Prevalence of elevated blood pressure in children and adolescents attending highschool

Prevalência de pressão arterial elevada em crianças e adolescentes do ensino fundamental

Prevalencia de presión arterial elevada en niños y adolescentes de la enseñanza fundamental

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ABSTRACT

Objective: To assess the prevalence of elevated blood pressure in schoolchildren and adolescents and the association of blood pressure with anthropometric measures.

Methods: This cross-sectional study, conducted in three schools in Botucatu, Brazil, collected blood pressure (BP) measurements taken at three different time points and anthropometric data: weight, height, body mass index (BMI), arm circumference, waist circumference, triceps and subscapular skinfolds. Blood pressure was measured using the auscultation method, and children were classified into two groups: pre-hypertension or hypertension for values between the 90th and 95th percentiles or above the 95th percentile. Data were compared according to sex using the Student's *t* test. The Pearson correlation coefficient was used to evaluate the association between blood pressure and anthropometric data. To evaluate blood pressure, the Z score according to BMI percentile categories, one-factor analysis of variance (ANOVA) and the Tukey post hoc test were used.

Results: This study evaluated 903 children and adolescents (51.7% boys) whose mean age was 9.3±2.5 years. The prevalence of pre-hypertension and hypertension was 9.1% and 2.9%. There was a positive correlation between both systolic and diastolic blood pressure and anthropometric variables, especially for weight (r=0.53 and r=0.45, $p<0.05$) and waist circumference (r=0.50 and r=0.38, $p<0.05$).

Conclusions: The prevalence of elevated blood pressure in this study was similar to what has been reported in international and national studies. A positive correlation with abnormal anthropometric measures was found. These results suggest that overweight affects blood pressure already in childhood.

Key-words: hypertension; pre-hypertension; child; adolescent; obesity.

RESUMO

Objetivo: Verificar a prevalência de pressão arterial elevada em crianças e adolescentes e sua associação com indicadores antropométricos.

Métodos: Estudo transversal de estudantes de três instituições de ensino em Botucatu (SP). As variáveis ava-

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liadas foram: pressão arterial (PA) (obtida em três ocasiões diferentes), peso, estatura, índice de massa corporal (IMC), circunferência braquial, circunferência abdominal (CA), dobras cutâneas tricipital e subescapular. A PA foi aferida por método auscultatório e classificada em pré-hipertensão (PH) e hipertensão arterial (HAS), para os valores entre os percentis 90 e 95 e maior que o percentil 95, respectivamente. Os dados antropométricos foram comparados, segundo o sexo, pelo teste *t* de Student. A correlação de Pearson foi utilizada para verificar a variação das PA sistólica (PAS) e diastólica (PAD) segundo dados antropométricos. A variação do escore Z da PA segundo percentil de IMC foi avaliada pela análise de variância seguida do teste de Tukey.

Resultados: Foram avaliadas 903 crianças (51,7% meninos), com idade de 9,3±2,5 anos para ambos os sexos. A prevalência de PH foi de 9,1% e de HAS foi de 2,9%. Houve correlação positiva significativa entre os níveis de PAS e PAD elevados e as variáveis antropométricas, com valores maiores para peso (r=0,53 e r=0,45, p<0,05, respectivamente) e CA (r=0,50 e r=0,38, p<0,05, respectivamente).

Conclusões: A prevalência de níveis pressóricos elevados nesta casuística foi compatível com outros estudos brasileiros e internacionais, correlacionando-se positivamente com indicadores antropométricos elevados, o que sinaliza a influência do excesso de peso na PA já na infância.

Palavras-chave: hipertensão; pré-hipertensão; criança; adolescente; obesidade.

RESUMEN

Objetivo: Verificar la prevalencia de presión arterial elevada en niños y adolescentes y su asociación con indicadores antropométricos.

Métodos: Estudio transversal incluyendo a estudiantes de tres instituciones de enseñanza de Botucatu (São Paulo, Brasil). Las variables evaluadas fueron: presión arterial (PA) (obtenida en tres ocasiones distintas), peso, estatura, índice de masa corporal (IMC), circunferencia braquial, circunferencia abdominal (CA), pliegues cutáneos tricipital y subescapular. La PA fue verificada por método auscultatorio, siendo posteriormente clasificada como pre-hipertensión (PH) e hipertensión arterial (HAS) para los valores entre los percentiles 90 y 95 y superior al percentil 95, respectivamente. Los datos antropométricos fueron comparados, conforme al sexo, por la prueba *t* de Student. La correlación de Pearson fue utilizada para verificar la variación de las PA sistólica (PAS) y diastólica (PAD) según datos antropométricos. La variación del escore Z de la PA según percentil de IMC fue evaluada por el análisis de variancia seguida por la prueba de Tukey.

Resultados: Se evaluaron 903 niños (51,7% niños), con edad de 9,3±2,5 años para ambos sexos. La prevalencia de PH fue de 9,1% y de HAS fue de 2,9%. Hubo correlación positiva significativa entre los niveles presóricos elevados (PAS/PAD ≥ percentil 90) y las variables antropométricas, con valores mayores para peso (r=0,53 y r=0,45, p<0,05, respectivamente) y CA (r=0,50 y r=0,38, p<0,05, respectivamente).

Conclusiones: La prevalencia de niveles presóricos elevados en esta casuística fue compatible con otros estudios brasileños e internacionales, correlacionándose positivamente con indicadores antropométricos elevados, lo que señaliza la influencia del exceso de peso en la PA ya en la infancia.

Palabras clave: hipertensión; pre-hipertensión; niño; adolescente; obesidad.

Introduction

Hypertension in childhood, as in adulthood, may be assigned to primary or secondary causes, but secondary causes are more common in pediatric populations. However, the growing prevalence of overweight among children and adolescents has contributed to an increase in the cases of primary hypertension in this age group[1]. Between 1988-1994 and 1999-2000, mean systolic and diastolic pressures of the pediatric population increased 1.4 mmHg and 3.3 mmHg in the United States, at the same time that overweight frequency increased from 28% to 31%[1]. Among Chinese and European children and adolescents, overweight prevalence is greater than 30%[2,3]. In the last 35 years, the prevalence of overweight among Brazilian children and adolescents tripled in a continuous increase, and now one third of the pediatric population is overweight[1,4].

High blood pressure (BP) increases the risks of heart disease and death due to ischemic cardiomyopathy among adults. High BP in childhood is a predictive factor of hypertension in adulthood, and its occurrence also depends on environmental factors, such as diet, physical activity and smoking[5]. Therefore, frequent BP measurements in pediatric clinical routine is necessary for the early detection of pre-hypertension and hypertension, and may enable the implementation of life style changes and treatment against hypertension[6].

Few Brazilian population studies have evaluated blood pressure values in childhood in different states. A Brazilian review of 11 national and international studies found 2% to 3% systemic hypertension among children and adolescents. However, those studies were conducted over 20 years ago, when the percentage of overweight children was also lower[7]. The authors stressed that BP in childhood is the best predictor of BP in adulthood currently available.

High blood pressure should be detected early in life, but few Brazilian studies have estimated its prevalence. This study investigated the prevalence of elevated BP among schoolchildren and adolescents (six to 14 years) and the association of BP levels with anthropometric indices.

Method

Three elementary schools (municipal, non-governmental, private) in Botucatu, Brazil, were chosen by convenience for this cross-sectional study, conducted from November 2006 to December 2007. The sample comprised boys and girls (n=903) attending the 1st to the 9th grade of elementary school in the morning or afternoon. Children younger than 6 years (n=21) and older than 14 years (n=13) were excluded because they represented a small group in comparison with the other age groups in the different grades. Children that were absent on the evaluation days and those that did not bring the informed consent term signed by their parents were also excluded. This study was approved by the Ethics in Research Committee of the School of Medicine of Botucatu, Universidade Estadual Paulista Júlio de Mesquita Filho (Unesp) under no. 579/2006.

Anthropometric data were weight, height, arm circumference, waist circumference and triceps and subscapular skinfolds, according to the World Health Organization norms[8] Weight was measured using an anthropometric platform scale (Filizola®) measuring weight up to 150kg to a precision 0.1kg. Schoolchildren were barefoot and wearing light clothes. Height was measured using a portable stadiometer (Seca®) to the nearest 0.1cm, and the value used in the study was the arithmetic mean of three consecutive measurements. The percentiles of height for age and body mass index (BMI) were also calculated according to the growth charts by the Centers for Disease Control and Prevention (CDC)[9]. Overweight was diagnosed when BMI was equal to or greater than the 85th percentile and lower than the 95th percentile, and obesity, for BMI equal to or greater than the 95th percentile[9].

Arm circumference was measured at the midpoint of the right upper arm, between the acromion and the olecranon process, and was used as reference to select cuff size. Waist circumference (WC) was measured at the midpoint between the lowest rib and the iliac crest, using an inelastic, non-stretch millimeter measuring tape (Sanny®) while the child was lying supine and after full expiration. Values equal to or greater than the 90th percentile were classified as elevated[10].

Triceps (TSF) and subscapular (SSSF) skinfolds were measured using a Lange® skinfold caliper. Both skinfolds were measured three times, and the final result was the arithmetic mean of the three measurements. TSF was measured at the midpoint of the right upper arm, between the acromion and the olecranon process, and the SSSF, two fingers below the inferior angle of the right scapula. The values described by Frisancho[11] for age and sex were used as reference.

BP was measured using the auscultation method. The child sat at rest for at least five minutes, and the cuff was placed around 80% of the arm circumference, at the level of the precordium. Three variable cuff sizes were used according to arm circumference: child (9cm long and arm circumference of 22 to 26cm), adolescent (10cm long and arm circumference of 26 to 34cm) and adult (13cm long and arm circumference of 34 to 44cm). Systolic BP (SBP) was determined at the appearance of the first Korotkoff sound (K1), and diastolic BP (DBP), at the 5th Korotkoff sound (K5). In children with audible sounds up to zero mmHg, the 4th Korotkoff (K4) sound was used to define DBP. BP was measured on three different days when the first measurement was equal to or greater than the 95th percentile for to sex, age or height percentile. Systemic hypertension was diagnosed when the mean value of three measurements was equal to or greater than the 95th percentile. Children and adolescents with BP values between the 90th and 95th percentile and adolescents with BP values equal to or greater than 120/80 mmHg were classified as having pre-hypertension. The procedures above followed the recommendations of the Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents[12].

Children and adolescents with BP values above the 95th percentile were referred to follow-up in the outpatient nephrology service of the Department of Pediatrics, School of Medicine of Botucatu, Unesp.

The software SPSS 17.0 was used for statistical analysis. First, the Kolmogorov-Smirnov test was used to test the normal distribution of data. Anthropometric and BP data were expressed as means, standard deviations and 95% confidence intervals (95% CI). The Student *t* test was used for comparisons of these variables according to sex. The variation of SBP and DBP according to anthropometric data was evaluated using the Pearson linear correlation coefficient. The SBP and DBP values in mmHg were transformed into Z scores using the means and standard deviations of the BP values of the pediatric population in the United States.[12] After that, the SBP and DBP values in Z scores were compared according to the BMI classification (percentiles) using one-way ANOVA followed by the Tukey test for multiple comparisons. The level of significance was set at 0.05.

Results

During the evaluation, 1018 children and adolescents were enrolled in the three schools included in the study. After the application of exclusion criteria, 903 children and adolescents (467 boys, 51.7%) were evaluated. Mean age was 9.3 years for both boys and girls. Of the 115 children and adolescents excluded from the study, 34 were not in the age group selected, and 81 did not hand in the signed parental consent form to participate in the study.

Mean values of anthropometric variables are shown in Table 1. Girls had significantly higher values than boys for triceps and subscapular skinfolds.

The prevalence of overweight was 15% (17.2% for girls and 13% for boys) and of obesity, 16.3% (14.6 for girls and 18% for boys). The analysis of other adiposity indices showed that 40.4% of the schoolchildren included in the study had a WC above reference values, and 21.3% and 14.5% had elevated TSF and SSSF values.

Table 2 shows the mean values and 95% CI of SBP and DBP according to age and sex. BP levels increased for both sexes as age increased, but not linearly.

Table 1 - Means, standard deviations and 95% confidence intervals of anthropometric data and blood pressure in children and adolescents

	Boys n	Mean±SD (95%CI)	Girls n	Mean±SD (95%CI)	*p*-value
Age (years)	467	9.3±2.5(9.1-9.5)	436	9.3±2.5(9.0-9.5)	0.724
Weight (kg)	467	37.1±14.4(35.8-38.4)	436	36.9±13.1(35.7-38.1)	0.879
Height (m)	467	1.4±0.2(-0.02-0.02)	436	1.4±0.1(-0.02-0.02)	0.943
BMI (kg/m²)	467	18.6±3.9(18.3-19.0)	436	18.7±3.7(18.4-19.1)	0.848
WC (cm)	467	64.2±10.6(63.2-65.1)	436	63.4±9.1(62.5-64.2)	0.250
AC (cm)	467	21.7±4.0(21.3-22.0)	436	21.9±3.8(21.5-22.2)	0.376
TSF (mm)	467	13.6±6.4(13.0-14.2)	436	15.7±6.0(15.2-16.3)	<0.001
SSSF (mm)	467	9.3±5.9(8.8-9.8)	436	10.9±5.9(10.3-11.4)	<0.001

SD: standard deviation; CI: confidence interval; BMI: body mass index; WC: waist circumference; AC: arm circumference; TSF: triceps skinfold; SSSF: subscapular skinfold

Table 2 - Means, standard deviations and 95% confidence intervals of systolic and diastolic blood pressure in children and adolescents according to age

Age	Boys	Mean±SD (95%CI)		Girls	Mean±SD (95%CI)	
(years)	n	SBP	DBP	n	SBP	DBP
6	60	98±8 (96-100)	62±8 (60-64)	61	94±9 (91-96)	61±6 (59-63)
7	68	97±9 (95-100)	63±7 (61-65)	66	96±10 (94-99)	62±7 (60-64)
8	64	101±7 (99-103)	63±6 (61-65)	50	101±10 (98-104)	65±8 (63-67)
9	65	98±10 (96-101)	64±8 (62-66)	80	98±9 (96-100)	64±7 (62-66)
10	73	97±10 (95-99)	61±9 (59-63)	46	97±8 (94-99)	60±7 (58-62)
11	50	101±11 (98-104)	62±7 (60-64)	47	99±8 (97-101)	61±8 (59-63)
12	22	99±11 (95-104)	63±6 (60-65)	30	102±10 (98-106)	67±9 (64-70)
13	28	102±15 (96-107)	65±9 (62-69)	24	106±12 (101-110)	66±9 (62-69)
14	37	105±12 (101-109)	66±11 (63-70)	32	104±11 (101-108)	65±10 (62-69)

SD: standard deviation CI: confidence interval SBP: systolic blood pressure; DBP: diastolic blood pressure

The percentage of students with elevated BP (BP≥ 90th percentile) was 12% (108 individuals) and, of these, 45% had elevated DBP, 29%, elevated SBP, and 26%, both SBP and DBP elevation. The analysis of only the first BP measurement (1st day) revealed that the percentage of children and adolescents with BP above the 95th percentile was 9.6%. This value fell to 3.2% when the individuals with BP above the 95th percentile were assessed two other times, on a total of three different measurement days. The diagnosis of pre-hypertension was made for 8.7% of the children. Changes in DBP, both in children with pre-hypertension and those with hypertension, was found in 49% of the cases. Pre-hypertension and hypertension was diagnosed primarily due to changes in DBP.

There was a positive correlation between anthropometric variables and SBP and DBP in children and adolescents with elevated BP levels (SBP/DBP≥90th percentile), mainly for body weight and waist circumference. Skinfolds had a low correlation both with SBP and DBP (Table 3).

To evaluate the variation of SBP and DBP in association with BMI, they were expressed as Z scores, according to the recommendations made in the Fourth Review of North American Data[12]. Because of the wide variation of age among the individuals included in the study, three age groups were analyzed (six to eight, nine to 11 and 12 to 14 years), to take into consideration, particularly, the effect of sexual maturation on BP data.

The behavior of SBP and DBP Z scores according to BMI classification differed between the age groups under analysis. For children six to eight years old, SBP and DBP Z scores were greater for normal-weight children than for overweight and obese children. For children six to eight years old, SBP and DBP Z scores were greater for obese children than for normal-weight children (Table 4).

Table 3 - Pearson correlation coefficient for anthropometric variables according to systolic and diastolic blood pressure of children with elevated blood pressure levels (≥90th percentile)

	Weight	BMI	WC	TSF	SSSF
SBP	0.53*	0.41*	0.50*	0.34*	0.41*
DBP	0.45*	0.32*	0.38*	0.25*	0.28*

SBP: systolic blood pressure; DBP: diastolic blood pressure; WC: waist circumference; BMI: body mass index; TSF: triceps skinfold; SSSF: subscapular skinfold. n=108. *$p<0.05$

Discussion

Mean BP values in this study were similar to those found in previous national and international studies, and there were no differences between sexes[13-15]. This type of data about blood pressure is not frequently found in Brazilian studies[13,16,17]. Mean BP levels were similar to those found for children living in Santos and Belo Horizonte, cities in two different Brazilian states. A study conducted by Bastos *et al*[16] in Botucatu, Brazil, 17 years ago found greater SBP and lower DBP values than those found in our study. However, they used the 4th Korotkoff sound for DBP, as recommended by a task force (1987) at the time of that study.

The difficulty in comparing BP levels in different national and international studies may be explained by the different age groups of children and adolescents under evaluation and, mainly, by the methods used to measure BP. Some of the method limitations seen in the studies that evaluate BP are: the number of times that BP is measured, as a single measurement increases prevalence in comparison with three

Table 4 - Means, standard deviations and 95% confidence intervals of Z scores of systolic and diastolic blood pressure according to percentile of body mass index

Age	BMI percentile	n	SBP Z score	DBP Z score
6 to 8 years (n=369)	<85%	237	0.04 (-0.07;0.14)*	0.44 (0.36;0.51)**
	85-95%	58	-0.38 (-0.66;-0.10)	0.28 (0.12;0.44)
	>95%	74	-0.18 (-0.35;-0.01)	0.17 (0.02;0.33)
9 to 11 years (n=361)	<85%	253	-0.56 (-0.67;-0.46)***	0.02 (-0.07;0.11)
	85-95%	57	-0.41 (-0.63;-0.18)	0.09 (-0.08;0.27)
	>95%	51	-0.14 (-0.41;0.12)	0.22 (0.04;0.39)
12 to 14 years (n=173)	<85%	133	-0.78 (-0.97;-0.60)***	0.01 (-0.13;0.14)**
	85-95%	18	-0.26 (-0.63;0.12)	0.34 (-0.02;0.69)
	>95%	22	0.15 (-0.28;0.57)	0.80 (0.45;1.14)

BMI: body mass index; DBP: diastolic blood pressure; SBP: systolic blood pressure; * difference of SBP Z scores between BMI<85th percentile and BMI between 85th and 95th percentile, $p<0.05$; ** difference of DBP Z scores between BMI<85th percentile and BMI>95th percentile, $p<0.05$; *** difference of SBP Z scores between BMI<85th percentile and BMI>95th percentile, $p<0.05$;

measurements; the type of device used (oscillometry may overestimate higher BP levels and underestimate lower BP levels); and the increase in mean height of children in the last decades, which may also have led to changes in the cut-off points for BP[18]. Another factor of variation between studies is the phase of Korotkoff sounds to define DBP: the Forth Task Force recommended the use of K5, whereas the Second Task Force (1987) advised the adoption of K4. These differences may lead to variations of up to 9.9 mmHg between two cut-off points[18]. Studies conducted before and after this latest classification are difficult to compare to each other.

One of the important aspects of our study was that three BP measurements were made at different time points when the first value was equal to or greater than the 95th percentile. Following this recommendation of the 4th Task Force[12] the diagnosis of hypertension was safely defined. The percentage of BP levels above the 95th percentile in the first measurement was three times greater than the mean of three measurements, a result that is similar to those reported in previous studies that measured BP on different days or at different times on the same day[13,14,18]. In epidemiological studies, BP is measured only once because of operational difficulties in returning to the study area to measure it one more time[18]. The reduction between the first and third measurements is assigned to the phenomenon of regression to the mean and to the fact that the child becomes used to the measurement procedure and is more relaxed.

The possible explanations for these frequent method variations between studies are the difficulties in establishing cut-off points for children that are associated with signs and symptoms of heart disease, such as in adults, and by the contemporary concern with the diagnosis of primary hypertension in childhood and adolescence[19]. The number of epidemiological studies that focus on primary hypertension in children and adolescents increased together with the progressive increase of overweight. In this study, one third of the children and adolescents had a diagnosis of overweight, similar to the result found in studies conducted in different Brazilian regions[14,20,21] and other places in the world[2,22].

Overweight may accelerate the appearance and exacerbate primary hypertension in children and adolescents with a family history of hypertension[23]. Reis *et al*[5] found that children of parents with hypertension had 15 times greater chances of having elevated BP. In addition to the possible polygenic nature of hypertension, environmental factors, such as inadequate diet and lack of physical activity, may affect BP levels[24].

In this study, the percentage of DBP changes was greater than those for SBP and correlated positively with anthropometric indices. Both SBP and DBP had a positive association with BMI, regardless of sex, age or height, similarly to findings in international studies[18] and in studies with adults[25]. Among individuals with pre-hypertension and hypertension, there was a positive correlation between anthropometric indices, particularly weight and waist circumference and SBP and DBP, as well as with previous studies[13,15,26]. In addition to weight increases, abdominal fat has also been classified as a risk factor for higher BP because it is associated with greater lipolytic activity, which, in turn, leads to insulin resistance and hyperactivity of the sympathetic nervous system and consequent elevation of BP levels[19].

SBP and DBP Z scores, according to BMI classifications, behaved differently among children aged six to eight or nine years or older. In children and adolescents nine to 14 years old, there was a significant progressive increase of SBP and DBP Z scores with BMI increases. However, for children younger than eight, SBP and DBP Z scores were greater for normal-weight children than for overweight and obese children. Based on these results, three possible hypotheses may be raised. The first is that the effect of the increase of body mass is lower in smaller children, but we are unaware of any confirmation of this hypothesis, which makes it less likely. The second is that there is a possible significant difference assigned to chance, as the SBP difference was found in the group of normal-weight and overweight children; if the effects were real, the differences should be even greater for obese children. The third hypothesis is that there might be a measurement bias in the younger group due to the difficulty in hearing the 5th Korotkoff sound precisely. In addition to overweight, two other factors may lead to BP elevations, such as uric acid levels, diet sodium and inflammation (increase of C-reactive protein or interleukins)[27].

The need to measure BP since childhood is justified by its associated consequences: elevated BP seems to be maintained along time together with growth (called tracking), which has been clearly demonstrated in classical longitudinal studies, such as those conducted by Bogalusa and Muscatine[28,29], and may lead to lesions in target organs, predominantly left ventricular hypertrophy and thickening of the coronary artery intima[28]. Differently from adults, for whom the cut-off points for the diagnosis of hypertension are based on well designed epidemiological studies and associated with coronary artery disease, the definition for children and adolescents is statistical, because it does not lead to clinical signs and symptoms of heart disease in childhood[30].

The measurement of BP is recommended as a clinical practice for patients as young as three years[12], and schools are an adequate place to measure and monitor BP. The evaluation of children with elevated BP levels but no symptoms is an excellent basis for the prevention and reduction of heart disease.

One of the limitations of this study is the fact that it did not evaluate other factors, in addition to anthropometric data, that contribute to changes in BP levels, such as family history of hypertension, ethnicity, birth weight, sedentary life style and eating habits, particularly sodium intake. The hypertensive effect of high sodium intake can be confirmed as early as in childhood, and both normal-weight and overweight children have been exposed to foods that have a high sodium content[31].

The selection of schools by convenience may have led to unimagined biases in this type of sample, and makes it impossible to extrapolate results of the prevalence of elevated BP for schoolchildren in Botucatu, Brazil. Another possible limitation is the difficulty to establish the causal direction of the association between overweight and elevated BP due to the study design (cross-sectional). Longitudinal studies are more adequate to establish this type of association and to detect factors that determine the elevation of BP. Studies with samples that represent national populations and that evaluate BP levels should be conducted to analyze trends of BP changes along time, as well as to identify risks or protective factors.

The prevalence of elevated BP was similar to that found in other national and international studies that also evaluated BP at different time points. Similarly to other data published, elevated BP levels were positively correlated with higher anthropometric indices. In the same ways as among adults, overweight was positively associated with a predominant elevation of DBP. Monitoring BP in schools is an important public health measure to screen and detect, at an early stage, children and adolescents with elevated BP, particularly those who are overweight.

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