

Childhood Obesity and Systemic Arterial Hypertension in Children and Adolescents: A Cross-Sectional Study

Rafaella Farias da Franca Almeida,¹ Livia Menezes Escorel,¹ Letícia Odete Guedes de Andrade Carvalho,¹ Camila Batista Gaudêncio,¹ Lara Ataíde Diniz,¹ Marcela Leite,² Marina Romero Costa,³ Alice Barbosa Maia,¹ Berenice Lempek dos Santos,¹ Michelle Barros de Aguiar,¹ Patrícia Vidal de Negreiros Nóbrega,¹ Eugênia Moreira Fernandes Montenegro,¹ Débora Alencar de Menezes Athayde,¹ Jessica Laureano Martins⁴

Centro Universitário de João Pessoa, ¹ João Pessoa, PB – Brazil

FAMENE,² João Pessoa, PB – Brazil

Complexo Hospitalar Infantil Arlinda Marques,³ João Pessoa, PB – Brazil

Instituto Dante Pazzanese de Cardiologia,⁴ São Paulo, SP – Brazil

Abstract

Background: The increase in obesity cases and the lack of screening and diagnosis of childhood hypertension highlight the need to examine these comorbidities in children.

Objectives: To investigate the relationships between systemic arterial hypertension (SAH) and childhood obesity (CO) in pediatrics and correlate the obesity level, abdominal circumference (AC), family history, and physical activity (PA) variables.

Methods: This cross-sectional study assessed age, sex, height, weight, body mass index (BMI), AC, family history, PA, CO, and blood pressure (BP) percentiles. The Chi-square test, Fisher's Exact test, and Spearman's correlation were used for data analysis, with a statistical significance level of 5%.

Results: After applying the inclusion and exclusion criteria, 30 patients aged between 3 and 18 years (incomplete) were evaluated at three different moments. The results showed that 83.3% (n = 25) of the patients were obese and 16.70% (n = 5) had severe obesity. Among them, 20% (n = 6) were diagnosed with SAH. Data showed an independence between CO and SAH (p = 0.702) and between SAH and PA time (p = 0.748). No correlations were observed between SAH and AC (p = 0.313). The history of SAH in first-degree relatives was significantly associated with the diagnosis of SAH (p = 0.004).

Conclusion: This study showed no correlation between CO and SAH in the evaluated sample, supporting the need for further research in the area.

Keywords: Hypertension; Pediatric Obesity; Pediatrics.

Introduction

Brazil was the fifth country with the highest number of obese children and adolescents in 2019 and has a 2% chance of reaching the target set by the World Health Organization for reducing obesity rates by the year 2025.¹ The pandemic caused by the new coronavirus increased the prevalence of childhood obesity (CO), highlighting the need to monitor its potential correlated comorbidities.

Among the pathologies possibly related to obesity, the risk of elevated blood pressure (BP) can be highlighted. As this

risk is increasing in the pediatric population, understanding the cardiovascular risks faced by children is essential through early detection and management of this condition.²

According to the Brazilian Society of Pediatrics (2019), systemic arterial hypertension (SAH) in the pediatric age has secondary causes. However, the primary causes (especially associated with overweight) have been increasing, and further studies are still needed to detect and identify the evolution of chronic diseases in adulthood originating from childhood.³

Based on these considerations, the main objective of this study was to investigate the relationship between SAH and CO in pediatric patients from João Pessoa, Northeastern Brazil. Among the secondary objectives, we evaluated whether other variables (physical activity [PA], family history, and abdominal circumference [AC]) influenced BP and investigated SAH in different groups of obese children and adolescents according to sex, age, height, and weight. The hypothesis adopted in the research was that children with obesity would have a high frequency of SAH, emphasizing the need for more regular BP screening in these patients.

Mailing Address: Rafaella Farias da Franca Almeida •

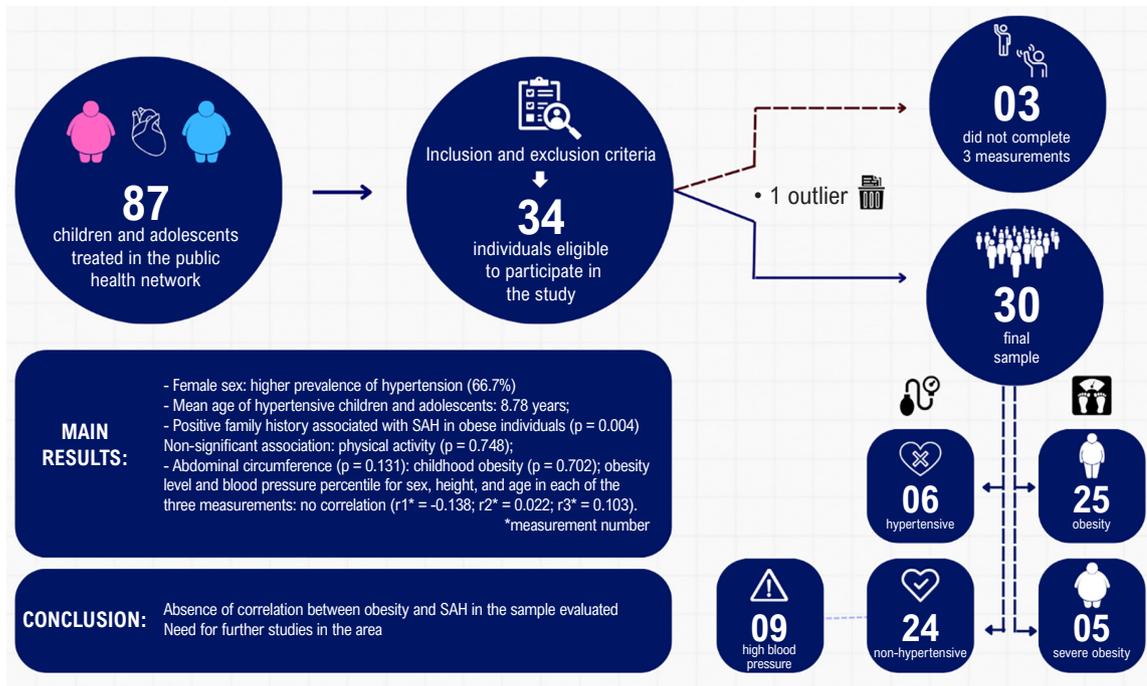
Centro Universitário de João Pessoa. BR-230. Postal code: 58053-000. Águas Fria, João Pessoa, PB – Brazil

E-mail: rafinhafarias83@hotmail.com

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Central Illustration: Childhood Obesity and Systemic Arterial Hypertension in Children and Adolescents: A Cross-Sectional Study

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Central Illustration : Summary figure, João Pessoa, Paraíba, 2023. Source: Elaborated by the author, 2023.

Methods

This observational cross-sectional study involved a non-probability sample of obese children and adolescents (according to body mass index [BMI]/ age curves for both sexes)⁴⁻⁷ attending health services in João Pessoa (Paraíba, Brazil). The sample size was determined by convenience. After the initial contact, data were collected in offices or via telemedicine and consisted of completing a pediatric evaluation form that included anamnesis and a physical examination.

Inclusion criteria were the following:

- Patients aged 3 to 18 years incomplete;
- Patients and guardians who voluntarily agreed to participate;
- Children and adolescents with a BMI categorized as obese according to the BMI/age curve;
 - Between 3 and 5 years: Z score $\geq +3$;
 - Over 5 years: Z score $\geq +2$.

Exclusion criteria were the following:

- Known congenital cardiac malformation;
- Children undergoing treatment with drugs that could raise BP (e.g., decongestants, caffeine, non-steroidal anti-inflammatory drugs, nutritional supplements, stimulants for the management of attention deficit hyperactivity disorder,

oral contraceptives, corticosteroids, tricyclic antidepressants, amphetamines, and cocaine);

- Diagnosis of syndromes that elevate BP or lead to obesity.

After excluding one outlier and the participants who did not provide three measurements, 30 patients were analyzed. The Central Illustration summarizes the methods, results, and conclusions. The study was approved by the research ethics committee of the Centro Universitário de João Pessoa (n^o 70443723.8.0000.5176). All individuals responsible for the patients were informed about the data collection procedures and signed an informed consent form authorizing their participation in the study. Additionally, participants were informed about the study using an informed assent form, which was completed playfully to help the children and adolescents understand what would be evaluated.

The following variables were included in the study:

- Dependent: BP percentile;
- Independent: CO, AC, PA, family history, sex, age, height, and weight.

After providing instructions about the study and addressing questions related to food intake (including coffee), PA, discomfort, and the urge to urinate, BP was measured in three different moments with the patient seated with uncrossed legs, feet on the floor, and back against the chair. One stethoscope (Littmann®, MN, USA) and one sphygmomanometer (Welch

Allyn®, NY, USA) with cuff suitable for the arm circumference (bag width at least 40% of the arm circumference, measured using a measuring tape [Cardiomed®, PR, Brazil]) were used.

BP was measured on the right arm with the patient lying supine and resting on the table; the cuff was positioned two centimeters above the cubital fossa, with its compressive part over the brachial artery. Systolic BP was estimated by palpating the radial pulse during cuff inflation until the pulse disappeared. After one minute of systolic BP measurement, the brachial artery was palpated, and the stethoscope bell was placed. Then, the cuff was inflated to exceed 30 mmHg above the systolic BP level and slowly deflated. The first and last Korotkoff sounds were used to determine the systolic and diastolic BP, respectively. BP values were assessed according to the percentile table presented in the guidelines on SAH in childhood and adolescence (2019) provided by the Brazilian Society of Pediatrics.

To reduce the loss of follow-up after the initial measurement conducted by a specialist, we instructed the individuals responsible for the patients to return to the family health units of their respective neighborhoods after data collection and ask healthcare professionals to perform two measurements at different times. This was performed with the help of a booklet created to outline all the steps and instructions for an accurate measurement. After the measurements, those responsible for the patients were contacted via mobile phone and asked about the data collected and specific dates of measurement.

For BMI, a weight scale (Welmy®, SP, Brazil) was used to measure weight (in kilograms), while a fixed wall stadiometer (Tonelli®) measured height. These data were interpreted using the World Health Organization growth curve. For AC analysis, a measuring tape was placed at the midpoint between the umbilical scar and the lower costal border of the last rib. Right after, the percentiles were calculated based on the values indicated for sex, age, and race;⁸ values above the 90th percentile were considered altered.

To organize the data, a pediatric care form was created using the following parameters and printed on A4 paper (Charmex®) to be completed during consultations: age, weight, height, BMI, sex, BP, BP percentiles, AC, PA, and family history of SAH.

Statistical analysis

Data management was conducted after responses were coded. Patient information and the corresponding variables were added to the database and organized in the Statistical Package for Social Sciences (SPSS®, IBM Corp, NY, USA), where figures were created and descriptive (PA and age) and inferential statistics (AC, family history, and SAH) were performed.

The Chi-square (X^2) test analyzed the association between AC and the onset of SAH in children and adolescents. The same test associated the variables related to PA and family history of SAH.

Fisher's Exact test analyzed the association between CO and SAH. Additionally, Spearman's correlation test was used to assess the correlation between BP percentiles and CO. Significance was set at 5%.

Results

A total of 87 participants were selected for the study. After eligibility criteria, 54 participants were excluded due to age (6), overweight (31), medication (14), endocrine-metabolic syndromes (one with hyperthyroidism and another with hypothyroidism; both used levothyroxine), and outlier (1). Moreover, 3 participants were lost due to the absence of 3 measurements, resulting in a final sample of 30 children and adolescents.

Table 1 presents data related to age (in years) and PA (in minutes per week). Frequency statistics were provided for these variables, including the number of individuals analyzed, mean, and standard deviation.

Table 2 demonstrates that the sample was composed predominantly of females ($n = 19$), with 66.7% ($n = 20$) presenting a negative history of SAH in first-degree relatives. Also, 83.30% ($n = 25$) of individuals presented obesity at non-severe levels, while 16.70% ($n = 5$) presented severe obesity.

Among patients diagnosed with SAH, the mean age was 8.78 years; 66.7% ($n = 4$) were female. Additionally, 30% ($n = 9$) of the sample had percentiles indicating high BP (Table 2).

Figure 2 shows that 30% ($n = 9$) of BP levels in the first measurement were compatible with SAH. Among these participants, four were identified as stage I and five as stage II. In the second measurement, patients with BP levels compatible with SAH represented 30% ($n = 9$), with 26.7% ($n = 8$) classified as stage I and 3.3% ($n = 1$) as stage II. In the third measurement, 36.70% ($n = 11$) had percentiles consistent with SAH, of which 26.70% ($n = 8$) were detected at the 95th percentile and 10% ($n = 3$) at the 95th percentile + 12 mmHg (Figure 1).

SAH was diagnosed at the end of the three measurements. As shown in Figure 1, 20% ($n = 6$) of obese participants were identified with SAH.

To evaluate the potential relationship between weekly PA time and SAH, values representing the number of individuals for each duration in minutes and the presence or absence of SAH diagnosis were analyzed. Using the X^2 , a significance of $p = 0.748$ was obtained. Therefore, PA time and SAH diagnosis were not associated (Table 3).

To evaluate the associations between AC measurement and SAH, the X^2 test was applied, yielding a significance of $p = 0.131$. Therefore, AC and SAH were independent variables in the sample (Table 4).

Table 1 – Descriptive statistics (frequency) of the variables age and PA, João Pessoa, Paraíba, 2023

Variables	Total (N)	Mean	Standard deviation
PA (min/week)	30	110.0	141.81
Age (years)	30	10.38	3.09

Source: Elaborated by the author, 2023. N: sample size; PA: physical activity.

Table 2 – Descriptive statistics (frequency) of the variables sex, family history of SAH, CO, high BP , and sex and age among those with SAH, João Pessoa, Paraíba, 2023

Sex	Frequency	Percentage (%)
Female	19	63.3
Male	11	36.7
Total	30	100.0
Family history of SAH	Frequency	Percentage (%)
Positive	10	33.3
Negative	20	66.7
Total	30	100.0
CO	Frequency	Percentage (%)
Obesity	25	83.6
Severe obesity	5	16.7
Total	30	100.0
Sex among individuals with SAH	Frequency	Percentage (%)
Female	4	66.7
Male	2	33.3
Total	6	100.0
Age of individuals with SAH	Hypertension	Age
Average	1.00	8.78
Median	1.00	8.04
High BP	Frequency	Percentage (%)
Yes	9	30.0
No	21	70.0
Total	30	100.0

Source: Elaborated by the author, 2023. CO: childhood obesity; BP: blood pressure; SAH: systemic arterial hypertension.

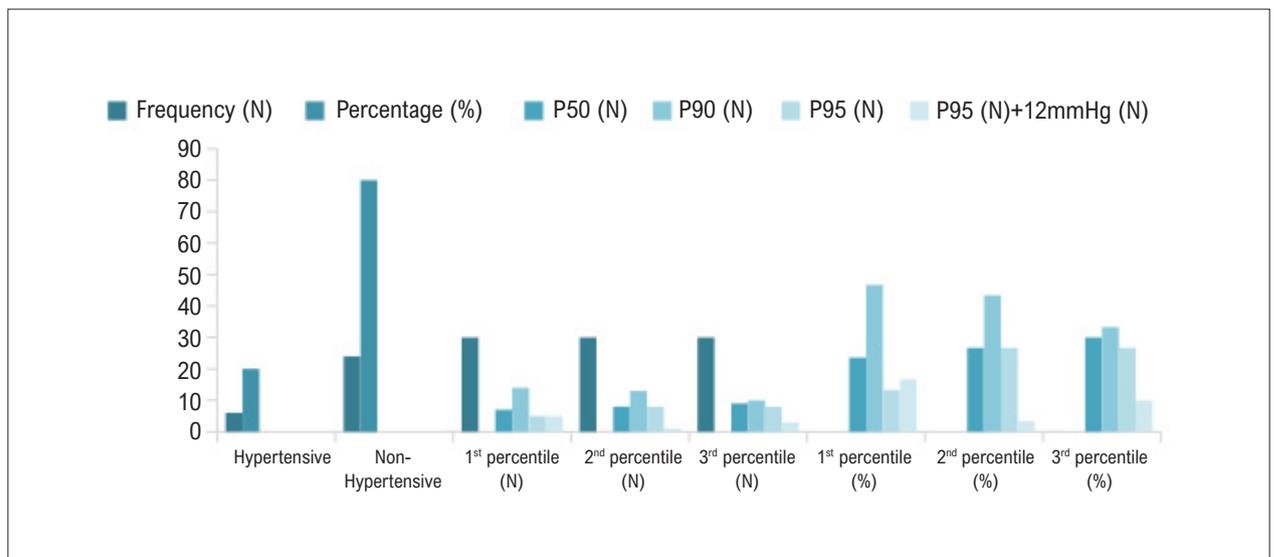


Figure 1 – Data from the first, second, and third BP measurements and descriptive statistics (frequency) of the SAH variable, João Pessoa, Paraíba, 2023. Source: Elaborated by the author, 2023. N: sample size.

Table 3 - Chi-square test for PA and SAH variables, João Pessoa, Paraíba, 2023

PA (Crosstab)	Hypertensive	Non-hypertensive	Total
0	2	10	12
30	0	1	1
60	1	2	3
90	1	0	1
100	0	1	1
120	1	3	4
160	0	1	1
180	1	1	2
240	0	1	1
300	0	1	1
400	0	1	1
480	0	2	2
Total	6	24	30
Chi-Square (X^2)	Value	Asymptotic Significance (two-sided)	
Pearson's X^2	7.604	0.748	
Number of valid cases	30	.	

Source: Elaborated by the author, 2023. PA: physical activity

Table 4 – Chi-square test between the AC and SAH variables, João Pessoa, Paraíba, 2023

Chi-Square (X^2)	Value	Asymptotic Significance (two-sided)
Pearson's X^2	2.283	0.131
Number of valid cases	30	.

Source: Elaborated by the author, 2023.

Fisher's Exact test analyzed the associations between SAH and CO and yielded a $p = 0.702$ (Table 5) that indicated non-significant relationships. Data regarding family history and the diagnosis of SAH were also described, and the X^2 test revealed a statistically significant association between these two variables ($p = 0.004$).

Table 6 shows the CO classification according to the BP percentile in the first measurement; no correlation was observed. Spearman's test also showed no correlation between the level of CO and BP percentile in the second measurement. Regarding the third BP measurement and CO classification, Spearman's test indicated a non-significant correlation.

Discussion

CO showed no significant correlation with SAH among children and adolescents in the study. However, 6 with SAH and 9 with increased BP were identified among the 30 individuals analyzed (Table 2), suggesting a possible relationship between obesity and elevated BP. The synergy

between obesity and SAH is still unknown,⁹ although these two conditions frequently coexist and are characterized by excessive inflammation and eventual heart dysfunction due to the formation of lesions and cardiac remodeling.¹⁰

Other variables were analyzed to investigate the possible associations with the diagnosis of SAH. Regarding PA and AC, no associations were found with SAH. On the other hand, the variable family history (first-degree relatives) of SAH presented a relationship similar to that described in the literature review by Meouchy, demonstrating the importance of genetic, epigenetic, and mitochondrial factors in the synergistic interaction between SAH and obesity.¹¹

In addition to the study by Meouchy, our results align with research that analyzed the incidence of SAH in children and adolescents according to four variables: biochemical profile, weight, cardiorespiratory fitness (CRFA), and the FTO gene polymorphisms rs9939609. In this study, even without an increase in BMI, AC, body fat percentage, glycemia, dyslipidemia, and CRFA, 12.8% of normotensive individuals developed borderline SAH, and

Table 5 – Fisher's Exact test for CO and SAH, and Chi-square results for family history and SAH, João Pessoa, Paraíba, 2023

CrossTab	Results	Variable		Total
		Hypertensive	Non-hypertensive	
CO	Obesity	5	20	25
	Severe obesity	1	4	5
	Total	6	24	30
Chi-Square (X^2)	Sig. Exact (one-sided)	.	.	.
Fisher's Exact test	0.702	.	.	.
Number of valid cases	30	.	.	.
CrossTab	Results	Variable		Total
		Hypertensive	Non-hypertensive	
Family history of SAH	Positive	5	5	10
	Negative	1	19	20
	Total	6	24	30
Chi-Square (X^2)	Value	Asymptotic Significance (two-sided)	.	.
Pearson's X^2	8.438	0.004	.	.
Number of valid cases	30	.	.	.

Source: Elaborated by the author, 2023. N: sample size; CO: childhood obesity; SAH: systemic arterial hypertension.

11.5% transitioned from normal values to SAH. Therefore, overweight and obese patients faced greater chances of evolving from normotensive to borderline SAH.¹² A similar result was observed in our study, in which nine were non-hypertensive obese patients with high BP. In cases of progression to SAH, no statistically significant results were found in overweight children, only in obese children and adolescents (OR: 4.84; 95% CI: 1.57 to 14.95; normotensive-hypertensive).

In 2022, a study analyzed the prevalence of comorbidities in CO and identified age, BMI, body composition, and puberty stage as risk factors related to the onset of the metabolic disorder. A total of 158 obese children, with a mean age of 12.48 and a Z-score of +3.24, were included in the study.¹³ The authors found an association between higher percentage of fat and male children as a risk factor for the comorbidities mentioned above. Compared with our results, the sample size and mean age of the sample were different, as indicated in Table 1, reinforcing the need for a larger sample.

In contrast, the case of a 7-year-old caucasian child with history of sedentary lifestyle and poor eating habits since the age of 3 was reported. The BMI of the patient was 31.4 kg/m², which was classified as higher than expected for females in the respective age group and based on the Z-score. An increase in BP levels above 95th percentile was also noted, and the diagnosis of SAH was confirmed. Therefore, SAH was reported together with severe obesity.¹⁴ However, the results of this study indicated that a sedentary lifestyle would not significantly contribute to the onset of SAH.

Notably, the associations observed were related to the sample of this study. Factors that limited the results and the small sample size included the exclusion criteria, the need for three measurements at different times, the short period of data collection, and the difficulty of accessing health services promptly to receive results. Although obesity is prevalent among people with higher socioeconomic statuses,¹⁵ the socioeconomic conditions were not addressed in this research because the municipal and state health units mainly serve individuals with lower socioeconomic statuses.¹⁶

Furthermore, a meta-analysis study that estimated the prevalence of CO in the various Brazilian regions showed higher rates in the South and Southeast due to better socioeconomic conditions and a greater number of health research initiatives, whereas the present study was conducted in the Northeast.¹⁷

Other barriers must also be considered, such as the inability of the study to control the quality of PA and the fact that BMI does not reproduce the body composition of individuals.

Therefore, the current study may serve as a pilot project for future researchers, who could incorporate additional variables and collect data at different moments to achieve a larger sample size and greater statistical significance and reliability.

Conclusions

The study demonstrated no relationship between CO and SAH for the evaluated sample. The methodology used

Table 6 – Data from Spearman’s correlation test for the BP percentiles and CO, João Pessoa, Paraíba, 2023

Correlation test	Variables	Results	BP percentile in the first measurement	CO
Spearman	BP percentile in the first measurement	Correlation coefficient	1.000	-0.138
		Sig. (two-sided)	.	0.468
		N	30	30
Spearman	CO	Correlation coefficient	-0.138	1.000
		Sig. (two-sided)	0.468	
		N	30	30
Correlation test	Variables	Results	BP percentile in the second measurement	CO
Spearman	CO	Correlation coefficient	1.000	0.022
		Sig. (two-sided)	-	0.908
		N	30	30
Spearman	BP percentile in the second measurement	Correlation coefficient	0.022	1.000
		Sig. (two-sided)	0.908	-
		N	30	30
Correlation test	Variables	Results	BP percentile in the third measurement	CO
Spearman	CO	Correlation coefficient	1.000	0.103
		Sig. (two-sided)	-	0.590
		N	30	30
Spearman	BP percentile in the third measurement	Correlation coefficient	0.103	1.000
		Sig. (two-sided)	0.590	-
		N	30	30

Source: Elaborated by the author, 2023. N: sample number. CO: childhood obesity; BP: blood pressure

facilitated an accurate evaluation of the analyzed variables and should serve as an example for future research proposals. Regarding patients diagnosed with SAH, the mean age was 8.78 years, with a prevalence of females. The family history variable suggested a relationship with SAH, indicating the need for further investigation in this area. PA time and AC measurement emerged as independent variables associated with SAH.

However, it is important to note that the results obtained involved a specific sample that was analyzed considering data regionalization and data collection times. Therefore, further studies with a larger sample size and extended outpatient follow-up are needed to confirm and clarify the effects of CO on the diagnosis of SAH in

children and adolescents, provide long-term prevention of cardiovascular pathologies, and emphasize the need for SAH screening in children.

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Author Contributions

Conception and design of the research: Almeida RFF, Escorel LM, Carvalho LOGA, Nóbrega PVN, Athayde DAM, Martins JL; acquisition of data: Almeida RFF, Escorel LM, Carvalho LOGA, Gaudêncio CB, Diniz LA, Leite M, Costa MR, Maia AB, Montenegro EMF; analysis and interpretation of the data: Almeida RFF, Escorel LM, Carvalho LOGA, Gaudêncio CB, Diniz LA, Santos BL, Nóbrega PVN; statistical analysis: Almeida RFF, Escorel LM, Carvalho LOGA, Santos BL, Aguiar MB, Nóbrega PVN; writing of the manuscript: Almeida RFF, Escorel LM, Carvalho LOGA, Gaudêncio CB, Diniz LA; critical revision of the manuscript for intellectual content: Almeida RFF, Escorel LM, Carvalho LOGA, Gaudêncio CB, Diniz LA, Santos BL, Nóbrega PVN, Athayde DAM, Martins JL.

Potential Conflict of Interest

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

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Study Association

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Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of the Centro Universitário de João Pessoa (UNIFE) under the protocol number 70443723.8.0000.5176. 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

The underlying content of the research text is contained within the manuscript.

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