to-vigorous physical activity: Total PA: total physical activity; rho: correlation coefficient of Spearman test; P: p-value for statistical significance (p≤0.05); Bold values indicate statistical significance.

findings. The cross-sectional design precludes causal inferences, and the temporal sequence between exposure, mediator, and outcome cannot be established. In addition, although analyses were adjusted for age, residual confounding from unmeasured variables, such as dietary patterns, sleep, psychosocial factors, and maturational status, may have influenced the observed associations. The simultaneous assessment of adiposity and BP also raises the possibility of reverse causation. Nevertheless, the identification of adiposity as a potential mediator in the relationship between VPA and BP provides relevant insights into underlying mechanisms and may contribute to the development of targeted interventions aimed at improving cardiovascular health in children.

Conclusion

Our findings suggest that adiposity partially mediates the inverse association between VPA and BP in children aged 7 to 10 years. These results reinforce the importance of VPA during childhood for cardiovascular health and highlight adiposity reduction as a central

Table 3 – Association between adiposity markers, physical activity and blood pressure according to sex in Brazilian children aged 7-10 years from Ivaiporã, Paraná, Brazil

Variables	SBP (mmHg)			DBP (mmHg)			MBP (mmHg)		
	β	(CI)	p	β	(CI)	p	β	(CI)	p
Boys (n=121)									
BMI (kg·m^{-2})	0.925	0.46 to 1.39	**<0.001**	0.514	0.16 to 0.87	**0.005**	0.651	0.30 to 1.00	**<0.001**
TMI (kg·m^{-3})	1.035	0.36 to 1.71	**0.003**	0.638	0.13 to 1.14	**0.014**	0.770	0.27 to 1.27	**0.003**
WC (cm)	0.355	0.15 to 0.56	**0.001**	0.211	0.06 to 0.36	**0.007**	0.259	0.11 to 0.41	**0.001**
%BF	0.267	0.12 to 0.41	**<0.001**	0.118	0.01 to 0.23	**0.037**	0.168	0.16 to 0.28	**0.003**
SB (h/day)	0.014	-0.01 to 0.03	0.166	0.007	-0.01 to 0.02	0.378	0.009	-0.01 to 0.02	0.230
LPA (min/day)	-0.033	-0.07 to 0.01	0.064	-0.011	-0.04 to 0.01	0.395	-0.018	-0.04 to 0.01	0.166
MPA (min/day)	-0.103	-0.23 to 0.03	0.131	-0.073	-0.17 to 0.02	0.152	-0.083	-0.18 to 0.02	0.105
VPA (min/day)	-0.122	-0.33 to 0.09	0.254	-0.152	-0.31 to 0.00	0.054	-0.142	-0.30 to 0.01	0.074
MVPA (min/day)	-0.064	-0.15 to 0.02	0.146	-0.057	-0.12 to 0.01	0.084	-0.059	-0.12 to 0.01	0.073
Total PA (min/day)	-0.029	-0.06 to 0.00	**0.046**	-0.013	-0.03 to 0.01	0.208	-0.019	-0.04 to 0.00	0.086
Girls (n=125)									
BMI (kg·m^{-2})	1.311	0.87 to 1.75	**<0.001**	0.432	0.04 to 0.82	**0.029**	0.725	0.36 to 1.09	**<0.001**
TMI (kg·m^{-3})	1.714	0.98 to 2.44	**<0.001**	0.481	-0.14 to 1.10	0.128	0.892	0.29 to 1.49	**0.004**
WC (cm)	0.594	0.38 to 0.80	**<0.001**	0.185	0.01 to 0.37	**0.048**	0.321	0.15 to 0.50	**<0.001**
%BF	0.628	0.35 to 0.91	**<0.001**	0.193	-0.04 to 0.43	0.108	0.338	0.11 to 0.56	**0.004**
SB (h/day)	0.012	-0.01 to 0.04	0.340	0.001	-0.02 to 0.02	0.956	0.004	-0.01 to 0.02	0.658
LPA (min/day)	-0.021	-0.06 to 0.01	0.233	-0.015	-0.04 to 0.01	0.287	-0.017	-0.04 to 0.01	0.219
MPA (min/day)	-0.257	-0.42 to -0.09	**0.003**	-0.079	-0.21 to 0.05	0.249	-0.139	-0.27 to -0.01	**0.040**
VPA (min/day)	-0.457	-0.74 to -0.18	**0.002**	-0.150	-0.38 to 0.08	0.197	-0.253	-0.48 to -0.03	**0.027**
MVPA (min/day)	-0.198	-0.31 to -0.08	**0.001**	-0.063	-0.15 to 0.03	0.186	-0.108	-0.20 to -0.02	**0.020**
Total PA (min/day)	-0.028	-0.06 to 0.00	0.061	-0.015	-0.04 to 0.01	0.210	-0.020	-0.04 to 0.00	0.100

SBP: systolic blood pressure; DBP: diastolic blood pressure; MBP: mean blood pressure; BMI: body mass index; TMI: triponderal mass index; WC: Waist circumference; %BF: body fat percentage; SB: sedentary Behavior; LPA: light physical activity; MPA: moderate physical activity; VPA: vigorous physical activity; MVPA: moderate-to-vigorous physical activity: Total PA: total physical activity; β: beta coefficient value; CI: confidence interval; P: p-value for statistical significance (p≤0.05); Bold values indicate statistical significance.

mechanism in this relationship. Future longitudinal and intervention studies are needed to establish causality and to inform age- and sex-specific PA guidelines for pediatric populations.

Author Contributions

Conception and design of the research and Data collection: Lopes WA, Carminato RA; Data analysis and interpretation: Lopes WA, Leite N, Tadiotto MC, Carminato RA, Duarte A, Brand C, Chiquito NCSM, Martins C; Statistical analysis: Leite N, Tadiotto MC, Carminato RA; Funding acquisition: Lopes WA; Manuscript drafting: Lopes WA, Leite N, Tadiotto MC, Carminato RA, Duarte A, Pereira BO, Rosario R, Brand C, Chiquito NCSM, Okawa RTP, Martins C, Mota J; Critical revision of the manuscript for important intellectual content: Lopes WA, Leite N, Duarte A, Pereira BO, Rosario R, Brand C, Chiquito NCSM, Okawa RTP, Martins C, Mota J.

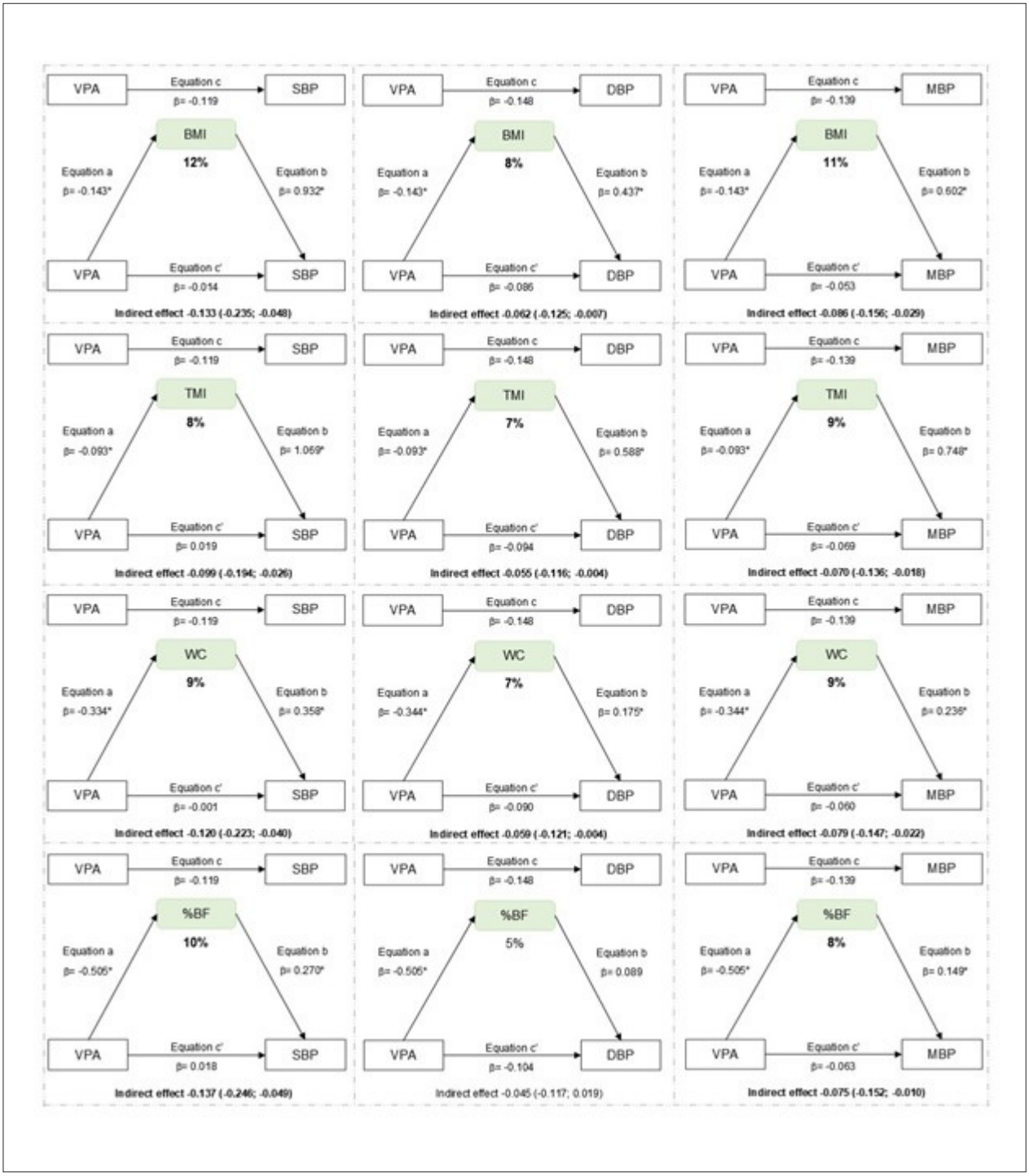

Figure 2 – *Mediation of adiposity markers (BMI, TMI, WC, %BF) in the association between VPA and BP (SBP, DBP, MBP) in boys aged 7-10 years from Ivaiporã, Paraná, Brazil. All analysis was controlled by age. MVPA: moderate-to-vigorous physical activity; SBP: systolic blood pressure; DBP: diastolic blood pressure; MBP: mean blood pressure; BMI: body mass index; TMI: tri-ponderal mass index; WC: waist circumference; %BF: body fat percentage; *significance p≤0.05; Bold values indicate statistical significance.*

Potential Conflict of Interest

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

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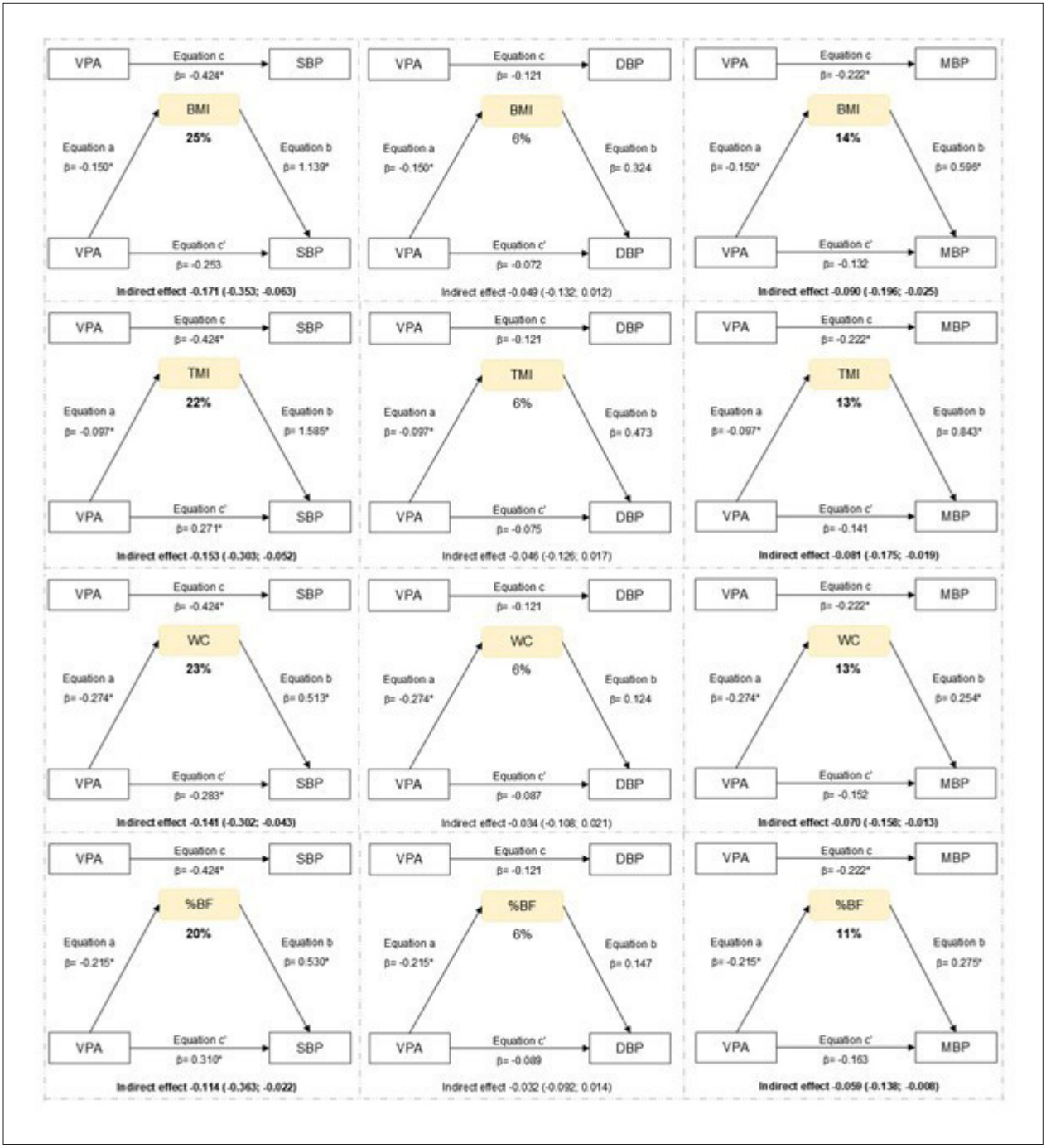

Figure 3 – *Mediation of adiposity markers (BMI, TMI, WC, %BF) in the association between VPA and BP (SBP, DBP, MBP) in girls aged 7-10 years from Ivaiporã, Paraná, Brazil; all analyses were adjusted for age; *VPA: vigorous physical activity; SBP: systolic blood pressure; DBP: diastolic blood pressure; MBP: mean blood pressure; BMI: body mass index; TMI: tri-ponderal mass index; WC: waist circumference; %BF: body fat percentage; p ≤ 0:05 indicates statistical significance; Bold values indicate statistically significant results.*

Study Association

This article is part of the thesis of Doctoral submitted by Ricardo Alexandre Carminato, from Universidade Estadual de Maringá.

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of the Nome da Instituição under the protocol number CAAE 40415120.4.0000.0104. 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.

Use of Artificial Intelligence

The authors did not use any artificial intelligence tools in the development of this work.

Availability of Research Data

All datasets supporting the results of this study are available upon request from the corresponding author.

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