International Journal of Contemporary Pediatrics
Dwivedi GN et al. Int J Contemp Pediatr. 2016 Aug;3(3):971-976
http://www.ijpediatrics.com
pISSN 2349-3283 | eISSN 2349-3291

DOI: http://dx.doi.org/10.18203/2349-3291.ijcp20162375

Research Article

Association of blood pressure with body mass index and waist circumference in adolescents

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Received: 05 May 2016
Accepted: 10 June 2016

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ABSTRACT

Background: Hypertension in children is increasing along with the childhood obesity epidemic. Body mass index (BMI) and waist circumference (WC) are commonly used indices to assess obesity. WC as a visceral fat indicator can be suggested to be a better predictor of CVD risk such as high BP than BMI, which reflects both lean and fat mass. There are few studies investigating the relationship between WC and elevated blood pressure in school age children. Hence this study was undertaken to study the effect of body mass index and waist circumference on blood pressure.
Methods: A total of 610 children aged 10-18 years who completed both anthropometric and BP measurements were studied. Height, weight, body mass index, waist circumference and blood pressure were recorded.
Results: SBP and DBP was found to be higher in children with high BMI (>85th percentile) and high WC (>90th percentile) groups. Waist circumference and BMI are strongly associated with both SBP and DBP ($p< 0.001$).
Conclusions: This study showed that increased BMI and WC are good predictors of rise in SBP and DBP. WC is easier to measure than blood pressure in terms of training and access to equipment, especially in low income settings. Therefore we suggest measurement of WC as a screening tool for childhood hypertension.

Keywords: Obesity, Waist circumference, Body mass index, Blood pressure

INTRODUCTION

There is alarming rise in obesity among children and adolescents worldwide. WHO has called obesity a "Global Epidemic".[1] Hypertension in children is increasing along with the childhood obesity epidemic. Childhood obesity may persist into adulthood and hence this may increase the risk of cardiovascular disease (CVD) later in life including hypertension and metabolic syndrome.[2-6] In addition, childhood obesity is associated with high risk of adult hypertension.[7]Blood pressure measurement is not a part of regular health check -ups in children and this leads to under diagnosis of hypertension in children.[8] Thus, the prevention of obesity in childhood may be important in reducing the risk of CVD later in life.

Body mass index (BMI) and waist circumference (WC) are commonly used indices to assess obesity. Considering that adiposity and fat distribution may be more strongly associated with CVD than simple body mass, and that WC reflects central adiposity, WC can be suggested to be a better indicator of CVD risk such as high BP, than BMI, which reflects both lean and fat mass.[9] Waist circumference (WC) as a visceral fat indicator has already been well explored in the adult population and has more recently been identified as a risk factor in children and adolescents.[10-12]

Evidences suggest the importance of measuring abdominal obesity besides general obesity for the evaluation of health risks in the first decades of life.[13] However, whether WC measured in childhood correlates better with high BP than BMI is still unresolved.[14,15]This cross sectional study was undertaken to study relationship of BMI and WC with blood pressure.

METHODS

This study was conducted as a part of regular health examination in different public schools of Kanpur. The study was approved by the Institutional Research Ethics Committee.

A total of 610 children aged 10-18 years who completed both anthropometric and BP measurements were studied. Informed consent from schools and parents of children was taken. Weight, height, waist circumference and BP measurements were recorded.

Weight was measured to the nearest 0.5 kg using electronic weighing scale, with the subjects wearing lightweight gown or underwear. Height was measured to the nearest 0.1 cm using wall mounted height board. Child stood straight with no shoes; heels, buttocks, shoulder blades and back of head touching the vertical wall surface and looking directly forwards with Frankfurt plane (the line joining floor of external auditory meatus to the lower margin of orbit) and the being horizontal. BMI was calculated using standard formula: weight (kilograms)/height (meters^2). According to BMI, children were categorized into 3 groups: normal weight, overweight and obese as per World Health Organization (WHO) child growth standards (BMI greater than 95th percentile obese; BMI between 85th and 95th percentile - overweight). Waist circumference was measured to the nearest 0.1 cm with nonelastic flexible tape with child standing without clothes. The smallest circumference between the hip and chest was measured at the end of gentle expiration. The following anatomical landmarks were used: laterally, midway between the lowest portion of the rib cage and iliac crest, and anteriorly midway between the xiphoid process of the sternum and the umbilicus. According to WC, children were divided into two groups (normal and high WC) using 90th percentile as cut-off for "high WC."

BP was measured by auscultatory method using a mercury sphygmomanometer and appropriately sized cuff (bladder width of approximately 40% of arm circumference midway between olecranon and acromion; inflatable bladder covering at least two thirds of upper arm length and 80-100% of its circumference). We measured BP after 5-10 minutes of quiet rest with the subjects seated and the right arm positioned at the level of the heart. To avoid the effects of white coat hypertension, blood pressure was measured twice on each occasion and blood pressure value was taken as the mean of the two measurements. The first and fifth Korotkoff sounds were recorded as the systolic and diastolic blood pressure.[16] Average systolic blood pressure (SBP)and/or diastolic blood pressure ≥ 90th percentile for age, sex and height was defined as cut off for "high SBP" and "high DBP," respectively.[17]

Data was analysed with the software Statistical Package for the Social Science 17.0 (SPSS 17.0). The non-paired Student t –test was used. Values were expressed as mean ± standard deviation. P values <0.05 indicated statistical significance.

RESULTS

The present study included 610 adolescents aged 10–18 years (355 boys and 255 girls). Out of these children, 32.79 % (200/610) had normal BMI, 44.26% (270/610) were overweight and 22.95% (140/610) were obese. 30.33% (185/610) children had normal waist circumference and 69.67% (425/610) had high waist circumference.

Table 1: Comparison of blood pressure in children with normal and high waist circumference.

Parameter	High WC(N=185)	Normal WC waist (N=425)	t	p value	Inference
Age	13.27±1.84	13.11±1.89	0.97	>0.05	Not significant
Weight	63.2±5.51	45.97±11.97	24.33	<0.001	Highly significant
Height	151.21±8.71	149.08±8.84	2.76	<0.05	Significant
BMI	28.16±2.77	20.33±4	27.83	<0.001	Highly significant
SBP	115.22±8.23	109.51±6.76	8.29	<0.001	Highly significant
DBP	71.49±5.45	68.12±3.44	7.76	<0.001	Highly significant

10% (20/200) children with normal BMI, 12.59% (34/270) overweight and 27.86% (39/140) obese children had systolic hypertension. Diastolic hypertension was present in 0.5% (1/200), children with normal BMI, 6.67% (18/270) overweight and 15.71% (22/140) obese children.

5.41% (23/425) children with normal waist circumference and 38.92% (72/185) children with high waist circumference had high systolic BP. High diastolic BP was present in 0.23% (1/425) children with normal waist circumference and 21.62% (40/185) children with high waist circumference.

To study the effect of BMI & WC on BP, analysis was done separately in these groups: normal waist circumference (≤90th percentile) vs. high waist circumference (>90th percentile) groups; normal BMI (BMI ≤85th percentile) vs. overweight (BMI between 85th and 95th percentile) and normal BMI vs. obese (>95th percentile). Age and height-adjustment was done as there are known effects of age and height on BP.

Table 2: Comparison of blood pressure in children with normal BMI and obese children.

Parameter	Normal BMI (N=200)	Obese (N=140)	t	p value	Inference
Age	13.05±2.01	13.07±1.69	0.09	>0.05	Not significant
Weight	35.59±5.87	65.00±0.00	70.85	<0.001	Highly significant
Height	146.27±8.42	150.82±8.25	4.96	<0.001	Highly significant
SBP	109.94±7.84	113.34±7.62	4.00	<0.001	Highly significant
DBP	67.19±3.73	70.25±4.83	6.29	<0.001	Highly significant

Table 3: Comparison of blood pressure in children with normal BMI and over weight children.

Parameter	Normal BMI (N=200)	Obese (N=140)	t	p value	Inference
Age	13.05±2.01	13.32±1.86	0.27	>0.05	Not significant
Weight	35.59±5.87	55.58±8.00	19.99	<0.001	Highly significant
Height	146.27±8.42	151.73±8.71	5.46	<0.001	Highly significant
	16.84±1.55	23.80±1.74	6.96	<0.001	Highly significant
SBP	108.94±7.84	111.12±7.4	3.06	<0.05	Highly significant
DBP	67.19±3.73	69.99±4.18	2.80	<0.05	Highly significant

SBP was more in children with high waist circumference (115.22 ± 8.23) than in children with normal waist circumference (109.51±6.76). DBP also showed greater values in children with high waist circumference (71.49±5.45) than in children with normal waist circumference (68.12±3.44). Thus, we found that waist circumference has strong association with both SBP and DBP (p< 0.001).

SBP in obese (113.34± 7.62) and overweight children (111.12±7.4) was greater than in children with normal BMI (108.94±7.84). DBP was also higher in overweight (69.99±4.18) and obese (70.25±4.83) than in children with normal BMI (67.19±3.73). Hence, BMI showed strong association with both SBP and DBP (p <0.001).

Our study showed that high BMI and high WC significantly increase the incidence of high SBP and DBP (>90th percentile) and are good predictors of rise in SBP and DBP.

DISCUSSION

Childhood obesity demands medical attention due to increasing prevalence worldwide and its long-term consequences in adulthood. BMI and WC are commonly used indices of obesity. Numerous studies have reported positive correlations between high BMI, high WC and elevated SBP and DBP in children and adolescents.[18-20] In adults, it has been shown that central distribution of body fat is closely associated with adverse cardiovascular outcomes. However, this has not been proven in children or adolescents so far.

Some reports demonstrate association between arterial blood pressure and BMI, suggesting that obesity is a strong risk factor for high blood pressure in childhood and adult life.[7,21] In a study by Bin Chen et al among preschool children, systolic BP and diastolic BP were significantly higher in obese children than that in normal weight children in both sexes (p<0.001). Overweight children had significantly higher systolic and diastolic BP than normal weight children in boys (p<0.01).[22] Wang WJ et al studied relationship of body mass index and blood pressure in 7 -15 years old children and adolescents of Beijing and found means of SBP and DBP to be significantly higher in obesity group than overweight, while overweight was significantly higher than normal weight group (P <0.0001).[23]

Qing HE et al showed that an increase in the adjusted BMI is associated with an increase in SBP and DBP in obese and non-obese children. He found both SBP and DBP to be significantly (P<0.05) related to body mass index (BMI) values for children in obese and non-obese groups after adjustment for age, gender, and height. To be specific, an increase of 1 BMI unit was associated with, on average, an increase of 0.56 mm Hg and 0.54 mm Hg

in SBP and DBP respectively, for obese children. In non-obese children, the increase in SBP and DBP was 1.22 mm Hg and 1.20 mm Hg, respectively.[24]

Ribeiro J et al found systolic and diastolic blood pressures to be significantly ($p < 0.05$) and positively related to BMI.[25] Fox et al showed that among obese patients, more than half had elevated BP: 31.5% were pre-hypertensive and 26.1% were hypertensive.[26] Israeli E et al also observed that prevalence of pre hypertension was significantly higher in obese subjects.[27]

In a study by Rao S et al among adolescents (age range 9-16 years) in Pune, mean level of SBP among overweight children was significantly ($P<0.001$) higher by about 12 mm Hg, whereas that for diastolic blood pressure was higher by 8 mm Hg ($P<0.001$) as compared to their non-overweight (age, sex matched) counterparts.[28] Gupta AK et al conducted study in 3,861 school children in the age group 5-15 years, among which 292 were obese. He found out that the mean blood pressure levels, both systolic and diastolic, were significantly higher in the obese subjects compared to the controls ($p< 0.001$). Out of 292, 10 were detected to have sustained elevations in BP levels (BP greater than mean + 2 SD for age & sex) on monthly follow up for 6 months.[29]

Luisa María et al also concluded that higher body mass index is associated with elevated systolic and diastolic blood pressure levels.[30] Flores Huerta S.et.al performed study in Mexico city schools among population ranging from 5–8 (n = 474), 9–12 (n = 643) and 13–17 (n = 912) years, respectively and concluded that the levels of blood pressure were higher in overweight and obese children and adolescents.[31]

Similar to above mentioned studies, our findings suggest that increase in body mass index exerts influence on both SBP and DBP.

Mazicioglu MM et al investigated relationship between various anthropometric parameters and elevated blood pressure in adolescents and found only BMI and WC to be significant among all participants irrespective of age and sex.[32] Da Silva AC et al concluded that BMI and WC have strong association with SBP and are easy, non-invasive, low cost methods to detect the risk of high BP in children and adolescents.[33] In a study by Young-Hwan Song et al systolic BP (SBP) in both sexes and diastolic BP (DBP) in boys were higher in the high BMI (>85th percentile) and high WC (>90th percentile) groups.[34]ColínRamírez E.et.al concluded that waist circumference was the main factor associated with systolic hypertension.[35] According to Genovesi et al waist circumference improves the ability of BMI to identify hypertension in obese children.[36] Ying Xiu Zhang observed the strongest correlation of BP with WC amongst BMI, WC, Waist Height Ratio and WC.[37] The prevalence of relatively high BP increased from 9.21% (boys) and 11.76% (girls) in the <5th WC percentile group to 58.99% (boys) and 40.34% (girls) in the ≥95th WC percentile group, an increase of 5.4 and 2.4 times.

Our study meticulously investigated the relationship between WC and elevated blood pressure among children aged 10-18 years and found waist circumference per se to be a useful parameter to predict elevated blood pressure independently of body mass index. Children with elevated blood pressure had higher mean WC than those with normal blood pressure. Similar associations between elevated blood pressure and WC have been documented among children in aforementioned studies.

CONCLUSION

Our study demonstrates that in addition to BMI, increased waist circumference is an indicator of high blood pressure in children. Blood pressure measurement requires greater operator skill and blood pressure is liable to be falsely elevated unless measured with care and in stress free situations. WC is much easier to measure than blood pressure in terms of training and access to equipment, especially in low income settings. Therefore we suggest measurement of WC as a screening tool for childhood hypertension.

ACKNOWLEDGEMENTS

Our special thanks to staff members of different schools for their cooperation during collection of data.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Dwivedi GN, Sethi S, Singh R, Singh S. Association of blood pressure with body mass index and waist circumference in adolescents. Int J Contemp Pediatr 2016;3:971-6.