

# Prehypertension in Adolescent Children

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## Abstract

Hypertension in adolescent children was very much ignored and not considered a major issue in the past but fortunately in the recent years, it has gradually become a source of concern especially as children are known to maintain and the predictor of their blood pressures into adulthood. In the year 2004, National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents recommended a new designation of pre-hypertension for children with mildly elevated blood pressure. Epidemiological transition with increasing prevalence of Cardiac risk factors is evident in adults as well as in children. The foundations of Raised blood pressure in the adult are laid in child age and in adolescence period. The phenomenon of tracking or follow up of blood pressure directs that children and adolescents are in a raised blood pressure category tend to all in the same category when they become adults. Early diagnosis and management of prehypertension and hypertension in children and adolescent population will help in reducing the prevalence of prehypertension and hypertension with its complications in the nearby future adult population.

**Keywords:** Adolescents • Blood pressure • Cardiovascular disease • Hypertension • Pre-hypertension

## Introduction

Globally raised blood pressure population is an important public health problem because of its association with more chances of cardiovascular diseases. It is one of the leading causes of morbidity and mortality worldwide and accounted for 9.4 million deaths and 7% of DALYs (Disability Adjusted Life Years) in 2010. In 2000, around one billion of adult world population had hypertension and by 2025, this is expected to increase to two billion. In India, hypertension is the leading Non Communicable Disease with risk of nearly 10% of all deaths. [1]

Recently childhood hypertension has reached epidemic problem worldwide which is largely associated with the increase prevalence of childhood obesity [2]. Hypertension once was considered rare because of under diagnosis and lack of awareness in children and adolescents which has now become a major public health challenge as it increases the risk of coronary artery calcifications, ventricular hypertrophy and increased carotid intima media thickness. High blood pressure is the strongest indicator of adult blood pressure [2].

India is undergoing a fast epidemiological transition; the problem of chronic diseases is over taking the burden of infectious diseases. According to world health report, 2002, in India, cardiovascular diseases will be major cause of morbidity and mortality by 2020. In 2020, 2.6 million, Indians are predicted to die due to coronary artery disease and nearly half of deaths are likely to occur in young and middle aged individuals. In short, Hypertension is the main leading cause of global disease burden [3].

Hypertension, at present becoming a source of growing concern in children in developing countries. Therefore, measurement of blood pressure and early detection of prehypertension and hypertension is essential to minimize complications later in life [4]. Hypertension is one of the ten

frequently occurred common chronic diseases in childhood which predisposes children to adult hypertension [5].

Adolescence (10-19 years) is an important period of growth and maturation of children. During this time period most of the mental and physical changes occurs to which continues till adulthood. It is a most important developmental phase (transition period) in the life of adolescents from childhood to adulthood. Here children start to make their individual choices and develop personal life styles. Unfortunately, most of the lifestyle patterns adopted by adolescent children are really a dangerous to their physical and mental health also to wellbeing. Nearly two- third of premature death and one- third of disease burden are associated with conditions or behaviors that began in adolescence including diet pattern, exercise, tobacco and alcohol use. Most of these behaviors and risk factors are preventable as well as modifiable if proper lifestyle modification is done. Early phase of adolescence childhood is the proper time for these interventions [1]. The foundations of hypertension in an adult life are laid in childhood and adolescence. There is a tendency for blood pressure to gradually increase with age [6].

Identification of the precursors of cardiac diseases in childhood is the very important milestone because the risk for cardiac disease starts at low levels of blood pressure. The National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents (Working Group-2004) with recent updated recommendations for the evaluation of elevated blood pressure in adults created a new designation of "Prehypertension" to identify children and adolescents for future risk of developing hypertension. Hypertension and prehypertension are well-defined, prevalent, asymptomatic, chronic conditions in children and adolescents [7,8].

The Fourth Report described "Prehypertension" as an indication for lifestyle modification and also recommended blood pressure monitoring

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approximately every 6 months. No recommendation was made on repeated measurement of blood pressure to verify the designation of prehypertension [9].

As per American medical classification, Prehypertension (high normal blood pressure or borderline hypertension) is increased blood pressure is above normal but not up to the level of to be considered as hypertension. Prehypertension is an early warning for possible changes that could lead to cardiac and renal diseases [10].

Prehypertension requires more careful attention and is a single significant risk factor for future development of hypertension in adolescents. Overweight and obesity are important contributing factors for adolescent prehypertension. Hypertension associated with obesity in childhood is largely preventable [11].

The trends of increasing prevalence of prehypertension and hypertension in urban as well as rural population alerts for a joint effort targeted at recognizing asymptomatic hypertension and prehypertension in children and adolescents. Earlier is the age of onset of untreated hypertension there will be more reduction in life expectancy [10]. Indian children are more susceptible for obesity mediated hypertension which is one of the modifiable risk factor for childhood hypertension.

## Prevalence of Pre-Hypertension

**Table 1.** Pre-Hypertension in Adolescents: Risk and Progression [8].

No.	Study	Place	Year	Prehypertension	Hypertension
1	Working Group report			12–17%	
2	Salma Shaziya and Soumya M	Madikeri, Karnataka	2015	16.13%	
3	Zhaoyang Fan ID et al.	Beijing, China	2019	6.0%	10.6%
4	Roya Kelishadia and Ramin Heshmatb	Isfahan, Iran	2013	6.9%	5.6%
5	Riley, Margaret, Anita K Hernandez, and Angela L Kuznia [14]	Ann Arbor, Michigan	2012	3.4%	3.6%
6	Ujunwa, Fortune A, Anthony N Ikefuna, Ada RC Nwokocho, and Josephat M Chinawa [10]	Enugu, Nigeria	2013	17.3%	5.4%
7	F. Odey et al.	Calabar, Nigeria	2003	7.5%	6.7%
8	Ostrowska-Nawarycz et al.	Poland	2007	11.1%	
9	McNiece et al.	USA	2007	9.5%	
10	Tony, Lawrence, Binu Areekal, AT Surendran Nair, and R Ramachandran, et al. [6]	Kerala, India	2016	21.3%	21.4%
11	Patel, Ashish, Anil Bharani, Meenakshi Sharma, and Anuradha Bhagwat, et al. [16]	Indore, M.P	2019	6.5%	6.8%
12	Sharma et al.	Shimla		12.3%	5.9%
13	Vedavathy S. Sangamesh	Bangalore, India	2016	3.6%	
14	Maryam Rafraf	Tabriz, Iran	2010	13.9%	19.4%
15	Juarez-Rojas et al.	Mexican	20 08	10%	10.6%
16	Moore et al.	America.	2009	16.7%	13.8%
17	Rajendra Bhimma et al.	KwaZulu-Natal, South Africa	2018	29.7%	13.7%
18	Chukwunonso ECC Ejike et al.	Nigeria	2009	22.2%	17.5%

### Definitions of prehypertension

The Fourth Report of the Task Force on Blood Pressure Control in Children commissioned by the National Heart, Lung and Blood Institute

(NHLBI)-When a child's average blood pressure exceeds the 90th percentile but is less than 95th percentile for age, sex and height (Tables 1 and 2) [4].

The World Health Organization classifies prehypertension as a blood pressure reading that measures between 120/80 and 139/89 [11,12].

**Table 2.** Blood pressure reading.

Classification	JNC 7 (mmHg)	2004 Working Group (Percentile for age, height and gender)
Normotensive	<120/80	<90th
Pre-hypertensive	120–139 / 80–89	90th – < 95th or if BP ≥ 120/80 mmHg even if <90th
Stage 1	140–159 / 90–99	95th–99th + 5 mmHg (at 3 separate visits)
Stage 2	≥160/100	>99th + 5 mmHg (at 3 separate visits)

**Causes of pre-hypertension and hypertension**

Primary hypertension: No underlying cause.  
 History of hypertension in any family member.  
 Overweight or obesity.  
 Common in infants.

Secondary hypertension: Known underlying medical cause (Table 3).  
 80% of children have kidney disease or blood vessel abnormalities.  
 5% have an endocrinological disorder.  
 2 to 5% have heart disease.  
 Common in Children and adolescents [13,14].

**Table 3.** Risk factors for Prehypertension [11-15].

Overweight and obesity	Medicines-Steroids or OC pills
Stress	Premature birth or low birth weight
Lack of exercise	Family history of hypertension
Too much salt in the diet	Long term breastfeeding reduces risk of hypertension.
Use of alcohol, tobacco or illegal drugs	Maternal smoking during pregnancy
Male sex	Eating high sodium foods
Black Childers	No clear genetic pattern.
Sedentary lifestyle	Children born to hypertensive parents
Poor diet habits	Disorders of sleep- Obstructive sleep apnea, primary snoring, sleep fragmentation

**Clinical features**

Most of the times Prehypertension is asymptomatic at the time of diagnosis (Table 4).

**Table 4.** Prehypertension symptoms [11,13].

Headaches	Chest pain
Loss of vision	Abdominal pain
Double-vision	Breathing problems
Fatigue	Dizziness

**Measurement of Blood Pressure**

Quiet and comfortably sitting child with back supported and feet are touching to the ground for five minutes.

Measurement of Blood pressure to be done in the right arm well supported at the level of heart.  
 Blood pressure cuff having inflatable bladder width of 40 percent and length of 80 to 100 percent of the arm circumference.  
 Blood pressure cuff is tied point midway between acromion and olecranon of arm circumference.

Measurements should be taken to the nearest 2 mmHg. First, fourth and fifth Korotkoff sound phases to be noted. First and fourth Korotkoff sounds are taken as the systolic and diastolic pressures respectively as recommended by the 4th Report on the diagnosis, evaluation and treatment of high blood pressure in children and adolescents. If blood pressure reading is more than 90th percentile, measurement should be repeated to confirm validity in same visit. To diagnose as a prehypertension or hypertension, Blood pressure readings should be elevated on three separate occasions [14] (Figures 1-4).

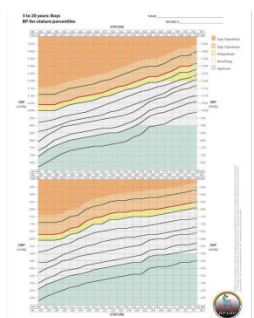


Figure 1. Percentile charts for Boys.

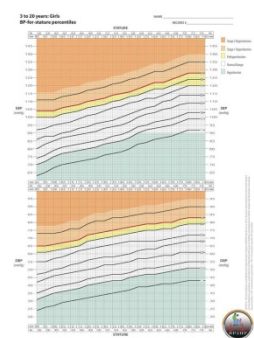


Figure 2. Percentile charts for Girls [15-17].

Age	Sex	Height Percentile	Systolic Blood Pressure (mmHg)	Diastolic Blood Pressure (mmHg)
10	Boys	5	100	60
10	Boys	10	105	65
10	Boys	15	110	70
10	Boys	20	115	75
10	Boys	25	120	80
10	Boys	30	125	85
10	Boys	35	130	90
10	Boys	40	135	95
10	Boys	45	140	100
10	Boys	50	145	105
10	Boys	55	150	110
10	Boys	60	155	115
10	Boys	65	160	120
10	Boys	70	165	125
10	Boys	75	170	130
10	Boys	80	175	135
10	Boys	85	180	140
10	Boys	90	185	145
10	Boys	95	190	150
10	Boys	100	195	155
10	Boys	105	200	160
10	Boys	110	205	165
10	Boys	115	210	170
10	Boys	120	215	175
10	Boys	125	220	180
10	Boys	130	225	185
10	Boys	135	230	190
10	Boys	140	235	195
10	Boys	145	240	200
10	Boys	150	245	205
10	Boys	155	250	210
10	Boys	160	255	215
10	Boys	165	260	220
10	Boys	170	265	225
10	Boys	175	270	230
10	Boys	180	275	235
10	Boys	185	280	240
10	Boys	190	285	245
10	Boys	195	290	250
10	Boys	200	295	255
10	Boys	205	300	260
10	Boys	210	305	265
10	Boys	215	310	270
10	Boys	220	315	275
10	Boys	225	320	280
10	Boys	230	325	285
10	Boys	235	330	290
10	Boys	240	335	295
10	Boys	245	340	300
10	Boys	250	345	305
10	Boys	255	350	310
10	Boys	260	355	315
10	Boys	265	360	320
10	Boys	270	365	325
10	Boys	275	370	330
10	Boys	280	375	335
10	Boys	285	380	340
10	Boys	290	385	345
10	Boys	295	390	350
10	Boys	300	395	355
10	Boys	305	400	360
10	Boys	310	405	365
10	Boys	315	410	370
10	Boys	320	415	375
10	Boys	325	420	380
10	Boys	330	425	385
10	Boys	335	430	390
10	Boys	340	435	395
10	Boys	345	440	400
10	Boys	350	445	405
10	Boys	355	450	410
10	Boys	360	455	415
10	Boys	365	460	420
10	Boys	370	465	425
10	Boys	375	470	430
10	Boys	380	475	435
10	Boys	385	480	440
10	Boys	390	485	445
10	Boys	395	490	450
10	Boys	400	495	455
10	Boys	405	500	460
10	Boys	410	505	465
10	Boys	415	510	470
10	Boys	420	515	475
10	Boys	425	520	480
10	Boys	430	525	485
10	Boys	435	530	490
10	Boys	440	535	495
10	Boys	445	540	500
10	Boys	450	545	505
10	Boys	455	550	510
10	Boys	460	555	515
10	Boys	465	560	520
10	Boys	470	565	525
10	Boys	475	570	530
10	Boys	480	575	535
10	Boys	485	580	540
10	Boys	490	585	545
10	Boys	495	590	550
10	Boys	500	595	555
10	Boys	505	600	560
10	Boys	510	605	565
10	Boys	515	610	570
10	Boys	520	615	575
10	Boys	525	620	580
10	Boys	530	625	585
10	Boys	535	630	590
10	Boys	540	635	595
10	Boys	545	640	600
10	Boys	550	645	605
10	Boys	555	650	610
10	Boys	560	655	615
10	Boys	565	660	620
10	Boys	570	665	625
10	Boys	575	670	630
10	Boys	580	675	635
10	Boys	585	680	640
10	Boys	590	685	645
10	Boys	595	690	650
10	Boys	600	695	655
10	Boys	605	700	660
10	Boys	610	705	665
10	Boys	615	710	670
10	Boys	620	715	675
10	Boys	625	720	680
10	Boys	630	725	685
10	Boys	635	730	690
10	Boys	640	735	695
10	Boys	645	740	700
10	Boys	650	745	705
10	Boys	655	750	710
10	Boys	660	755	715
10	Boys	665	760	720
10	Boys	670	765	725
10	Boys	675	770	730
10	Boys	680	775	735
10	Boys	685	780	740
10	Boys	690	785	745
10	Boys	695	790	750
10	Boys	700	795	755
10	Boys	705	800	760
10	Boys	710	805	765
10	Boys	715	810	770
10	Boys	720	815	775
10	Boys	725	820	780
10	Boys	730	825	785
10	Boys	735	830	790
10	Boys	740	835	795
10	Boys	745	840	800
10	Boys	750	845	805
10	Boys	755	850	810
10	Boys	760	855	815
10	Boys	765	860	820
10	Boys	770	865	825
10	Boys	775	870	830
10	Boys	780	875	835
10	Boys	785	880	840
10	Boys	790	885	845
10	Boys	795	890	850
10	Boys	800	895	855
10	Boys	805	900	860
10	Boys	810	905	865
10	Boys	815	910	870
10	Boys	820	915	875
10	Boys	825	920	880
10	Boys	830	925	885
10	Boys	835	930	890
10	Boys	840	935	895
10	Boys	845	940	900
10	Boys	850	945	905
10	Boys	855	950	910
10	Boys	860	955	915
10	Boys	865	960	920
10	Boys	870	965	925
10	Boys	875	970	930
10	Boys	880	975	935
10	Boys	885	980	940
10	Boys	890	985	945
10	Boys	895	990	950
10	Boys	900	995	955
10	Boys	905	1000	960
10	Boys	910	1005	965
10	Boys	915	1010	970
10	Boys	920	1015	975
10	Boys	925	1020	980
10	Boys	930	1025	985
10	Boys	935	1030	990
10	Boys	940	1035	995
10	Boys	945	1040	1000
10	Boys	950	1045	1005
10	Boys	955	1050	1010
10	Boys	960	1055	1015
10	Boys	965	1060	1020
10	Boys	970	1065	1025
10	Boys	975	1070	1030
10	Boys	980	1075	1035
10	Boys	985	1080	1040
10	Boys	990	1085	1045
10	Boys	995	1090	1050
10	Boys	1000	1095	1055
10	Boys	1005	1100	1060
10	Boys	1010	1105	1065
10	Boys	1015	1110	1070
10	Boys	1020	1115	1075
10	Boys	1025	1120	1080
10	Boys	1030	1125	1085
10	Boys	1035	1130	1090
10	Boys	1040	1135	1095
10	Boys	1045	1140	1100
10	Boys	1050	1145	1105
10	Boys	1055	1150	1110
10	Boys	1060	1155	1115
10	Boys	1065	1160	1120
10	Boys	1070	1165	1125
10	Boys	1075	1170	1130
10	Boys	1080	1175	1135
10	Boys	1085	1180	1140
10	Boys	1090	1185	1145
10	Boys	1095	1190	1150
10	Boys	1100	1195	1155
10	Boys	1105	1200	1160
10	Boys	1110	1205	1165
10	Boys	1115	1210	1170
10	Boys	1120	1215	1175
10	Boys	1125	1220	1180
10	Boys	1130	1225	1185
10	Boys	1135	1230	1190
10	Boys	1140	1235	1195
10	Boys	1145	1240	1200
10	Boys	1150	1245	1205
10	Boys	1155	1250	

Rennin	High levels of CRP
Aldosterone	Increased levels of plasminogen activator inhibitor-1 (pai-1)
Vitamin d3	Urinary albumin excretion (UAE)
Homocysteine	B-type natriuretic peptide
Aldosterone level,	N-terminal pro-atrial natriuretic peptide

**Table 7.** Biomarkers in disease progression.

CRP	PAI-1	OX-LDL
Leptin	TNF ALPHA	ADMA
SDMA	EH	

Biomarker in control of HTN- There is an increase in CD45+ and CXCR2+ cells in the aorta (Tables 8-11).

**Biomarkers of target organ damage due to hypertension**

**Table 8.** Cardiac damage.

Microalbuminuria	BNP
Galectin 3 (gal-3)	Cardiac troponins
Markers of collagen turnover	

**Table 9.** Vascular damage.

E-selectin	Plasma vascular endothelial growth factor (plasma VEGF)
Fibrinogen	Serum cystatin-C concentration

**Table 10.** Renal damage.

Serum creatinine	GFR	UAE
Adrenomedullin	Vanil mandellic acid (VMA)	Metanephrin

**Table 11.** Cerebral damage.

Ubiquitin C-terminal hydrolase-L1 (UCH-L1) levels
Enolase (NSE) are promising future biomarkers

Avoid junk foods.

**Lifestyle modification**

- Reaching and maintaining a healthy weight [12].
- Regular exercise for 30 minutes of moderate exercise such as brisk walking [22].
- Stress control.

**Medications**

Use of thiazide diuretics, Angiotensin-converting enzyme inhibitors, calcium channel blockers and angiotensin receptor blockers are effective and safe also well tolerated by children and adolescents [14].  
Beta blockers are not used as first line treatment in children [17].  
Drug therapy with antihypertensive in Children should be with lowest recommended dosage and titrated up periodically every two to four weeks till the decided blood pressure is achieved [22] (Table 12).

**Table 12.** SBP reduction range.

No.	Modification	SBP reduction (range)
1	Weight reduction	5-20 mm Hg/10 kg
2	Adopt DASH eating plan	8-14 mm Hg
3	Dietary sodium reduction	2-8 mm Hg
4	Physical activity	4-9 mm Hg

**Treatment**

**Diet**

DASH diet- Dietary Approaches to Stop Hypertension.  
A low-sodium and high potassium diet.  
More fruits in diet [11].  
Non-starchy vegetables like beans, green leafy vegetables, cucumbers, carrots and tomatoes [19].  
Use of Whole grains.  
Limit diet with Tran's fatty acid.  
Low proportion of refined carbohydrates like sugar, white flour and corn syrup in diet [20].  
Drink plenty of water.  
Eat Potassium rich fruits like papaya, banana, dark leafy greens, sweet potato, prune juice, tomato juice, avocado, oranges, yogurt, milk, dried beans and black beans, chickpeas, lentils, fish, beef, pork, nuts and seeds such as flax, pistachio, pumpkin, almonds and sunflower seeds [21].

5	Smoking cessation	2-4 mm Hg
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## Prevention of Pre Hypertension

- Keep normal weight as per height.
- Daily Exercise for about an hour.
- Take healthy and nutritious diet.
- Don't take alcohol, tobacco products, or illegal drugs [15].
- Keep stress levels low, practice relaxation and breathing exercises.
- Don't take extra salt in food.
- Avoid fast food and junk foods.
- Checking of blood pressure and monitoring of weight regularly [23-25].

## Prognosis

Prehypertension increases the chances of heart attacks, congestive heart failure, strokes and kidney failure. Prehypertensive adolescents are three times more prone to have a heart attack compared to a person with normal blood pressure [11].

## Conclusion

The following conclusions can be drawn from the above study:

Raised blood pressure in children and adolescents is a growing health problem which is mostly overlooked. Children and adolescents should be screened for elevated blood pressure annually from the age of three years or at every visit if risk factors are presents.

Periodic screening and monitoring of blood pressure of adolescents should be incorporated into the school health Programme, also general public health education on hypertension and its associated risk factors should be strengthened.

The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents emphasized that all children of 3 years should be doing their blood pressure measurement regularly by every six months.

Education regarding the prevalence of prehypertension and hypertension in Paediatrics population would be useful for policy makers, in order to highlight the significance of training health professionals about integrating blood pressure measurement and tracking in healthy children, and to increase the public awareness about the importance of prevention and control of Pre hypertension from early life.

It is suggested that blood pressure measurement should be done during routine checkup and visit with adolescents whenever they attend clinics.

Health care providers should be sensitized about the situation and made capable of providing preventive measures and guidance on the issue of Prehypertension and hypertension in children.

Circulating biomarkers will be the future of primordial prevention, better control and decrease in death and disability related to Prehypertension and hypertension in children.

Always keep in mind that blood pressure in childhood is the best independent predictor for future Pre hypertension and hypertension in adult life.

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