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Blood pressure and BMI in adolescents in Aracaju, Brazil

Jorinde Polderman[1], Ricardo Queiroz Gurgel[2], José Augusto S Barreto-Filho[2], Rik Roelofs[1], Ricardo Emanoel de O Ramos[2], Jeroen S de Munter[1], Johannes F Wendte[1] and Charles Agyemang[1,*]

[1]Department of Public Health, Academic Medical Centre, University of Amsterdam, Meibergdreef 9, 1105 AZ Amsterdam, The Netherlands: [2]Department of Medicine and Post Graduate Nucleus of Medicine, Federal University of Sergipe, Aracaju, Brazil

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Abstract

Objective: To assess the prevalence of high blood pressure (BP) and the association of overweight and obesity with high BP among adolescents in Aracaju, Brazil.

Design: Cross-sectional study. The main outcome measure was the proportion of adolescents with high BP (sex-, age- and height-specific ≥95th percentile). The main predictor variables were overweight and obesity defined according to the criteria of the International Obesity Task Force. Other covariates included age, socio-economic status and leisure-time physical activity.

Setting: Aracaju, Brazil, capital city of Sergipe State, north-eastern Brazil.

Subjects: A random sample of 1002 adolescents (442 boys and 560 girls) aged 12–17 years selected from twenty public schools and ten private schools were studied.

Results: The prevalence of high BP was 16·9 % (95 % CI 13·1, 21·7) in boys and 12·9 % (95 % CI 9·0, 18·0) in girls. After adjusting for age, socio-economic status and leisure-time physical activity in both boys and girls, overweight (prevalence ratio (PR) = 1·93, 95 % CI 1·08, 3·48; PR = 4·34, 95 % CI 2·58, 7·30, respectively) and obesity (PR = 4·87, 95 % CI 2·35, 10·11; PR = 5·18, 95 % CI 2·67, 10·06, respectively) were found to be associated with high BP.

Conclusions: These findings indicate a high prevalence of high BP in both boys and girls in Aracaju, Brazil. Overweight and obesity were strongly associated with high BP. These findings underscore the urgent need for public health measures to prevent increasing high BP in adolescents in Brazil. Targeting intervention in adolescence may be a critical method for preventing high BP in later life.

Keyword
High blood pressure
Obesity
Adolescent
Brazil

Hypertension has been identified as one of the leading causes of CVD and premature mortality in the world[1,2]. In the past few decades, the prevalence of hypertension has increased dramatically worldwide[2–4]. In Brazil, for example, hypertension prevalence has increased substantially to as high as 33 % in Aracaju among adults aged ≥18 years[5,6]. The rising prevalence of hypertension in Brazil reflects well on the high prevalence of CVD. IHD (25 % of total deaths) and cerebrovascular diseases (34 %) are the leading causes of mortality in Brazil[7].

In children, blood pressure (BP) tracking patterns confirm that persistent BP increase may be related to hypertension in adulthood[8,9]. Increased BP in childhood has also been linked to left ventricular hypertrophy[10]. As a result, detection and management of high BP at an early age may be an important approach for limiting the disease burden ascribed to high BP[11].

The prevalence of high BP in children in Western countries ranges from 7 % to 19 % on the basis of measurements taken on one visit[12–14]. In contrast, few population-based studies have been conducted in children and adolescents in middle- and low-income countries[15–22]. Continuous assessment of high BP in children is relevant for health-care policy and prevention strategies.

Furthermore, childhood obesity has increased considerably over the past few decades. Many studies have shown that overweight and obesity are associated with BP in children and adolescents[2,3,23–25]. In the USA, for example, overweight children have been shown to be two to four times more likely than non-overweight children to have high BP[3]. However, information on the relationship between body size and high BP in children and adolescents in non-Western countries is limited. In addition, some studies suggest that BP levels in children

*Corresponding author: Email c.o.agyemang@amc.uva.nl

have recently increased in parallel to the obesity epidemic[2,26]. Other studies, by contrast, have shown that BP levels have decreased over time in spite of upward trends of obesity[27]. These findings suggest that the strength of the relationship between BP and body weight in children and adolescents may differ between populations in different settings.

In Brazil, information on high BP in adolescents is limited[20–22,28]. Evidence also suggests that overweight and obesity in children are becoming a major problem in Brazil. The prevalence of overweight and obesity in adolescents has increased dramatically from 4·0 % and 8·2 % in 1975 to 17·9 % and 15·4 % in 2003 in both boys and girls, respectively[29]. More recent studies show even higher prevalence rates of overweight and obesity ranging from 24·0 % in São Paulo to 36·9 % in Salvador, Bahia[20,30]. Despite the increasing prevalence of overweight and obesity, information on the relationship between body size and high BP in adolescents is limited in Brazil. Therefore, the main aim of the present study was to estimate the prevalence of high BP and the association of overweight and obesity with high BP among adolescents in Aracaju, Brazil.

Methods

Study area

The present study was carried out in Aracaju, the capital city of Sergipe State, Brazil. Aracaju is located in the northeastern part of Brazil, about 350 km north of Salvador. Aracaju has a population of about 544 039 inhabitants, which represents approximately 33 % of the state population. Sugar cane and petroleum extraction are its main economic activities. The majority of the population (about three-quarters) is of African descent and of mixed African and Portuguese descent.

Study design

Data were collected between February and May 2008 from healthy adolescents aged between 12 and 17 years from thirty different schools. The schools were randomly selected from all eighty-one schools (fifty public and thirty-one private schools) in the five districts of Aracaju. According to official statistics, the total number of adolescents (10–18 years of age) in Aracaju is 72 683. For each of the five districts, four public schools and two private schools were randomly selected. The selection of schools in this way allowed us to obtain representative samples of students from different school types and locality. In each school, we randomly selected fifty students among those aged 12–17 years. All the selected students were given an informed consent form to be signed by their parents. Of the 1500 students, 1016 returned the consent form (response rate: 67·7 %). The response rate was relatively similar in both public (68·0 %) and private (64·5 %) schools. The 12-year-olds had a lower response rate (57 %) than 13–17-year-olds, ranging from 60 % to 78 %. Fourteen adolescents were excluded from the study because they did not meet the age criterion. Ethical approval was obtained from the Research Ethics Committee of the Federal University of Sergipe, Brazil.

Physical measurements

All measurements were taken in a private room provided by the schools.

Main outcome measure

The main outcome measure was high BP, which was measured according to the European Society of Hypertension Guidelines[31]. BP was measured with a validated oscillometric automated digital BP device (Omron M-6; Omron Healthcare Europe BV, Hoofddorp, The Netherlands) by trained medical students from Aracaju (Brazil) and Amsterdam (The Netherlands). Using appropriate cuff sizes, three readings of 2 min intervals were taken on the right arm in a seated position after at least 5 min rest. The mean of the last two readings was used for analysis. Sex-, age- and height-specific percentile levels were defined using US normative BP tables for children and adolescents[11,32]. High BP was defined as systolic BP and/or diastolic BP ≥ 95th percentile[11].

Primary covariate

The main predictor variables were overweight and obesity. Height was measured without shoes with a measuring tape to the nearest 0·01 m. Weight was measured to the nearest 0·1 kg after removal of shoes, jackets, heavy clothing and pocket contents using a digital Seca scale. BMI was calculated as weight in kilograms divided by the square of height in metres (kg/m^2). Overweight and obesity were defined using the sex- and age-specific BMI criteria of the International Obesity Task Force[33].

Other covariates

In addition, participants were asked to complete a questionnaire including questions on age, sex and physical activity. Physical activity was based on the number of days per week engaged in leisure-time physical activity outside school. The type of school (private or public school) was used as proxy for socio-economic status. Public schools are free of charge, but private schools charge a tuition fee.

Data analysis

Cross-tabulations were analysed using the χ^2 test. Continuous outcome variables were analysed by independent samples t test. Linear regression analyses were used to assess the relationship between overweight and obesity and mean BP. Prevalence ratios (PR) of high BP and their 95 % CI were estimated by means of Poisson regression with robust variance to assess the relationship between overweight and obesity and high BP[34], adjusting for factors that are known to be associated with high BP in adolescents (age, socio-economic status and physical activity)[5,22]. The analyses were stratified by sex, because there was a significant interaction between sex and overweight and obesity. *P* values and 95 % CI were calculated with two-tailed tests with correction for the cluster design effect. All statistical analyses were performed using the STATA statistical software package version 11·0 (StataCorp., College Station, TX, USA).

Results

Characteristics of the study population

In Table 1, the characteristics of the study population are shown for boys and girls. Girls were shorter, lighter and had a somewhat higher BMI than boys. Boys were more physically active than girls.

Blood pressure levels and association of overweight and obesity with high blood pressure among Aracaju adolescents

The mean systolic BP was higher but diastolic BP was lower in boys than in girls. The prevalence of high BP was higher in boys than in girls, although the 95 % CI overlapped slightly.

Overweight and obese boys and girls had higher mean systolic and diastolic BP levels compared with their normal-weight peers (Table 2). The differences hardly changed after adjusting for type of school and leisure-time physical activity in linear regression models. These differences were observed at all ages for systolic BP (Fig. 1a, b) and diastolic BP (Fig. 2a, b) in both boys and girls, with the systolic BP differences being statistically significant for 14- and 17-year-old boys and for all age groups in girls.

Overweight and obese boys and girls had a higher prevalence of high BP compared with their normal-weight peers (Table 3). The differences persisted after adjustments for age, type of school and physical activity: overweight boys (PR = 1·93, 95 % CI 1·08, 3·48) and obese boys (PR = 4·87, 95 % CI 2·35, 10·11) were more likely than normal-weight boys to have high BP. Overweight girls (PR = 4·34, 95 % CI 2·58, 7·30) and obese girls (PR = 5·18, 95 % CI 2·67, 10·06) also had a higher PR of high BP compared with their normal-weight peers.

Discussion

Key findings

We found a high prevalence of high BP in both boys and girls. Overweight and obesity were strongly associated with high BP in both boys and girls.

Discussion of the key findings

Studies on high BP and association of overweight and obesity with high BP among adolescents are limited in Brazil[22–24]. In Guimarães *et al.*'s[20] study, the prevalence rates of high systolic BP and high diastolic BP were 20·4 % and 17·6 %, respectively, in Salvador[22]. However, high BP was defined as ≥90th percentile and the analyses were based on boys and girls combined. Guimarães *et al.*'s[20] study was also conducted in a middle-class neighbourhood in Salvador. Evidence suggests that BP increases with socio-economic status in Brazil[7,24], which may indicate that the results found by Guimarães *et al.*[20] may not represent the actual prevalence of high BP in children in urban Brazil. Data were collected in all socio-economic groups in our study and therefore give a better reflection of BP in adolescents in an urban setting in Brazil.

The other studies in Brazil were also based on children or younger adolescents and the results were also reported for boys and girls combined[21,24]. Rodrigues *et al.* studied 10–14-year-olds in Victoria, Espirito Santo[21], and reported a 3·4 % rate of high BP among boys and girls combined. Costanzi *et al.*[22] also studied children aged 7–12 years in Caxias do Sul, State of Rio Grande do Sul, and the rate of

Table 1 Characteristics of the study population of Aracaju adolescents by sex

	Boys (*n* 442)		Girls (*n* 560)		
Characteristic	Mean or %	95 % CI	Mean or %	95 % CI	*P* value
Age (years)	14·2	13·8, 14·5	14·1	13·8, 14·3	0·292
Number of adolescents attending private school (%)	33·3	17·6, 53·7	32·9	17·7, 52·8	0·906
Leisure-time physical activity (d/week)*	3·1	2·8, 3·3	1·8	1·5, 2·0	<0·001
Weight (kg)	54·6	51·8, 57·4	51·1	49·9, 52·3	0·004
Height (cm)	164·5	162·1, 166·8	158·0	157·1, 158·9	<0·001
BMI (kg/m^2)	19·9	19·3, 20·3	20·4	20·0, 20·7	0·058
Overweight (%)	12·9	9·7, 16·1	14·3	11·6, 17·6	0·553
Obesity (%)	3·6	2·1, 6·1	3·8	2·6, 5·4	0·890
Systolic BP (mmHg)	116·9	115·0, 118·8	112·6	111·1, 114·2	0·001
Diastolic BP (mmHg)	65·6	64·3, 66·8	68·9	65·5, 72·3	0·017
High BP (%)†	16·9	13·1, 21·7	12·9	9·0, 18·0	0·105

BP, blood pressure.
*Leisure-time physical activity was defined as days per week the participant was physically active outside school.
†High BP is defined as ≥95th percentile.

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Table 2 Mean and regression coefficient of systolic and diastolic BP by body size among Aracaju adolescents by sex

		Mean and regression coefficient of systolic BP									Mean and regression coefficient of diastolic BP							
				Model 1		Model 2		Model 3				Model 1		Model 2		Model 3	
	n	Mean	95 % CI	β	95 % CI	β	95 % CI	β	95 % CI	Mean	95 % CI	β	95 % CI	β	95 % CI	β	95 % CI
Boys																	
Normal weight	371	115·5	113·5, 117·5		Ref.		Ref.		Ref.	65·1	63·7, 66·4		Ref.		Ref.		Ref.
Overweight	55	120·9	118·3, 123·5	5·43	1·60, 9·26	5·03	1·13, 8·93	4·69	0·69, 8·70	67·2	65·2, 69·1	2·09	−0·06, 4·26	2·11	−0·13, 4·36	1·91	−0·47, 4·29
Obese	16	133·9	125·8, 142·0	16·58	9·39, 23·77	15·79	8·56, 23·03	16·21	8·78, 23·63	72·0	66·9, 77·2	6·49	0·95, 12·02	6·66	0·97, 12·34	6·65	0·80, 12·5
Girls																	
Normal weight	460	111·0	109·3, 112·6		Ref.		Ref.		Ref.	66·0	64·5, 67·4		Ref.		Ref.		Ref.
Overweight	77	121·1	118·5, 123·6	10·01	8·01, 12·75	10·38	7·89, 12·86	10·38	7·92, 12·85	71·5	69·7, 73·3	5·52	3·80, 7·25	5·63	4·00, 7·27	5·75	3·99, 7·51
Obese	22	120·9	115·3, 126·5	9·94	4·49, 15·39	10·45	4·71, 16·19	10·68	5·07, 16·28	70·7	67·6, 73·7	4·71	1·44, 7·97	4·86	1·59, 8·13	5·02	1·88, 8·16

BP, blood pressure; Ref., reference category.
Model 1, adjusted for age; model 2, plus type of school; model 3, plus physical activity.

high BP (8·4 %) was also based on boys and girls combined. Our findings suggest important difference in BP between boys and girls. The prevalence rates found among adolescents in our study are relatively high compared with the rates found among younger age groups in Brazil. This indicates that high BP increases sharply with age and highlights the need for early intervention among children in Brazil.

The prevalence of high BP in our study is similar to the prevalence found among similar age groups (14–17 years) in Suriname, South America. In the Suriname study, the prevalence of high BP ranged from 9·7 % in Maroon boys to 18·8 % in mixed race boys, and from 3·5 % in Hindustani girls to 12·0 % in mixed race girls[35]. The mean systolic BP among Aracaju adolescent boys (116·9 mmHg) was somewhat similar to that of Surinamese adolescent boys, except for Maroon boys (112·5 mmHg) and Hindustani boys (114·2 mmHg). The mean systolic BP was, however, higher in Aracaju girls (112·6 mmHg) than in girls in Suriname in all ethnic groups, ranging from 104·5 mmHg in Hindustani girls to 107·9 mmHg in Creole girls[35].

BP and obesity are strongly related[2,3,23–25]. Our present findings are in agreement with previous findings in Brazil[20–22,36]. Although the mechanisms by which overweight and obesity may lead to high BP are not well elucidated, it is now generally recognised that overweight and obesity increase the risk of high BP[37]. Sinaiko *et al.*'s[37] prospective study showed that increases in BMI in early life were significantly related to an increased risk of high BP and other CVD in adulthood. Our findings clearly indicate the need to prevent the increasing prevalence of overweight and obesity early in life to prevent future sequelae of overweight- and obesity-related diseases.

Several studies in children showed that weight loss results in a reduction of BP[23]. The recommended intervention strategy is a hypoenergetic diet plus physical activity[38]. Increasing physical activity level in adolescents can be a low-cost intervention to prevent high BP. The physical activity level among adolescents in our study was relatively low. The international guideline for physical activity for children under 18 years of age recommends exercise of moderate intensity for at least 1 h/d[7]. The average leisure-time physical activity was 3 d/week for boys and 2 d/week for girls in our study population, which is far less than the international guideline. The physical activity patterns were relatively low in normal-weight, overweight and obese individuals, with only small differences between the groups. This may explain why the result remained the same after adjustment for physical activity in the multivariate analyses. Similar low prevalence of physical activity has also been reported in other parts of Brazil. In a study in Maceio, Alagoas, the prevalence of a sedentary lifestyle, defined as no moderate-to-intense physical activity, was 93·5 % in 7–17-year-olds[39]. These findings clearly suggest that effective measures are urgently needed to increase physical activity level among adolescents in urban Brazil.

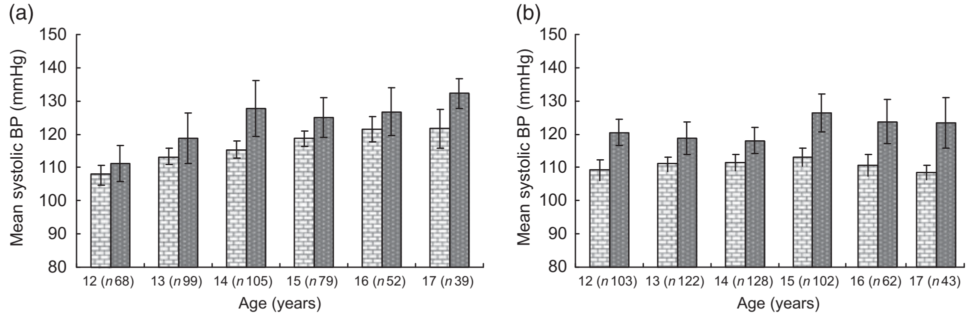

Fig. 1 Mean systolic blood pressure by BMI category and age in boys (a) and girls (b); ▤, normal weight; ■, overweight/obese

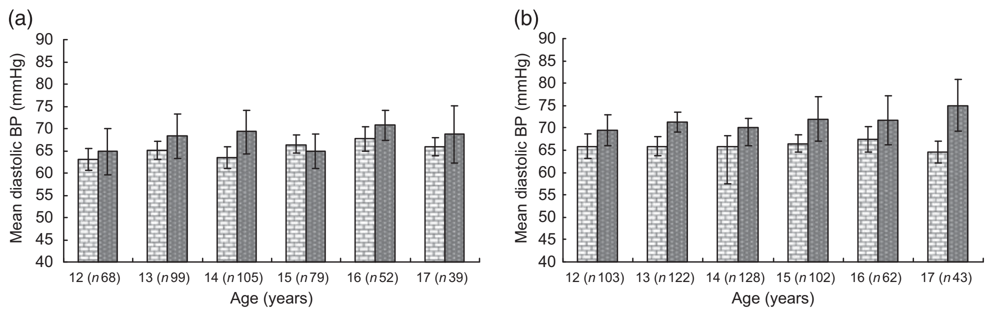

Fig. 2 Mean diastolic blood pressure by BMI category and age in boys (a) and girls (b); ▤, normal weight; ■, overweight/obese

Table 3 Adjusted PR of high BP with corresponding 95 % CI by body size and sex among Aracaju adolescents

			Model 1		Model 2		Model 3	
	n	%	PR	95 % CI	PR	95 % CI	PR	95 % CI
Boys								
Normal weight	371	14·8	1·00	Ref.	1·00	Ref.	1·00	Ref.
Overweight	55	28·2	1·80	1·02, 3·18	1·96	1·10, 3·50	1·93	1·08, 3·48
Obese	16	56·2	3·54	2·03, 6·15	4·42	2·15, 9·09	4·87	2·35, 10·11
Girls								
Normal weight	460	8·5	1·00	Ref.	1·00	Ref.	1·00	Ref.
Overweight	77	33·6	4·06	2·40, 6·86	4·27	2·52, 7·26	4·34	2·58, 7·30
Obese	22	38·1	4·49	2·49, 8·09	5·33	2·90, 9·82	5·18	2·67, 10·06

PR, prevalence ratios; BP, blood pressure; Ref., reference category.
Model 1, adjusted for age; model 2, plus type of school; model 3, plus physical activity.

Limitations

Our study has limitations. As in many epidemiological studies, our BP level was based on an average of three measurements at a single visit. A more precise estimate of BP level would be obtained by multiple measurements obtained during several visits[11]. The physical activity levels were based on only leisure-time exercise, and was self-reported, which may be subjected to response bias. We had no information on other important factors that are known to influence high BP, such as dietary behaviour, which may also affect our study conclusions. Also the non-response rate was high, particularly in the 12-year-olds (43 %). It is possible that the health of the respondents and non-respondents may differ, which may affect our study conclusions. Nevertheless, the non-response rates were similar in both public (32·0 %) and private (33·6 %) schools. In addition, we corrected for the cluster design effect in the analyses. Furthermore, the distribution of boys and girls in our study is consistent with Aracaju's young population (male/female ratio: 47:53)[40]. Finally, our sample was based on Aracaju and its surroundings and therefore the findings may not be representative of other parts of Brazil. Despite these limitations, our present findings provide very important information on the relationship between overweight and obesity and BP among adolescents in Brazil.

In conclusion, our results show a high prevalence of high BP among this population in Brazil. Overweight and obesity were strongly associated with high BP in both boys and girls. Prevention strategies are needed in Brazil to prevent the future burden of hypertension and reduce pressure on the public health-care system. BP reductions in adolescents can be achieved by weight loss through reducing excessive energy intake[41] and increasing physical activity strategies[42]. These cost-effective measures may lead to a significant reduction in BP in adolescents, thereby sparing the next generation from high BP-related complications.

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References

1. Murray CJ & Lopez AD (1997) Mortality by cause for eight regions of the world: global burden of disease study. *Lancet* **349**, 1269–1276.
2. Muntner P, He J, Cutler JA *et al.* (2004) Trends in blood pressure among children and adolescents. *JAMA* **291**, 2107–2113.
3. Falkner B, Gidding SS, Ramirez-Garnica G *et al.* (2006) The relationship of body mass index and blood pressure in primary care pediatric patients. *J Pediatr* **148**, 195–200.
4. Chobanian AV, Bakris GL, Black HR *et al.* (2003) Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. *Hypertension* **42**, 1206–1252.
5. Ala L, Gill G, Gurgel R *et al.* (2004) Evidence for affluence-related hypertension in urban Brazil. *J Hum Hypertens* **18**, 775–779.
6. Ordunez P, Silva LC, Rodriguez MP *et al.* (2001) Prevalence estimates for hypertension in Latin America and the Caribbean: are they useful for surveillance? Pan. *Am J Public Health* **10**, 226–231.
7. World Health Organization (2008) World health statistics. http://www.who.int/countries/bra/en/ (accessed February 2009).
8. Bao W, Threefoot SA, Srinivasan SR *et al.* (1995) Essential hypertension predicted by tracking of elevated blood pressure from childhood to adulthood: The Bogalusa Heart Study. *Am J Hypertens* **8**, 657–665.
9. Lauer RM & Clarke WR (1989) Childhood risk factors for high adult blood pressure: The Muscatine Study. *Pediatrics* **84**, 633–641.
10. Daniels SR, Loggie JM, Khoury P *et al.* (1998) Left ventricular geometry and severe left ventricular hypertrophy in children and adolescents with essential hypertension. *Circulation* **97**, 1907–1911.
11. National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents (2004) The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. *Pediatrics* **114**, Suppl. 2, 555–576.
12. Sorof JM, Lai D, Turner J *et al.* (2004) Overweight, ethnicity, and the prevalence of hypertension in school-aged children. *Pediatrics* **113**, 475–482.
13. Paradis G, Lambert M, O'Loughlin J *et al.* (2004) Blood pressure and adiposity in children and adolescents. *Circulation* **110**, 1832–1838.
14. Genovesi S, Giussani M, Pieruzzi F *et al.* (2005) Results of blood pressure screening in a population of school-aged children in the province of Milan: role of overweight. *J Hypertens* **23**, 493–497.
15. Jafar TH, Islam M, Poulter N *et al.* (2005) Children in South Asia have higher body mass-adjusted blood pressure levels than white children in the United States: a comparative study. *Circulation* **111**, 1291–1297.
16. Proctor MH, Moore LL, Singer MR *et al.* (1996) Risk profiles for noncommunicable diseases in rural and urban schoolchildren in the Republic of Cameroon. *Ethn Dis* **6**, 235–243.
17. Agyemang C, Redekop WK, Owusu-Dabo E *et al.* (2005) Blood pressure patterns in rural, semi-urban and urban children in the Ashanti region of Ghana, West Africa. *BMC Public Health* **5**, 114.
18. Monyeki KD, Kemper HC & Makgae PJ (2006) The association of fat patterning with blood pressure in rural South African children: The Ellisras Longitudinal Growth and Health Study. *Int J Epidemiol* **35**, 114–120.
19. Chiolero A, Madeleine G, Gabriel A *et al.* (2007) Prevalence of elevated blood pressure and association with overweight in children of a rapidly developing country. *J Hum Hypertens* **21**, 120–127.
20. Guimarães IC, de Almeida AM, Santos AS *et al.* (2008) Blood pressure: effect of body mass index and of waist circumference on adolescents. *Arq Bras Cardiol* **90**, 393–399.
21. Rodrigues AN, Moyses MR, Bissoli NS *et al.* (2006) Cardiovascular risk factors in a population of Brazilian schoolchildren. *Braz J Med Biol Res* **39**, 1637–1642.
22. Costanzi CB, Halpern R, Rech RR *et al.* (2009) Associated factors in high blood pressure among schoolchildren in a middle size city, southern Brazil. *J Pediatr (Rio J)* **85**, 335–340.
23. Torrance B, McGuire KA, Lewanczuk R *et al.* (2007) Overweight, physical activity and high blood pressure in children: a review of the literature. *Vasc Health Risk Manag* **3**, 139–149.
24. Aristimuño GG, Foster TA, Voors AW *et al.* (1984) Influence of persistent obesity in children on cardiovascular risk factors: The Bogalusa Heart Study. *Circulation* **69**, 895–904.
25. Weiss R, Dziura J, Burgert TS *et al.* (2004) Obesity and the metabolic syndrome in children and adolescents. *N Engl J Med* **350**, 2362–2374.
26. Ford ES, Mokdad AH & Ajani UA (2004) Trends in risk factors for cardiovascular disease among children and adolescents in the United States. *Pediatrics* **114**, 1534–1544.
27. Watkins D, McCarron P, Murray L *et al.* (2004) Trends in blood pressure over 10 years in adolescents: analyses of cross sectional surveys in the Northern Ireland Young Hearts project. *BMJ* **329**, 139.
28. Mendonça da Silva MA, Romero Rivera I, Goretti Barbosa de Souza M *et al.* (2007) Blood pressure measurement in children and adolescents: guidelines of high blood pressure recommendations and current clinical practice. *Arq Bras Cardiol* **88**, 491–495.
29. Brazilian Institute of Geography and Statistics (2006) *Family Budget Survey 2002–2003. Athropometric and Nutritional Status Analysis in Brazil.* Rio de Janeiro: IBGE.
30. Nobre MR, Domingues RZ, da Silva AR *et al.* (2006) Prevalence of overweight, obesity and life style associated with cardiovascular risk among middle school students. *Rev Assoc Med Bras* **52**, 118–124.

31. Parati G, Stergiou GS, Asmar R *et al.* (2008) ESH Working Group on Blood Pressure Monitoring. European Society of Hypertension guidelines for blood pressure monitoring at home: a summary report of the Second International Consensus Conference on Home Blood Pressure Monitoring. *J Hypertens* **26**, 1505–1526.
32. Centers for Disease Control and Prevention (2000) CDC clinical growth charts. http://www.cdc.gov/growthcharts/ (accessed December 2008).
33. Cole TJ, Bellizzi MC, Flegal KM *et al.* (2000) Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* **320**, 1240–1243.
34. Barros AJ & Hirakata VN (2003) Alternatives for logistic regression in cross-sectional studies: an empirical comparison of models that directly estimate the prevalence ratio. *BMC Med Res Methodol* **3**, 21.
35. Agyemang C, Oudeman E, Zijlmans W *et al.* (2009) Blood pressure and body mass index in an ethnically diverse sample of adolescents in Paramaribo, Suriname. *BMC Cardiovasc Disord* **9**, 19.
36. Campana EM, Brandao AA, Pozzan R *et al.* (2009) Blood pressure in young individuals as a cardiovascular risk marker. The Rio de Janeiro Study. *Arq Bras Cardiol* **93**, 608–615.
37. Sinaiko AR, Donahue RP, Jacobs DR Jr *et al.* (1999) Relation of weight and rate of increase in weight during childhood and adolescence to body size, blood pressure, fasting insulin, and lipids in young adults. The Minneapolis Children's Blood Pressure Study. *Circulation* **99**, 1471–1476.
38. Ribeiro MM, Silva AG, Santos NS *et al.* (2005) Diet and exercise training restore blood pressure and vasodilatory responses during physiological maneuvers in obese children. *Circulation* **111**, 1915–1923.
39. Silva MA, Rivera IR, Ferraz MR *et al.* (2005) Prevalence of cardiovascular risk factors in child and adolescent students in the city of Maceió. *Arq Bras Cardiol* **84**, 387–392.
40. Abdelgalil S, Gurgel RG, Theobald S *et al.* (2004) Household and family characteristics of street children in Aracaju, Brazil. *Arch Dis Child* **89**, 817–820.
41. Gallist S, Sudi KM, Aigner R *et al.* (2001) Changes in serum interleukin-6 concentrations in obese children and adolescents during a weight reduction program. *Int J Obes Relat Metab Disord* **25**, 1640–1643.
42. Rocchini A, Katch V, Anderson J *et al.* (1988) Blood pressure in obese adolescents: effect of weight loss. *Pediatrics* **82**, 16–23.