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Hypertension in Asian Indian Children and Adolescents: A Systematic Review on the Prevalence and Associated Risk Factors

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ABSTRACT Hypertension in children is becoming a growing health problem. It is often asymptomatic and overlooked by the physician. Although death and cardiovascular disability do not occur in hypertensive children, evidences of target organ damages are detectable in children with hypertension. Moreover, hypertension in childhood continues into adulthood. This review summarizes the insights into the epidemiology of hypertension in children, emphasizing the prevalence and risk factors for the development of hypertension in Asian Indian children. A systematic literature review was carried out using PubMed and Google Scholar along with manual searching from 1971 to 2017. The prevalence of hypertension ranges from 0.5 to 11.7 percent. Though, the prevalence is higher in urban population, an upward trend is noticeable in rural population as well. The strongest risk factor for hypertension in children is obesity. Lower insulin sensitivity may also play an important role for the development of hypertension in Asian Indian children.

INTRODUCTION

Hypertension is now recognized globally as a major public health problem (Cappuccio et al. 2004). Being a leading risk factor of non-communicable diseases like cardiovascular disease, type 2 diabetes mellitus and renal disease (Monyeki et al. 2006), hypertension accounted for 9.4 million deaths and seven percent of disability adjusted life years globally in 2010 (Lim et al. 2013). Hypertension ranked second for its attributed death and disease burden in south Asia (Lopez et al. 2006). It is directly responsible for fifty-seven percent of all stroke deaths and twenty-four percent of all coronary heart disease deaths in India (Gupta 2004).The prevalence of hypertension in India is twenty-five percent and ten percent in urban and rural area, respectively (Anchalaa et al. 2014). It has been predicted that by 2025, 22.9 percent men and 23.6 percent women in India will be hypertensive (Kearney et al. 2005).

Not only in adults, hypertension in children and adolescents are also becoming a growing heath problem (Riley and Bluhm 2012) with increasing prevalence and rate of diagnosis (Luma and Spiotta 2006). But, little attention has been given to the problem of hypertension in young. This might be due to the lack of awareness, considering it as a problem of adult and asymptomatic nature in children (Luma and Spiotta 2006; Anyaegbu and Dharnidharka 2014). Interestingly, the negative and potentially severe consequences of hypertension as observed in adults were also observed in children. Papers documented the evidence of target organ damages including left ventricular hypertrophy and pathological vascular changes (Lande et al. 2006; Drukteinis et al. 2007), as well as neurological changes including reduced cognitive function (Lande et al. 2009) in children also.

The current global prevalence of primary hypertension in children and adolescent is estimated to be about one to five percent (Grinsell and Norwood 2009; Thompson et al. 2013; Anyaegbu and Dharnidharka 2014). The strongest risk factor for primary hypertension in children and adolescent is overweight and obesity (Bancalari et al. 2011; Kumar et al. 2017). Other risk

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factors for primary hypertension includes low birth weight (Duncan et al. 2011), dietary pattern (Damasceno et al. 2011; Kajale et al. 2016), breastfeeding duration (Martin et al. 2004), ethnicity (Berenson et al. 1979), sex (Dasgupta et al. 2006), age (Saha et al. 2008), sodium intake (Yang et al. 2012), physical inactivity (Vale et al. 2015), parental smoking (Simonetti et al. 2011), lower socioeconomic status (Schreier and Chen 2010) and family history of hypertension (Robinson et al. 2005).

Since the publication of the first report from the National Heart Lung and Blood Institute (NHLBI) on high blood pressure in children in 1977, several papers accepted the hypothesis that essential hypertension in adulthood has its origin in the childhood (National Heart Lung and Blood Institute 1977; Salgado et al. 2003; National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004; Chen and Wang 2008). Bogalusa's Heart Study demonstrated that children with elevated blood pressure are 2 to 3 times more likely to develop essential hypertension in young adulthood (Bao et al. 1995). Meta-analysis of longitudinal studies demonstrated that systolic blood pressure measured in childhood predicts future blood pressure with an overall tracking coefficient of about 0.40 (Chen and Wang 2008). Though, adult hypertension is the leading cause of premature death including cardiovascular disease, data relating childhood hypertension with related events such as cardiovascular disease, kidney failure, stroke in adulthood are lacking (Chobanian et al. 2003). However, an association of elevated blood pressure in childhood with intermediate markers of cardiovascular disease like left ventricular hypertrophy (Daniels et al. 1998), change in left ventricular mass (Urbina et al. 1995), carotid artery intima-media thickness and arterial stiffness (Urbina et al. 2011) has been observed.

Objectives

The objectives of this review are to summarize the insights into the epidemiology of primary hypertension in children, emphasizing on the prevalence and risk factors for the development of hypertension in Asian Indian children.

METHODOLOGY

Literature was researched from 1971 to 2017 on hypertension in Asian Indian children and adolescents using electronic search engines PubMed and Google Scholar along with manual searching. Cross references of all selected papers were also used to identify further relevant papers. The keywords used were 'hypertension', 'hypertension in Asian Indian', 'hypertension in Asian Indian children and adolescent', 'hypertension in school going children', 'hypertension in urban children', 'hypertension in rural children', 'elevated blood pressure in Asian Indian children and adolescents' and 'hypertension risk factors in Asian Indian children and adolescents'. Published papers for the present review were selected from available published papers conducted in samples from India and restricted to English language. At first, the title of the paper and abstracts were reviewed for relevance, and then potential relevant full text papers or abstracts, where full texts were not available were extracted. Papers without full text where abstracts were also unavailable were excluded from the review.

Definition and Classification of Hypertension in Children and Adolescents

The definition of hypertension in adult is based on outcomes like myocardial infarction and stroke, as the incidence of these events increases in a linear fashion with blood pressures >120/80 mmHg (Chobanian et al. 2003; Lande and Flynn 2009). However, such outcomes are very rare in children and adolescents, and thus the definition of hypertension in children and adolescents is based on the normative distribution of blood pressure in healthy children (National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004; Lande and Flynn 2009).

The most recent and worldwide adopted definition and classification scheme for blood pressure in children and adolescents is that recommended by the United States National High Blood Pressure Education Program (NHBPEP) working group on high blood pressure in children and adolescents in 2004 (Table 1) (National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004). According to the NHBPEP (National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004) normal blood pressure is defined as systolic blood pres-

Table 1: Classification of hypertension in children and adolescents

Classification	*Systolic or diastolic blood pressure percentile*[*]
Normal	<90th
Prehypertension/ high normal	90th to <95th or if BP exceeds 120/80 mmHg even if below 90th percentile up to <95th percentile
Stage 1 hypertension	95th percentile to the 99th percentile plus 5 mmHg
Stage 2 hypertension	>99th percentile plus 5 mmHg

[*]Based on sex, age, and height; measured on at least three separate occasions
Source: National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004.

sure (SBP) and diastolic blood pressure (DBP) that is less than the 90th percentile for sex, age, and height. Hypertension is defined as average SBP or DBP that is greater than or equal to the 95th percentile for sex, age, and height on at least three separate occasions. Average SBP or DBP levels that are greater than or equal to the 90th percentile, but less than the 95th percentile, had been designated as "high normal" or "pre hypertension" and were considered to be an indication of high risk for developing hypertension (National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004).

On the basis of etiology, hypertension in children and adolescent can be classified into two main types, namely, primary (essential) and secondary hypertension (National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004; Bagga et al. 2007). Primary hypertension is typically characterized by mild or Stage one hypertension and is often associated with being overweight or obesity, positive family history of hypertension and cardiovascular disease (National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004; Anyaegbu and Dharnidharka 2014). Secondary hypertension is more common in very young children than others and associated with an underlying cause like renal parenchymal disease, endocrine disorder, vascular or neurological condition (Bagga et al. 2007; Anyaegbu and Dharnidharka 2014).

OBSERVATIONS AND DISCUSSION

Prevalence of Hypertension: Indian Perspective

The majority of recent papers revealed an increase in the prevalence of hypertension in children and adolescents throughout the world (Muntner et al. 2004; Din-Dzietham et al. 2007; Bancalari et al. 2011; Durrani and Waseem 2011; Maldonado et al. 2011; Zhang and Wang 2011). The increase in childhood blood pressure level is largely due to the obesity (Muntner et al. 2004; Malatesta-Muncher and Mitsnefes 2012). Data from recent papers in children and adolescents reported similar findings from India also as well.

In a current paper Arora et al. (2017) demonstrated that the prevalence of systolic and diastolic hypertension was 10 percent and 10.5 percent, respectively among adolescents in Amritsar. In another paper by Raj et al. (2007) in 24,842 children aged 5-16 years from Kerala, hypertension was seen in 10.1 percent of normal weight children; however the prevalence was 17.3 percent and 18.3 percent for overweight and obese children, respectively. Another paper from urban Chennai (Jagadesan et al. 2014) demonstrated that the prevalence of hypertension was 20.4 percent among obese adolescents, compared to 5.2 percent among non-obese adolescents.

Laroia et al. (1989) found the overall prevalence of hypertension was 2.9 percent in school children between the age group of 5-14 years. A paper by Ghosh and Bandyopadhyay (2013) showed that the prevalence of hypertension in girls aged between 5-16 years of West Bengal was 8.6 percent. The prevalence of hypertension was seen in 6.4 percent adolescents in New Delhi (Goelet al. 2010). Patil and Garg (2014) observed the overall prevalence of hypertension was three percent in rural area of Wardha. Sharma et al. (2010) observed the prevalence of hypertension in Shimla was 5.9 percent. In Karnataka, the prevalence of hypertension was 2.6 percent among children and young adults aged between 0-25 years (Kumar et al. 2008). In Rajasthan, the prevalence of hypertension was 1.5 percent in school going children aged between 12-18 years (Dholpuria et al. 2007). Another paper from the Western part of Indian showed that the prevalence of hypertension was 7.2 percent in middle and upper-middle class adolescent school children aged between 13-17 years in Jaipur (Gupta et al. 1998). A paper from Punjab dem-

onstrated the prevalence of hypertension was 2.8 percent at the first screening but decreased to 1.3 percent and 1.1 percent by 6 and 9 months, respectively in apparently healthy school children of 5 to15 years (Verma et al. 1994). The overall prevalence of hypertension was found to be 9.4 percent among school children aged between 12-16 years in Aligarh (Durrani and Waseem 2011).

However, the overall prevalence of pediatric hypertension in India is unknown, due to the ethnic heterogeneity, distribution of reference blood pressure data and lack of national level health surveys on blood pressure in children and adolescent. However, some regional attempts have been made to understand the prevalence of hypertension in different ethnic groups. According to the available reports the prevalence of childhood hypertension ranges from 0.5 percent to 11.7 percent in Indian children (Anand and Tandon 1996; Chadha et al. 1999). A recent analysis of school based cross-sectional data on 6380 children aged 6-18 year from five major cities (Chennai, Delhi, Kolkata, Pune and Raipur) in India revealed that the overall prevalence of hypertension was 5.6 percent (Kajale et al. 2014). Studies that were conducted both in urban and rural areas demonstrated that the prevalence of hypertension was comparatively higher in urban areas than rural areas (Mohan et al. 2004; Mitra et al. 2011). A previous paper by Sharma et al. (2010) showed that the prevalence of hypertension was higher in urban children, but interestingly pre hypertension was higher in rural children. However, Narayanappa et al. (2012) have found no significant differences in the prevalence of hypertension between rural and urban areas.

Risk Factors of Hypertension: Indian Perspective

There is commonly an underlying disorder for hypertension in younger children (that is, secondary hypertension). A recent hospital based paper among 135 children demonstrated an underlying cause for secondary hypertension in 93.3 percent children (Kota et al. 2013). In some cases, the underlying causes were present in more than 98 percent (98.4%) of children (Hari et al. 2000). However, few attempts have been made to understand the causes of hypertension in Asian Indian children (Khalil et al. 1991; Kota et al. 2013; Kumar et al. 2017). The chief causes identified for secondary hypertension includes chronic glomerulonephritis, endocrine disorders, obstructive uropathy, reflux nephropathy, renovascular disease, Takayasu's disease, thrombotic micro angiopathy and intrinsic renal parenchymal disease (Khalil et al. 1991; Hari et al. 2000; Kota et al. 2013).

However, in older children and adolescents, high blood pressure is primarily due to essential (primary) hypertension (Falkner 2010; Kota et al. 2013; Uddaraju and Ram 2013). Primary hypertension is the most common form of hypertension in clinical practice (Uddaraju and Ram 2013) among children and often coexists with other cardiovascular risk factors. Though, there is no specific underlying disorder that causes primary hypertension, presence of some factors may increase the risk of developing primary hypertension. A number of community based papers have demonstrated that there were a positive relationship between anthropometric measurements and blood pressures in children (Durrani and Waseem 2011; Ghosh and Bandyopadhyay 2013; Ahmed et al. 2016; Kumar et al. 2017). However, the strongest risk factor for primary hypertension in children, both in urban and rural population was elevated body mass index (BMI) (Mohan et al. 2004; Kajale et al. 2014; Verma and Sinah 2014; Goel et al. 2016) (Table 2). However, the rate of change in BMI appears to be more significant than the absolute level of BMI in influencing pediatric blood pressure as evidenced by a recent cohort of 12129 children (Raj et al. 2010). Children who are overweight or obese have two to three times higher risk of developing hypertension. It was observed (Gupta and Ahmad 1990; Mohan et al. 2004; Raj et al. 2007; Sharma et al. 2010; Borade et al. 2011; Jagadesan et al. 2014) that the rates of hypertension were significantly higher among those with high BMI (overweight and obese) compared to those with normal BMI. The association of hypertension with overweight and obesity is particularly a concern of urban society, where the number of overweight and hypertensive children is increasing and more in affluent society (Mitra et al. 2011). A recent paper in an urban area of South India (Jagadesan et al. 2014) demonstrated that the prevalence of overweight and obesity was high among private schools with a higher incident of hypertension among them. However, not only hypertension, but also hypertriglyceridemia, low high density lipoprotein-cholesterol and dysglycemia were also more commonly observed in overweight and obese children (Tandon et al. 2013).

Table 2: Hypertension risk factors in Asian Indian children and adolescents

Authors	*Year*	*Area of study*	*Study design*	*Age range*	*Major findings*
Kumar et al.	2017	Patna	Cross-sectional	13-15 years	Overall prevalence of hypertension was 4.6 percent. Both systolic and diastolic blood pressures had positive and significant correlation with age, height and BMI. Moreover, the prevalence of hypertension increases with age.
Kajale et al.	2014	Chennai, Delhi, Kolkata, Pune and Raipur	Cross-sectional	6-18 years	Overweight children demonstrated double risk of hypertension and this was seven times higher for obese children than normal-weight children. Higher waist circumterence and waist height ratio exhibited 1.5 times risk and larger Wrist 1.3 times higher risk of hypertension.
Patil and Garg	2014	Wardha	Cross-sectional	6-16 years	Both systolic and diastolic blood pressure demonstrated significant positive correlation with height, weight, BMI and WC in both sexes.
Ghosh and Bandyopadhyay	2013	Howrah	Cross-sectional	5-16 years	WC is the best adiposity measure in predicting hypertension in girls. However, there was no significant association of BMI with hypertension.
Sharma et al.	2010	Shimla	Cross-sectional	11-17 years	Rates of elevated blood pressure were significantly higher among those with high body mass index (overweight and obese) compared to those with normal body mass index.
Goel et al.	2010	New Delhi	Cross-sectional	14-19 years	Hypertension was associated with obesity, higher serum lipids and family history of hypertension.
Saha et al.	2008	Kolkata	Cross-sectional	10-19 years	Age, educational status, diet, family history of hypertension, weight, height and body mass index were significantly correlated with both systolic and diastolic blood pressures.
Tripathy and Gupta	2007	Leh, Bylakuppe, Chandragiri and Delhi	Cross-sectional	10-19 years	Measures of adiposity (SFT, BMI and MUAC) have a significant effect on blood pressures. Children and adolescents at high altitude demonstrated lower blood pressure values compared to low altitude children and adolescents.
Mohan et al.	2004	Ludhiana	Cross-sectional	11-17 years	There was significant increase in prevalence of hypertension in both rural and urban population. Blood pressure is frequently elevated in obese children as compared to lean subjects.
Verma et al.	1995	Punjab	Cross-sectional	5-15 years	Systolic as well as diastolic blood pressure increased with age in both sexes. Obesity and family history of hypertension in children were significantly associated with elevated blood pressure.
Gupta	1991	Aligarh	Cross-sectional	5-15 years	Children of people with hypertension or other morbid cardiovascular events are more likely to have persistently elevated blood pressures than children from families without such a history.

Different multinomial regression models for e-tracking parameter in Asian Indian children indicated that the relative risk of hypertension was highest with high pulse wave velocity, low density lipoprotein-cholesterol and elastic modulus, which were also significantly higher in obese and overweight children compared to normal weight children (Pandit et al. 2011). Serum e-selectin levels also revealed strong positive association with both systolic and diastolic blood pressure in children. Higher e-selectin levels can induce endothelial activation and play an essential role in the

earliest stage of the atherosclerotic process in obese and overweight children (Rao et al. 2011).

Papers also demonstrated that children with family history of hypertension are more likely to have elevated blood pressures than children without family history of hypertension (Gupta and Ahmad 1990; Gupta 1991; Verma et al. 1994; Verma and Chhatwal 1995; Anand and Tandon 1996; Joshi et al. 2003; Goel et al. 2016). Borade et al. (2011) in a recent paper observed positive family history of hypertension in 76.4 percent hypertensive adolescents, compared to 23.6 percent in adolescents without hypertension. It was also observed that children with elevated blood pressure and family history of hypertension had higher serum cholesterol, serum triglycerides, twenty four hour urinary sodium excretion and BMI as compared to controls (Joshi et al. 2003; Saha et al. 2008; Goel et al. 2010; Borade et al. 2011).

Sex has not been consistently linked to hypertension risk in Asian Indian children. Some papers demonstrated no significant differences in the prevalence of hypertension between two sexes (Verma et al. 1994; Savitha et al. 2007), while others demonstrated that the prevalence was more in boys than girls (Kajale et al. 2014). Patil and Garg (2014) in a recent paper observed that the prevalence of hypertension in female was found to be comparatively higher than the male, though the difference was not statistically significant. The dissimilarity in pattern of blood pressure between male and female is probably related to certain biological and psychosocial factors. The appearance of secondary sex characters together with the menarche may associate with a high level of anxiety resulting in higher blood pressure values in girl (Durrani and Waseem 2011).

Other factors that are responsible for hypertension in Asian Indian children include lifestyle changes such as physical inactivity (Saha et al. 2008) and inappropriate dietary practices like high fast food consumption and low fruit consumption (Joshi et al. 2003; Singh et al. 2006). Low dietary-calcium intakes also increase the risk of hypertension (Kajale et al. 2016). It was observed that Asian Indian adolescents received less energy from carbohydrates and more from fats in comparison to the recommended standard (Dholpuria et al. 2007). Sodium intake was also found to be very high among them, whereas fiber intake was low (Joshi et al. 2003; Dholpuria et al. 2007; Goel et al. 2010).

Geographic location was also found to be associated with elevated blood pressure (Krishna et al. 2007). It was observed that children and adolescents from high altitude have lower mean blood pressure than low altitude children (Tripathy and Gupta 2007).

In general, literature review in Indian perspective revealed a typical pattern in Asian Indian children. They have higher mean blood pressure compared to white with a lower BMI, but, interestingly had higher body fat (Clark et al. 1998; Nazroo et al. 2001; Whincup et al. 2002; Ramachandran et al. 2004; Raj et al. 2007; Ramachandran et al. 2007). Moreover, central obesity measure was more strongly associated with hypertension risk than general obesity measure (Goel et al. 2010; Ghosh and Bandyopadhyay 2013). Asian Indian children also have lower insulin sensitivity compared to others (McKeigue et al. 1993; Ramachandran et al. 2004; Ramachandran et al. 2007). Elevated blood pressure at a lower BMI in Asian Indian children may be related to lower insulin sensitivity (Ramachandran et al. 2007). Because, insulin sensitivity is inversely associated with body fat, especially at central region (Ferrannini et al. 1996; Reaven 1998; Gupta 2004; Ramachandran et al. 2007). In the paper Ramachandran et al. (2007) demonstrated that majorities of the normal weight children had at least one cardio-metabolic abnormality including elevated blood pressure and both plasma insulin and waist circumference was strongly associated with these abnormalities.

CONCLUSION

Hypertension, previously considered a disease of adulthood, has now become increasingly common in the pediatric population, especially in urban areas. The primary reason for this is attributed to increased prevalence of childhood obesity, due to the rapid economic growth and related improvement in nutritional and socioeconomic status of the country. Along with these, behavioral transition in terms of dietary pattern and sedentary lifestyle of children also played an important role for increasing incidents of obesity and associated hypertension in India. However, it is interesting that there was an upward trend noticeable in rural population as well. This might be the effect of urbanization and gradual

declination of rural population towards sedentary life style.

RECOMMENDATIONS

The results obtained from such studies could be used for effective prevention and management of hypertension in Asian Indian children. Because, initiation of intervention at an early stage could potentially decrease the rate and progression of hypertension from childhood to adulthood and thus it could reduce the clinical consequences of hypertension in adulthood.

LIMITATIONS

The limitation of this review is the lack of sufficient data, especially from rural areas. Owing to the vast ethnic and cultural heterogeneity in Indian population, a comprehensive review considering different ethnic groups from different parts of India is necessary to understand the prevalence and risk factors of hypertension in Asian Indian children.

REFERENCES

Ahmed A, Ali SW, Massodi S, Bhat MA 2016. Blood pressure-to-height ratio as a screening tool for hypertension in Children. *Indian Pediatr,* 53: 137-139.

Anand NK, Tandon L 1996. Prevalence of hypertension in school going children. *Indian Pediatr,* 33: 377-381.

Anchalaa R, Kannurib NK, Pantb H, Khana H, Francoc OH, Angelantonioa ED, Prabhakaran D 2014. Hypertension in India: A systematic review and meta-analysis of prevalence, awareness, and control of hypertension. *J Hypertens,* 32: 1170-1177.

Anyaegbu E, Dharnidharka V 2014. Hypertension in teenager. *Pediatr Clin North Am,* 61: 131–151.

Arora S, Gupta S, Singh P 2017. Assessment of risk factors for hypertension and obesity among adolescents. *Sri Lanka Journal of Child Health,* 46: 48-54.

Bagga A, Jain R, Vijayakumar M, Kanitkar M, Ali U 2007. Evaluation and management of hypertension. *Indian Pediatr,* 44: 103-121.

Bancalari R, Diaz C, Martínez-Aguayo A, Aglony M, Zamorano J, Cerda V, Fernández M, Garbin F, Cavada G, Valenzuela M, García H 2011. Prevalence of hypertension in school age children and its association with obesity. *Rev Chil,* 139: 872-879.

Bao W, Threefoot SA, Srinivasan SR, Berenson GS 1995. Essential hypertension predicted by tracking of elevated blood pressure from childhood to adulthood: The Bogalusa Heart Study. *Am J Hypertens,* 8: 657-665.

Berenson GS, Voors AW, Webber LS, Dalferes ER Jr, Harsha DW 1979. Racial differences of parameters associated with blood pressure levels in children- the Bogalusa Heart Study. *Metabolism,* 28: 1218–1228.

Borade A, Kadam GS, Bhide G, Dhongade R 2011. Study of blood pressure and blood sugar levels in adolescence and comparison with body mass index. *Indian J Med Sci,* 65: 297-310.

Cappuccio FP, Micah FB, Emmett L, Kerry SM, Antwi S, Martin-Peprah R, Phillips RO, Plange-Rhule J, Eastwood JB 2004. Prevalence, detection, management and control of hypertension in Ashanti, West Africa. *Hypertension,* 43: 1017-1022.

Chadha SL, Tandon R, Shekhawat S, Gopinath N 1999. An epidemiological study of blood pressure in school children (5-14 years) in Delhi. *Indian Heart J,* 51: 178-182.

Chen X, Wang Y 2008. Tracking of blood pressure from childhood to adulthood: A systematic review and meta-regression analysis. *Circulation,* 117: 3171–3180.

Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL Jr, Jones DW, Materson BJ, Oparil S, Wright JT Jr, Roccella EJ, Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure 2003. National heart, lung, and blood institute; national high blood pressure education program coordinating committee. The seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure: The JNC 7 report. *JAMA,* 289: 2560–2572.

Clark PM, Atton C, Law CM, Shiell A, Godfrey K, Barker DJ 1998. Weight gain in pregnancy, triceps skinfold thickness, and blood pressure in offspring. *Obstet Gynecol,* 91: 103-107.

Damasceno MM, de Araujo MF, de Freitas RW, de Almeida PC, Zanetti ML 2011.The association between blood pressure in adolescents and the consumption of fruits, vegetables and fruit juice: An exploratory study. *J Clin Nurs,* 20: 1553–1560.

Daniels SR, Loggie JM, Khoury P, Kimball TR 1998. Left ventricular geometry and severe left ventricular hypertrophy in children and adolescents with essential hypertension. *Circulation,* 97: 1907–1911.

Dasgupta K, O'Loughlin J, Chen S, Karp I, Paradis G, Tremblay J, Hamet P, Pilote L 2006. Emergence of sex differences in prevalence of high systolic blood pressure: Analysis of a longitudinal adolescent cohort. *Circulation,* 114: 2663-2670.

Dholpuria R, Raja S, Gupta BK, Chahar CK, Panwar RB, Gupta R, Purohit VP 2007. Atherosclerotic risk factors in adolescents. *Indian J Pediatr,* 74: 823-826.

Din-Dzietham R, Liu Y, Bielo MV, Shamsa F 2007. High blood pressure trends in children and adolescents in national surveys, 1963 to 2002. *Circulation,* 116: 1488-1496.

Drukteinis JS, Roman MJ, Fabsitz RR, Lee ET, Best LG, Russell M, Devereux RB 2007. Cardiac and systemic hemodynamic characteristics of hypertension and prehypertension in adolescents and young adults: The Strong Heart Study. *Circulation,* 115: 221-227.

Duncan AF, Heyney RJ, Morgan JS, Ahmad N, Rosenfeld CR 2011. Elevated systolic blood pressure in preterm very-low-birth-weight infants ≤ 3 years of life. *Pediatr Nephrol,* 26: 1115–1121.

Durrani AM, Waseem F 2011. Blood pressure distribution and its relation to anthropometric measurements among school children in Aligarh. *Indian J Public Health*, 55: 121-124.

Falkner B 2010. Hypertension in children and adolescents: Epidemiology and natural history. *Pediatr Nephrol*, 25: 1219-1224.

Ferrannini E, Muscelli E, Stern MP, Haffner SM 1996. Differential impact of insulin and obesity on cardiovascular risk factors in non-diabetic subjects. *Inter J Obesityb Relat Metab Disord*, 20: 7–14.

Ghosh JR, Bandyopadhyay AR 2013. Central adiposity and the risk of hypertension in Asian Indian girls. *World J Pediatr*, 9: 256-260.

Goel R, Misra A, Agarwal SK, Vikram N 2010. Correlates of hypertension among urban Asian Indian adolescents. *Arch Dis Child*, 95: 992-997.

Goel M, Pal P, Agrawal A, Ashok C 2016. Relationship of body mass index and other life style factors with hypertension in adolescents. *Ann Pediatr Cardiol*, 9: 29-34.

Grinsell MW, Norwood VF 2009. At the bottom of the differential diagnosis list: Unusual causes of pediatric hypertension. *Pediatr Nephrol*, 24: 2137–2146.

Gupta AK 1991. Influence of family history of morbid cardiovascular events on blood pressure levels of school children. *Indian Pediatr*, 28: 131-139.

Gupta AK, Ahmad AJ 1990. Normal blood pressures and the evaluation of sustained blood pressure elevation in childhood. *Indian Pediatr*, 27: 33-42.

Gupta AK, Ahmad AJ 1990.Childhood obesity and hypertension. *Indian Pediatr*, 27: 333-337.

Gupta R 2004. Trends in hypertension epidemiology in India. *J Hum Hypertens*, 18: 73–78.

Gupta R, Goyle A, Kashyap S, Agarwal M, Consul R, Jain BK 1998. Prevalence of atherosclerosis risk factors in adolescent school children. *Indian Heart J*, 50: 511-515.

Hari P, Bagga A, Srivastava RN 2000. Sustained hypertension in children. *Indian Pediatr*, 37: 268-274.

Jagadesan S, Harish R, Miranda P, Unnikrishnan R, Anjana RM, Mohan V 2014. Prevalence of overweight and obesity among school children and adolescents in Chennai. *Indian Pediatr*, 51: 544-549.

Joshi S, Gupta S, Tank S, Malik S, Salgaonkar DS 2003. Essential hypertension: Antecedents in children. *Indian Pediatr*, 40: 24-29.

Kajale NA, Khadilkar AV, Chiplonkar SA, Khadilkar VV 2014. Body fat indices for identifying risk of hypertension in Indian children. *Indian Pediatr*, 51: 555-560.

Kajale NA, Mughal Z, Khadilkar V, Chiplonkar SA, Khadilkar A 2016. Association of dietary calcium intake and body fat with hypertension in Indian adolescents. *Indian Pediatr*, 53: 434-435.

Kearney PM, Whelton M, Reynolds K, Muntner P, Whelton PK, He J 2005. Global burden of hypertension: analysis of worldwide data. *Lancet*, 365: 217-223.

Khalil A, Singh TP, Arora R, Puri RK 1991. Pediatric hypertension: Clinical profile and etiology. *Indian Pediatr*, 28: 141-146.

Kota SK, Kota SK, Meher LK, Sruti J, Kotni G, Panda S, Tripathy PR, Modi K 2013. Clinical analysis of hypertension in children: an urban Indian study. *Saudi J Kidney Dis Transpl*, 24: 844-852.

Krishna P, Bajaj S, Thennarasu K, Desai N, Prasanna Kumar KM 2007. Regional differences in the reference blood pressure in young Indians. *Indian Pediatr*, 44: 921-923.

Kumar P, Krishna P, Reddy SC, Gurappa M, Aravind SR, Munichoodappa C 2008. Incidence of type 1 diabetes mellitus and associated complications among children and young adults: Results from Karnataka Diabetes Registry 1995-2008. *J Indian Med Assoc*, 106: 708-711.

Kumar P, Kumar D, Ranjan A, Singh CM, Pandey S, Agarwal N 2017. Prevalence of hypertension and its risk factors among school going adolescents of Patna, India. *J Clin Diagn Res*, 11: SC01-SC04.

Lande MB, Adams H, Falkner B, Waldstein SR, Schwartz GJ, Szilagyi PG, Wang H, Palumbo D 2009. Parental assessments of internalizing and externalizing behavior and executive function in children with primary hypertension. *J Pediatr*, 154: 207–212.

Lande MB, Carson NL, Roy J, Meagher CC 2006. Effects of childhood primary hypertension on carotid intima media thickness: A matched controlled study. *Hypertension*, 48: 40-44.

Lande MB, Flynn JT 2009. Treatment of hypertension in children and adolescents. *Pediatr Nephrol*, 24: 1939–1949.

Laroia D, Sharma M, Diwedi V, Belapurkar KM, Mathur PS 1989. Profile of blood pressure in normal school children. *Indian Pediatr*, 26: 531-536.

Lim SS, Vos T, Flaxman AD et al. 2013. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: A systematic analysis for the Global Burden of Disease Study 2010. *Lancet*, 380: 2224-2260.

Lopez AD, Mathers CD, Ezzati M, Jamison DT, Murray CJ 2006. Global and regional burden of disease and risk factors, 2001: Systematic analysis of population health data. *Lancet*, 367: 1747–1757.

Luma GB, Spiotta RT 2006. Hypertension in children and adolescents. *Am Fam Physician*, 73: 1158-1168.

Malatesta-Muncher R, Mitsnefes MM 2012. Management of blood pressure in children. *Curr Opin Nephrol Hypertens*, 21: 318-322.

Maldonado J, Pereira T, Fernandes R, Santos R, Carvalho M 2011. An approach of hypertension prevalence in a sample of 5381 Portuguese children and adolescents. The AVELEIRA registry 'hypertension in children'. *Blood Press*, 20: 153-157.

Martin RM, Ness AR, Gunnell D, Emmett P, Davey Smith G, ALSPAC Study Team 2004. Does breastfeeding in infancy lower blood pressure in childhood? The Avon Longitudinal Study of Parents and Children (ALSPAC). *Circulation*, 109: 1259-1266.

McKeigue PM, Ferrie JE, Pierpoint T, Marmot MG 1993. Association of early onset coronary heart disease in South Asian men with glucose intolerance and hyperinsulinemia. *Circulation*, 87: 152–161.

Mitra S, Bhattacharya H, Bhattacharya R, Mondal K, Patra DK, Nath S 2011. Prevalence of overweight and hypertension among rural and urban school going children and association of hypertension with overweight. *J Indian Med Assoc*, 109: 564-565.

Mohan B, Kumar N, Aslam N, Rangbulla A, Kumbkarni S, Sood NK, Wander GS 2004. Prevalence of sustained hypertension and obesity in urban and rural school going children in Ludhiana. *Indian Heart J*, 56: 310-314.

Monyeki KD, Kemper HCG, 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.

Muntner PH, J Cutler JA, Wildman RP, Welton PK 2004. Trends in blood pressure among children and adolescents. *Jama,* 291: 2107–2113.

Narayanappa D, Rajani HS, Mahendrappa KB, Ravikumar VG 2012. Prevalence of prehypertension and hypertension among urban and rural school going children. *Indian Pediatr,* 49: 755-756.

National Heart Lung and Blood Institute 1977. Report of the task force on blood pressure control in children. *Pediatrics,* 59: 797-820.

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: 555-576.

Nazroo J, Becher H, Kelly Y, McMunn A 2001. Children's health. In: B Erens, P Primatesta, G Prior (Eds.): *Health Survey for England — the Health of Minority Ethnic Groups '99 London*. London: The Stationary Office, pp. 345-395.

Pandit D, Kinare A, Chiplonkar S, Khadilkar A, Khadilkar V 2011. Carotid arterial stiffness in overweight and obese Indian children. *J Pediatr Endocrinol Metab*, 24: 97-102.

Patil RR, Garg BS 2014. Prevalence of hypertension and variation in blood pressure among school children in rural area of Wardha. *Indian J Public Health,* 58: 78-83.

Raj M, Sundaram KR, Paul M, Deepa AS, Kumar RK 2007. Obesity in Indian children: Time trends and relationship with hypertension. *Natl Med J India,* 20: 288-293.

Raj M, Sundaram KR, Paul M, Sudhakar A, Kumar RK 2010. Body mass index trend and its association with blood pressure distribution in children. *J Hum Hypertens,* 24: 652-658.

Ramachandran A, Snehalatha C, Vijay V 2004. Low risk threshold for acquired diabetogenic factors in Asian Indians. *Diabetes Res Clin Pract,* 65: 189-195.

Ramachandran A, Snehalatha C, Yamuna A, Murugesan N, Venkat Narayan KM 2007. Insulin resistance and clustering of cardiometabolic risk factors in urban teenagers in southern India. *Diabetes Care*, 30: 1828-1833.

Rao GS, Gurumurthy P, Gururajan P, Saibabu R, Cherian KM 2011. Serum E-selectin levels in Indian children and adolescents: Relation to clinical and biochemical parameters. *Pediatr Int*, 53: 40-45.

Reaven GM 1998. Banting lecture 1988: Role of insulin resistance in human disease. *Diabetes,* 37: 1595-1607.

Riley M, Bluhm B2012. High blood pressure in children and adolescents. *Am Fam Physician,* 85: 693-700.

Robinson RF, Batisky DL, Hayes JR, Nahata MC, Mahan JD 2005. Significance of heritability in primary and secondary pediatric hypertension. *Am J Hypertens,* 18: 917-921.

Saha I, Paul B, Dasgupta A, Ghosh P 2008. Variations of adolescent blood pressure by multifactorial analysis in an urban slum of Kolkata. *J Indian Med Assoc*, 106: 571-572.

Salgado C, Carvalhaes J 2003. Hipertensao arterial nainfancia. *J Pediatr,* 79: S115-S124.

Savitha MR, Krishnamurthy B, Fatthepur SS, Yashwanth Kumar AM, Khan MA 2007. Essential hypertension in early and mid-adolescence. *Indian J Pediatr,* 74: 1007-1011.

Schreier HMC, Chen E 2010. Socioeconomic status in one's childhood predicts offspring cardiovascular risk. *Brain Behav Immun*, 24: 1324-1331.

Sharma A, Grover N, Kaushik S, Bharadwaj R, Sankhyan N 2010. Prevalence of hypertension among school children in Shimla. *Indian Pediatr*, 47: 873-876.

Simonetti GD, Schwertz R, Klett M, Hoffmann GF, Schaefer F, Wühl E 2010. Determinants of blood pressure in preschool children: The role of parental smoking. *Circulation,* 2011. 123: 292–298.

Singh AK, Maheshwari A, Sharma N, Anand K 2006. Lifestyle associated risk factors in adolescents. *Indian J Pediatr,* 73: 901-906.

Tandon N, Garg MK, Singh Y, Marwaha RK 2013. Prevalence of metabolic syndrome among urban Indian adolescents and its relation with insulin resistance (HOMA-IR). *J Pediatr Endocrinol Metab,* 26: 1123-1130.

Thompson M, Dana T, Bougatsos C, Blazina I, Norris SL 2013. Screening for hypertension in children and adolescents to prevent cardiovascular disease. *Pediatrics,* 131: 490-525.

Tripathy V, Gupta R 2007. Blood pressure variation among Tibetans at different altitudes. *Ann Hum Biol*, 34: 470-483.

Uddaraju A, Ram CVS 2013. Hypertension in children, not a "small" problem. *Indian Heart J,* l65: 501-503.

Urbina EM, Gidding SS, Bao W, Pickoff AS, Berdusis K, Berenson GS 1995. Effect of body size, ponderosity, and blood pressure on left ventricular growth in children and young adults in the Bogalusa Heart Study. *Circulation,* 91: 2400-2406.

Urbina EM, Khoury PR, McCoy C, Daniels SR, Kimball TR, Dolan LM 2011. Cardiac and vascular consequences of pre-hypertension in youth. *J Clin Hypertens,* 13: 332-342.

Vale S, Trost SG, Rego C, Abreu S, Mota J 2015. Physical activity, obesity status, and blood pressure in preschool children. *J Pediatr,* 167: 98-102.

Verma M, Chhatwal J, George SM 1994. Obesity and hypertension in children. *Indian Pediatr,* 31: 1065-1069.

Verma M, Chhatwal J, George SM 1995. Biophysical profile of blood pressure in school children. *Indian Pediatr,* 32: 749-754.

Verma V, Sinah SK 2014. Influence of lean body-mass index versus that of fat mass index on blood pressure of Gujarati school going adolescents. *Indian J Physiol Pharmacol,* 58: 39-44.

Whincup PH Gilg JA, Papacosta O, Seymour C, Miller GJ, Alberti KG, Cook DG 2002. Early evidence of ethnic differences incardiovascular risk: Cross-sectional comparison of British Asian and white children. *BMJ,* 324: 635-638.

Yang Q, Zhang Z, Kuklina EV, Fang J, Ayala C, Hong Y, Loustalot F, Dai S, Gunn JP, Tian N, Cogswell ME, Merritt R 2012. Sodium intake and blood pressure among US children and adolescents. *Pediatrics,* 130: 611-619.

Zhang YX, Wang SR 2011. Monitoring of blood pressure in overweight and obese children in Shandong, China. *Ann Hum Biol*, 38: 603-607.

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