Prevalence and Determinants of Hypertension in Apparently Healthy Schoolchildren in India: A multi-center study

Rajiv Narang, Anita Saxena, Ankush Desai, Sivasubramanian Ramakrishnan, Rajendra Singh Thangjam, Snehal Kulkarni, Kedareshwar Narvencar, Ana Karina Jacques' e Costa, Amit Dias, Ritesh Sukharamwala, John Cleland

(*: corresponding author)

Corresponding Author:

Anita Saxena, M.D. and D.M.,

Department of Cardiology,

All India Institute of Medical Sciences,

New Delhi, INDIA

Email: anitasaxena@hotmail.com

Tel: +91 11 2659 4861

Running title: Hypertension in Indian Children

Keywords: Hypertension, Children, Blood pressure, Epidemiology

Abstract

Background: Hypertension (HT) in children is often under recognized, especially in developing countries. Data from rural areas of developing countries is particularly lacking.

Objectives: To study prevalence of HT and its determinants in apparently health school children from predominantly rural populations of India.

Methods: Apparently healthy schoolchildren (N=14,957) aged 5 to 15 years (mean(SD) age 10.8(2.8) years; 55.5% boys) at 4 predominantly rural sites in separate states of India were studied. Systolic and diastolic blood pressures were recorded by trained staff in addition to age, gender, height, weight, type of school and season. Waist circumference was also recorded in 12,068 children. Geographic location and type of school (government, government-aided or private) were used to determine socio-economic status (SES).

Results: Systolic and/or diastolic HT was present in 3443 (23%) children. Systolic HT was present in 13.6%, diastolic HT in 15.3% and both in 5.9%. Isolated systolic HT was present in 7.7% while isolated diastolic HT was present in 9.4%.

On univariate analysis, age, gender, geographical location, SES, season and anthropometric parameters (z-scores of height, weight and waist circumference, waist/height ratio and body mass index) were all significantly related to risk of HT ($P<0.0001$ for each). Similar association was observed with weight group (normal, overweight and obese). Multiple regression analysis showed lower age, female gender, richer socio-economic status, certain geographical locations, higher weight and larger waist circumference to be independently associated with a greater risk of HT.

Conclusion: There is a high prevalence of hypertension in apparently healthy schoolchildren even in predominantly rural areas of India. Screening and management programs targeted to high risk groups identified may prove cost-effective.

Introduction

There is increasing interest in blood pressure (BP) and hypertension (HT) in children(1–3). HT in children has been shown to be associated with HT in adulthood and with cardiovascular risk in later life(4–8). The adverse effects are shown to increase in the presence of obesity, of which the world is currently witnessing an epidemic(9). The recording of BP has also become easier with widespread availability of reliable oscillometric (digital) BP recording instruments. These can be used by paramedical and even lay people, including parents, to record BP at home or at school.

There is also increasing interest in regional variation in BP and in prevalence of HT since reports from different parts of world have shown wide variation(10–13). Pattern may be different in developing countries since obesity is less of a problem there as compared to western world. Moreover, children from rural areas are less well studied than their urban counterparts. It will also be important to determine prevalence of HT in undernourished (rather than overnourished obese) children. We report here the prevalence and factors determining HT in schoolchildren in 4 predominantly rural areas located in different parts of India.

Methods

This cross-sectional epidemiological study was conducted in primary and secondary schools in 4 states of India (Haryana, Goa, Gujarat and Manipur) as part of a rheumatic heart disease screening program. Details of the method of the study are already published(14). Informed consent was taken from the School Principal as well as parents for the project. Study was approved by institutional ethics committees at all sites. Children with known major hepatic, renal, cardiac or respiratory diseases were excluded. No child was excluded based on BP reading. For the current analysis, apparently healthy school-children with completed age of 5-15 years age were included (N=14957). Children were screened by clinical examination and echocardiography and those found to have significant heart disease were excluded.

During the survey, trained paramedical staff documented demographic and anthropometric data, including height, weight and waist circumference. Waist circumference was recorded in 12068 of total 14957 children (it was not recorded at one site). Children sat and rested for 5 minutes before measurement of BP. BP was measured in sitting position by trained medical attendants. It was measured using oscillometric instrument in Haryana (Omron HEM 7080) and Gujarat, anaeroid instrument in Manipur and mercury sphygmomanometer [Diamond(R)] at Goa. The digital and aneroid instruments were calibrated against mercury sphygmomanometer. Children with high BP reading underwent repeat BP measurements by research physicians after an interval of about 5 minutes and the second reading was taken as the final one. All children with BP values normal for their age did not have a repeat BP check. Two cuff sizes were used in this study according to the growth of the child. No child was excluded based on BP reading.

Socioeconomic status ("richer", "poorer" or "mixed") was assigned to each school depending on type of school and development of the area where the school was located. This socioeconomic status (SES) was applied to all participating children of that school. Season when BP was measured was taken to be ‘summer’ for April to September months and ‘winter’ for other months. HT was defined as given by the Fourth Report using BP according to age and gender tables but with 50th centile for height taken for all children[7],[12]. We have earlier reported simplified percentile tables and charts derived from BP of 7761 children from one of these site (Haryana)[11].

Statistical analysis:

Data is presented as mean(SD) unless specified otherwise. Ninety-five percent confidence intervals were calculated whenever appropriate. The z-scores were used for anthropometric parameters (height, weight and waist circumference) as standardized values (using age, gender and site).

For univariate analysis, Student’s t-test was used for comparison of continuous variables and Chi-square test was used to compare categorical variables between hypertensive and non-hypertensive children. Multiple logistic regression analysis was performed to identify independent predictors of HT. For this purpose, weight, height were divided by 10 get odds ratio for every 10 unit change rather than 1 unit change. Similarly, waist circumference was divided by 5 for multiple regression. Children were divided into weight categories of normal, overweight and obese. Overweight was defined as weight in 85th to 95th percentile, while obesity was defined as weight greater than 95th percentile for age and gender of the child. Graphs of prevalence of hypertension versus continuous variables like age were plotted using LOESS Curve Fitting (Local Polynomial Regression) technique. The shaded areas indicate 95% confidence intervals unless stated otherwise. P values <0.05 were considered to be statistically significant. All statistical analyses were done using R verson 3.3.3.

Results

Table 1 shows age and gender distribution of children included in the study. Mean(SD) age was 10.8(2.8) years and 55.5% were males. The mean(SD) height was 136.7(16.6) cm, weight was 31.5(11.8) kg, waist circumference was 55.0(9.8) cm and BMI was 16.3(3.1) kg/m2.

Number(proportion) of children studied at 4 sites, i.e. Gujarat, Goa, Haryana and Manipur, were 2324(15.5%), 1939(12.9%), 7761(51.9%) and 2933(19.6%), respectively. The SES was "richer" for 47.6%, "poorer" for 39.4% and "mixed" for 13% children. Baseline characteristics are summarized in Table 2.

Prevalence of different types of hypertension: The overall prevalence of HT (systolic, diastolic or both) was 23%. Systolic HT was present in 13.6%, diastolic HT in 15.3% and both systolic and diastolic HT was present in 5.9% children. Isolated systolic HT was present in 7.7% while isolated diastolic HT was present in 9.4% (Table 2).

Univariate analysis:

Geographic location vs prevalence of HT: The prevalence was 9.9%, 13.6%, 26.5% and 29.9% at 4 sites of Goa, Gujarat, Haryana and Manipur, respectively ($P<0.0001$). The prevalence was much higher at 2 northern sites than the southern sites which are also closer to the ocean (see map in Figure 1).

Prevalence of HT vs age and gender: Overall prevalence of HT in boys was 20.2% and that in girls was 26.5% ($P<0.0001$). Figure 2A shows the relation of prevalence of HT with age in boys and girls. Prevalence of HT was seen to decline with age, especially in boys. From age of 5 to 15 years, prevalence of HT reduced from 33% to 16.3% in boys and from 30.1% to 23% in girls.

Anthropometric Parameters versus prevalence of HT: prevalence of HT was found to be positively related to z-scores of height, weight and waist ($P<0.0001$ for each). There was also a positive relation with waist-height ratio ($P<0.0001$) and body mass index ($P<0.0001$). Relation with various anthropometric parameters in boys and girls are shown in Figure 3. Waist z-score and waist height ratio have most linear relation with prevalence of HT.

Prevalence of HT in normal, overweight and obese children was 20.7%, 32.6% and 42%, respectively ($P=0.0001$) . Figure 2B shows prevalence of HT at different ages in obese and overweight children as compared with the rest. Risk was found to be highest in obese but there was considerable overlap with overweight children.

Socio-economic factors versus prevalence of HT: Analyzing for socio-economic status, prevalence of HT was 29.9%, 19% and 9.9% in richer, poorer and mixed groups, respectively ($P<0.0001$). Figure 2C shows prevalence of HT in each of these three groups to be consistently different at most ages.

Season versus prevalence of HT: The prevalence of HT was higher (29.4%) in group whose BP was measured in winter (October to March) as compared with those where it was measured in summer (April to September) months (18.7%; $P<0.0001$). Figure 2D shows prevalence of HT to start rising at end of summer, reaching a peak in first 2 months of the year, with a smaller rise during peak of summer as well. This pattern is seen in both boys and girls.

Multiple regression analysis:

Since waist circumference was not recorded at one site (Gujarat), multiple regression analysis was performed excluding and including this variable. Age, gender, site, SES, height, weight and season were other predictor variables in the model. Height and weight were divided by 10 to obtain odds ratios for each 10 unit change in parameter. For similar reason, waist circumference was divided by 5.

In the first analysis without waist circumference, complete data was available for 14957 children from all 4 sites (Figure 4a). Age, male gender, lower SES, sites of Goa and Gujarat were independently associated with lower risk while weight, site of Manipur and winter season were independent predictors of higher risk of HT. P value was < 0.0001 for all these except for lower SES ($P=0.002$). For height P value was of borderline significance ($P=0.047$).

In the second analysis which included waist circumference, complete data was available for 12068 children from 3 sites. Same predictor variables as above were taken in addition to waist. Higher age, male gender and site of Goa were independently associated with lower risk of HT while weight, waist and winter season were independently associated with increased risk of HT. The odds ratios are shown in Figure 4b.

Discussion

Bassareo et al called pediatric HT a "burning problem" and emphasized that management of HT in children should be considered a preventive measure(15). The problem of obesity hypertension in children has reached epidemic proportions in the western world and is rising rapidly in the developing world(9). A disturbingly high cumulative incidence of HT has been reported in Chinese children (50.1% and 70% in overweight and obese children, respectively)(11). Major finding of our study is also a high prevalence of HT amongst Indian children. Studies on newer aspects of HT in children, such as relation with adult derived genetic BP scores, prenatal exposure to maternal stress and effect of traffic related air pollution, are also being reported (16–18).

Highly significant associations ($P<0.0001$) found in our univariate analysis are likely related to large sample size of this study. A significant variation of prevalence of HT between different geographical locations was observed. This variation could be due to local diet (especially salt intake) as well as other environmental factors (including temperature, humidity, exercise habits etc). Prevalence was higher at 2 sites which are more in the north and have lower ambient temperatures over the year. Two sites with lower prevalence are also closer to the ocean, where higher humidity could cause increased perspiration and hence salt and water loss from body. Additionally, ethnic variation and genetic factors could also be important.

Contrary to expectation, we found the prevalence to be higher in younger children and in females, though this has been observed in other studies as well(10,19). Prevalence of hypertension at the upper end of our age group could be affected by onset of puberty, though we did not study this aspect.

A clear relation between anthropometric variables and prevalence of HT found in our study is consistent with earlier reports. Multiple regression analysis including waist circumference showed that weight and to a lesser extent waist, were independent predictors, while height was not. Our data strengthens the evidence that obesity is an important risk factor of prevalence of HT. Association of richer SES with higher prevalence of HT was also expected. Since this relation is independent of obesity in our analysis, other factors such as psychosocial stress and greater intake of salt and processed foods in higher SES group could be contributing mechanisms.

There was significant association of prevalence of HT with season of the year, and higher prevalence was found in winter months. Increase of BP in winter months has also been reported in several earlier studies (20–22). It is most likely due to increased salt and water loss with perspiration during hot weather that occurs during the summer months in most parts of the country.

Measurement of BP on a single day raises the possibility that the prevalence observed in our study represents a falsely high value. Chiolero et al found the prevalence to be lower if measurements are repeated over a period of a few weeks(23). The possibility of overestimation of prevalence of HT was also highlighted by Wirix et al(24). Another confounding factor could be using 50^{th} percentile of height values for all children to classify hypertension using Fourth report tables. However, a number of reports have stressed the need for simplification of current definition of HT for children(25–28). Recent update of the Fourth report has also included a simplified screening BP table based on age and gender only(29).

High prevalence of HT seen in our study also raises the possibility that Fourth report definition (which is based on children in different areas of the USA) may not be applicable to Indian children. Normative data is being reported from different parts of the world(30–34).

Recently published update to the Fourth report has thresholds which are generally even lower, though slightly (29). There has also been attempts to develop more representative international defintion to be developed(1).

There are many data supporting association of childhood HT with cardiovascular risk in adulthood. Chen et al documented evidence of BP tracking from childhood into adulthood in a meta-regression analysis(4). Theodore et al found that prehypertension and hypertension in childhood are associated with development of more cardiovascular risk factors over time and predict adult cardiovascular risk(5). In the Bogulosa heart study, Berenson et al showed association between multiple cardiovascular risk factors and atherosclerosis in children and young adults(7). In addition, systolic BP was found to an independent predictor of arterial stiffness in young adults, providing evidence that target organ damage occurs as a result of childhood HT also(8). In a recent further analysis, they reported BP trajectories from childhood to adult life and found puberty to be a critical stage in development of adult HT(35). Systolic BP was also one of the predictors of Carotid Artery Intima-Media Thickness (CIMT) in the Cardiovascular Risk in Young Finns Study(6). Similarly, in International Childhood Cardiovascular Cohort Consortium, a study of 4210 subjects, individuals with persistently elevated BP were found to be at higher risk of carotid atherosclerosis, as measured directly by CIMT, than those in whom high BP in childhood resolved by adulthood(36). The difference persisted after controlling for age, gender, adiposity and defintion of HT used. Hence, there is a great deal of evidence that elevated BP in childhood causes target organ damage and an active approach to screening and managing childhood HT is likely to be rewarding.

We have recorded blood pressure twice only in children in whom the first reading was high. It is possible that the prevalence may be higher if mean of two recordings were taken for all children, as recommended by some published guidelines (37–39).

Conclusions

Even in predominantly rural populations of India, the prevalence of HT is high in childhood. Both systolic and diastolic HT are common. Richer socio-economic status, high weight (obesity) and increased waist circumference (abdominal obesity) are important independent predictors and efforts should be made to contain the obesity epidemic. Relation of higher risk of HT with lower age, female gender, certain geographical locations and winter months need further studies for confirmation and to clarify underlying pathogenetic mechanisms. Factors identified in this study can help plan cost-effective strategies of screening and management programs to control this widespread public health problem.

Acknowledgements of grant support:

The study was funded by restricted research grant from Medtronics Foundation, USA [through Public Health Foundation of India (PHFI), grant number: F087] and Indian Council of Medical Research (grant number: 5/4/1-14/09-NCD-II). The funding agencies had no role in conduct of study and collection of data.

Role of funding source:

The study was funded by restricted research grant from Medtronics Foundation, USA and Indian Council of Medical Research, India. The sponsors had no role in design of study; collection, analysis, or interpretation of the data; or writing of the manuscript and in the decision to submit the paper for publication. The corresponding author had full access to all the data in the study and take final responsibility for the decision to submit for publication.

Acknowledgements:

The authors thank the administration and staff of all the participating schools in the conduction of the study. The contribution of the parents and children who underwent the screening is deeply appreciated.

Conflict of interests:

The authors report no relationships that could be construed as a conflict of interest.

Authorship:

AS and SR contributed to the conception or design of the work. RN, AkD, RST, SK, KN, AKJC, AD and RS contributed to the acquisition, analysis, or interpretation of data for the work. RN and AS drafted the manuscript. AkD, JC critically revised the manuscript. All authors gave final approval. RN, AS, AkD, SR, RST and SK agree to be accountable for all aspects of work ensuring integrity and accuracy.

References:

1. Xi B, Zong X ’nan, Kelishadi R, Hong YM, Khadilkar A, Steffen LM, et al. Establishing International Blood Pressure References Among Nonoverweight Children and Adolescents Aged 6 to 17 Years. Circulation. 2016 Jan;133(4):398–408.

2. Stergiou GS, Vazeou A, Stabouli S, Ntineri A, Kollias A, Boubouchairopoulou N, et al. Screening for hypertension in children and adolescents: the controversy, the research questions and a plan for action. J Hypertens. 2015 Jul;33(7):1359–63.

3. Xi B, Zhang T, Zhang M, Liu F, Zong X, Zhao M, et al. Trends in Elevated Blood Pressure Among US Children and Adolescents: 1999-2012. Am J Hypertens. 2016 Feb;29(2):217–25.

4. Chen X, Wang Y. Tracking of blood pressure from childhood to adulthood: a systematic review and meta-regression analysis. Circulation. 2008 Jun;117(25):3171–3180.

5. Theodore RF, Broadbent J, Nagin D, Ambler A, Hogan S, Ramrakha S, et al. Childhood to Early-Midlife Systolic Blood Pressure Trajectories: Early-Life Predictors, Effect Modifiers, and Adult Cardiovascular Outcomes. Hypertens Dallas Tex 1979. 2015 Dec;66(6):1108–15.

6. Raitakari OT, Juonala M, Kähönen M, Taittonen L, Laitinen T, Mäki-Torkko N, et al. Cardiovascular risk factors in childhood and carotid artery intima-media thickness in adulthood: the Cardiovascular Risk in Young Finns Study. JAMA. 2003 Nov;290(17):2277–2283.

7. Berenson GS, Srinivasan SR, Bao W, Newman WP, Tracy RE, Wattigney WA. Association between multiple cardiovascular risk factors and atherosclerosis in children and young adults. The Bogalusa Heart Study. N Engl J Med. 1998 Jun;338(23):1650–6.

8. Li S, Chen W, Srinivasan SR, Berenson GS. Childhood blood pressure as a predictor of arterial stiffness in young adults: the bogalusa heart study. Hypertens Dallas Tex 1979. 2004 Mar;43(3):541–6.

9. Sorof J, Daniels S. Obesity hypertension in children: a problem of epidemic proportions. Hypertens Dallas Tex 1979. 2002 Oct;40(4):441–7.

10. Chiolero A, Madeleine G, Gabriel A, Burnier M, Paccaud F, Bovet P. Prevalence of elevated blood pressure and association with overweight in children of a rapidly developing country. J Hum Hypertens. 2007 Feb;21(2):120–7.

11. Wang J, Zhu Y, Jing J, Chen Y, Mai J, Wong SHS, et al. Relationship of BMI to the incidence of hypertension: a 4 years' cohort study among children in Guangzhou, 2007-2011. BMC Public Health. 2015 Aug;15:782.

12. Cinteza E, Balgradean M. Hypertension in romanian children and adolescents: a cross-sectional survey. Ma Edica. 2013 Mar;8(1):5–10.

13. Moser DC, Giuliano I de CB, Titski ACK, Gaya AR, Coelho-e-Silva MJ, Leite N. Anthropometric measures and blood pressure in school children. J Pediatr (Rio J). 2013 Jun;89(3):243–9.

14. Saxena A, Desai A, Narvencar K, Ramakrishnan S, Thangjam RS, Kulkarni S, et al. Echocardiographic prevalence of rheumatic heart disease in Indian school children using World Heart Federation criteria - A multi site extension of RHEUMATIC study (the e-RHEUMATIC study). Int J Cardiol. 2017 Dec 15;249:438–42.

15. Bassareo PP, Mercuro G. Pediatric hypertension: An update on a burning problem. World J Cardiol. 2014 May;6(5):253–259.

16. Jansen MA, Dalmeijer GW, Visseren FL, van der Ent CK, Leusink M, Onland-Moret NC, et al. Adult derived genetic blood pressure scores and blood pressure measured in different body postures in young children. Eur J Prev Cardiol. 2017 Feb;24(3):320–7.

17. Plana-Ripoll O, Liu X, Momen NC, Parner E, Olsen J, Li J. Prenatal exposure to maternal stress following bereavement and cardiovascular disease: A nationwide population-based and sibling-matched cohort study. Eur J Prev Cardiol. 2016 Jul;23(10):1018–28.

18. Bilenko N, Rossem L van, Brunekreef B, Beelen R, Eeftens M, Hoek G, et al. Traffic-related air pollution and noise and children's blood pressure: Results from the PIAMA birth cohort study. Eur J Prev Cardiol. 2015 Jan;22(1):4–12.

19. Urrutia-Rojas X, Egbuchunam CU, Bae S, Menchaca J, Bayona M, Rivers PA, et al. High blood pressure in school children: prevalence and risk factors. BMC Pediatr. 2006 Nov;6:32.

20. Polat M, Akil I, Yuksel H, Coskun S, Yilmaz D, Erguder I, et al. The effect of seasonal changes on blood pressure and urine specific gravity in children living in Mediterranean climate. Med Sci Monit Int Med J Exp Clin Res. 2006 Apr;12(4):CR186-190.

21. Abdulla K, Taka M. Climatic effects on blood pressure in normotensive and hypertensive subjects. Postgrad Med J. 1988 Jan;64(747):23–6.

22. Kunutsor SK, Powles JW. The effect of ambient temperature on blood pressure in a rural West African adult population: a cross-sectional study. Cardiovasc J Afr. 2010 Feb;21(1):17–20.

23. Chiolero A, Cachat F, Burnier M, Paccaud F, Bovet P. Prevalence of hypertension in schoolchildren based on repeated measurements and association with overweight. J Hypertens. 2007 Nov;25(11):2209–17.

24. Wirix AJG, Nauta J, Groothoff JW, Rabelink TJ, HiraSing RA, Chinapaw MJ, et al. Is the prevalence of hypertension in overweight children overestimated? Arch Dis Child. 2016 Mar;

25. Kaelber DC, Pickett F. Simple table to identify children and adolescents needing further evaluation of blood pressure. Pediatrics. 2009 Jun;123(6):e972–974.

26. Kelishadi R, Heshmat R, Ardalan G, Qorbani M, Taslimi M, Poursafa P, et al. First report on simplified diagnostic criteria for pre-hypertension and hypertension in a national sample of adolescents from the Middle East and North Africa: the CASPIAN-III study. J Pediatr (Rio J). 2014 Feb;90(1):85–91.

27. Narang R, Saxena A, Ramakrishnan S, Dwivedi SN, Bagga A. Oscillometric Blood Pressure in Indian School Children: Simplified Percentile Tables and Charts. Indian Pediatr. 2015 Nov;52(11):939–45.

28. Zuijdwijk C, Feber J, Murnaghan O, Nakhla M. Detection of hypertension and prehypertension in paediatric patients with type 1 diabetes using a simple blood pressure table. Paediatr Child Health. 2013 Nov;18(9):461–464.

29. Flynn JT, Kaelber DC, Baker-Smith CM, Blowey D, Carroll AE, Daniels SR, et al. Clinical Practice Guideline for Screening and Management of High Blood Pressure in Children and Adolescents. Pediatrics. 2017 Sep;140(3).

30. Jackson LV, Thalange NKS, Cole TJ. Blood pressure centiles for Great Britain. Arch Dis Child. 2007 Apr;92(4):298–303.

31. Neuhauser HK, Thamm M, Ellert U, Hense HW, Rosario AS. Blood pressure percentiles by age and height from nonoverweight children and adolescents in Germany. Pediatrics. 2011 Apr;127(4):e978–988.

32. Krmar RT, Holtbäck U, Bergh A, Svensson E, Wühl E. Oscillometric casual blood pressure normative standards for Swedish children using ABPM to exclude casual hypertension. Am J Hypertens. 2015 Apr;28(4):459–68.

33. Yip GWK, Li AM, So H-K, Choi KC, Leung LCK, Fong N-C, et al. Oscillometric 24-h ambulatory blood pressure reference values in Hong Kong Chinese children and adolescents. J Hypertens. 2014 Mar;32(3):606–619.

34. Yan W, Liu F, Li X, Wu L, Zhang Y, Cheng Y, et al. Blood pressure percentiles by age and height for non-overweight Chinese children and adolescents: analysis of the China Health and Nutrition Surveys 1991-2009. BMC Pediatr. 2013;13:195.

35. Shen W, Zhang T, Li S, Zhang H, Xi B, Shen H, et al. Race and Sex Differences of Long-Term Blood Pressure Profiles From Childhood and Adult Hypertension: The Bogalusa Heart Study. Hypertens Dallas Tex 1979. 2017;70(1):66–74.

36. Juhola J, Magnussen CG, Berenson GS, Venn A, Burns TL, Sabin MA, et al. Combined effects of child and adult elevated blood pressure on subclinical atherosclerosis: the International Childhood Cardiovascular Cohort Consortium. Circulation. 2013 Jul;128(3):217–24.

37. Pickering TG, Hall JE, Appel LJ, Falkner BE, Graves J, Hill MN, et al. Recommendations for blood pressure measurement in humans and experimental animals: part 1: blood pressure measurement in humans: a statement for professionals from the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research. Circulation. 2005 Feb 8;111(5):697–716.

38. Leung AA, Nerenberg K, Daskalopoulou SS, McBrien K, Zarnke KB, Dasgupta K, et al. Hypertension Canada's 2016 Canadian Hypertension Education Program Guidelines for Blood Pressure Measurement, Diagnosis, Assessment of Risk, Prevention, and Treatment of Hypertension. Can J Cardiol. 2016;32(5):569–88.

39. Harris KC, Benoit G, Dionne J, Feber J, Cloutier L, Zarnke KB, et al. Hypertension Canada's 2016 Canadian Hypertension Education Program Guidelines for Blood Pressure Measurement, Diagnosis, and Assessment of Risk of Pediatric Hypertension. Can J Cardiol. 2016;32(5):589–97.

****

Figure legends:

Figure 1: Map of India showing prevalence of hypertension at different locations. Circle sizes are proportional to prevalence.

Figure 2: Relation of prevalence of HT (prevHT) with (A) age and gender, (B) age and overweight/obese status, (C) age and socio-economic status and (D) month of the year in boys and girls. Shaded areas indicate 95% confidence intervals around locally weighted scatterplot smoothing or local regression (LOESS) lines.

Figure 3: Relation between various anthropometric parameters and prevalence of hypertension in boys and girls. Parameters are (from left to right and top to bottom) height, weight, waist circumference, height z-score, weight z-score, waist z-score, body mass index (BMI), body surface area (BSA) and waist/height ratio. Shaded areas indicate 95% confidence intervals around locally weighted scatterplot smoothing or local regression (LOESS) lines.

Figure 4: Forest plot of odds ratios from multiple regression analysis performed (A) without and (B) with waist circumference in model. Age, gender, winter season, Goa site and weight are significant and independent predictors of hypertension in both models. Waist was significant predictor in second model. Height was of border significance in first and not significant in the second model. Lower socio-economic status, Gujarat and Manipur sites were significant predictors in one model only. For numeric parameters, odds ratios are shown for for 1 year change in age, 5 cm change in waist circumference and 10 cm change in height or weight.