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Research Article

Anthropometric variables and cardiovascular risk factors in adolescents

Gopal N. Dwivedi, Shiny Sethi*, Rachna Singh, Sushil Sharma

Department of Pediatrics, GSVM Medical College, Kanpur, Uttar Pradesh, India

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***Correspondence:**
Dr. Shiny Sethi,
E-mail: dr.shinysethi@gmail.com

ABSTRACT

Background: Childhood Obesity is increasing worldwide including the developing countries. Obesity defined by body mass index (BMI) is likely to be associated with increased risk of cardiovascular disease. However, waist circumference (WC), a marker of central adiposity, may be better indicator of cardiovascular disease risk. In children, the relationship between body-fat distribution and disease risk factors is not yet clear. Hence this study was undertaken to explore the relationship between anthropometric variables, lipid concentrations, and blood pressure (BP) and to assess the clinical relevance of waist circumference in identifying children with higher cardiovascular risk.

Methods: A total of 610 children (355 boys and 255 girls) were studied. Height, weight, waist circumference, BP and plasma lipid profile (total cholesterol, LDL cholesterol, Apo-lipoprotein A1 (Apo-A1), and Apo-lipoprotein B (Apo-B) were determined.

Results: The plasma lipid profile and blood pressure was significantly higher in children with high waist circumference than in children with normal waist circumference. Waist circumference showed strong association with plasma lipid profile and blood pressure ($p< 0.001$).

Conclusions: Since WC is a good predictor of cardiovascular risk factors, we suggest that all children with high WC should undergo routine screening for hypertension and abnormal lipid profile.

Keywords: Obesity, Waist circumference, Body mass index, Plasma lipid profile, Blood pressure

INTRODUCTION

Obesity is becoming an important health problem worldwide including the developing countries. WHO has labelled it as Global epidemic.[1] This global increase in the prevalence of childhood obesity is cause of concern as obesity in childhood has been shown to develop into adulthood obesity, and hence, it may increase the risk of cardiovascular disease (CVD) later in life.[2-5] It is associated with adverse levels of cardiovascular disease (CVD) risk factors such as total cholesterol, Low Density Lipoprotein (LDL) cholesterol, High Density Lipoprotein (HDL) cholesterol, triglycerides, fasting insulin, and systolic blood pressure. Thus, the prevention of childhood obesity may be important in reducing the risk of CVD later in life. This suggests the need for early diagnosis of obesity as well as simple and sensitive indexes of metabolic and cardiovascular risks in obese individuals early in life.

Several epidemiological studies support the hypothesis that the relationship between adiposity and risk of disease begins early in life.[6,7] Assessment of body-fat distribution could possibly identify subjects with the highest risk of adverse lipid profile and hypertension. Accurate methods used to assess total body fat (DXA) and body-fat distribution (computed tomography and magnetic resonance imaging) in humans are not suitable for use in large population studies because of cost, irradiation exposure (i.e., computed tomography), and limited availability outside the research setting.[8] To obtain a reasonable estimation of body-fat distribution in children, several anthropometric parameters have been proposed, such as subcutaneous skinfolds and body circumferences, which are easy to perform and have a sufficient degree of accuracy.

Simple anthropometric measures, such as body mass index (BMI) and waist circumference (WC), have been used to investigate the association between adiposity and cardiovascular risk factors in adults.[9] Recently, studies on children seem to confirm the usefulness of waist circumference as an appropriate index of metabolic and cardiovascular risk also in the prepuberty years.[10,11] However, few data are available for the period during puberty. Puberty affects cardiovascular and metabolic risk factors differently in males and females by the combined effects of hormones, changes of body composition and body fat distribution, and psycho behavioural changes that may have relevant effects on one's lifestyle and nutritional habits.

Since WC reflects central adiposity, it can be suggested to be a better indicator of CVD risk such as high BP, than BMI, which reflects both lean and fat mass. [12] Waist circumference 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.[13-15] However, the degree of association between cardiovascular risk factors and anthropometric parameters has not been studied extensively in children. Few data is available on the relationship between body-fat distribution and cardiovascular risk factors in children Evidences suggest the importance of measuring abdominal obesity besides general obesity for the evaluation of health risks in the first decades of life.[16] Hence, the present study was undertaken to explore the relationship between anthropometric variables, lipid concentrations, and blood pressure (BP) and to assess the clinical relevance of waist circumference in identifying adolescent children with higher cardiovascular risk.

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 were studied. Informed consent from schools and parents of children was taken. Out of 610, 255 were females and 355 were males. Weight, height, waist circumference and BP measurements were recorded along with lipid parameters.

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 biauricular plane being horizontal. BMI was calculated using standard formula: weight (kilograms)/height (meter^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 non-elastic 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.[17] 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.[18]

For lipid determinations, venipuncture samples were drawn after 8-12 hours of fasting. Plasma levels for total cholesterol (TC), low-density lipoprotein (LDL) were measured enzymatically, using spectrophotometric methods.[19] ApolipoproteinA1 (ApoA1) and apolipoprotein B (ApoB) were measured by radial immunodiffusion. [20]The low density lipoprotein (LDL) cholesterol level was calculated using the Friedewald formula (LDL cholesterol 5 TC 2 HDL cholesterol 2 TG/5).[21] The cut-off points were 110 mg/dL for LDL cholesterol, 170 mg/dL for TC, 110 mg/dl for APOA1 and 125 mg/dl for APO B.

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.

To study the effect of BMI & WC on different lipid parameters and 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. The cut off points for LDL cholesterol, total cholesterol, APO-A1 and APO B were 110 mg/dL, 170 mg/dL, 110 mg/dl and 125 mg/dl respectively.

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

Parameter	High WC (N=18)	Normal WC(N=425)	t	p value	Inference
Age	13.27±1.84	13.11±1.89	0.97	>0.05	Non-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
TCHL	167.84±23.7	160.45±10.54	4.05	<0.001	Highly significant
LDL	104.73±14.6	100.15±9.16	3.93	<0.001	Highly significant
Apo-A	116.45±7.4	125.45±9.18	12.80	<0.001	Highly significant
Apo-B	119.77±6.55	117.64±5.69	3.83	<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

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

Parameter	Normal BMI(N=200)	Obese(N=140)	t	p	Inference
Age	13.05±2.01	13.07±1.69	0.09	>0.05	Non- 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
BMI	16.84±1.55	29.49±1.49	75.47	<0.001	Highly significant
TCHL	158.81±7.52	164.28±23.67	2.64	<0.05	Significant
LDL	101.26±10.15	103.67±14.90	1.66	<0.05	Significant
Apo-A	125.66±71.3	116.28±6.62	1.84	<0.05	Significant
Apo-B	117.73±5.79	119.76±6.29	3.02	<0.05	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

94% children with normal BMI had normal serum LDL cholesterol. It was abnormally high in only 6% (12/200) children with normal BMI, 14.8% (40 /270) overweight and 28.57% (40/140) obese children. 7.1% (30/425) children with normal waist circumference and 29.7% (55/185) children with high waist circumference had high LDL cholesterol levels.

Serum cholesterol was normal in 97% children with normal BMI. High serum cholesterol was present in 3% (6/200) children with normal BMI, 18.5% (50/270) overweight and 28.6% (40/140) obese children. 7.7% (33/425) children with normal waist circumference and 34.05% (63/185) children with high waist circumference had high total cholesterol levels.

Low Serum apolipoprotein A-1 (<110 mg/dl) was seen in 0.5% (1/200) children with normal BMI, 5.6% (15/270) overweight and 14.28% (20/140) obese children. 1.1% (5/425) children with normal WC and 16.2% (32/185) children with high WC had low Apo-A1 values.

None (0/200) of children with normal BMI had high serum apolipoprotein B (>125 mg/dl). 8.89% (24/270) overweight and 20% (28/140) obese children had high Apo-B values. 12/425 (2.8%) children with normal WC and 35/185 (21.6%) children with high WC had high Apo –B values.

Blood levels of LDL cholesterol, total cholesterol, Apo-B in obese children (103.67±14.90, 164.28±23.67and 119.76± 6.29 respectively) were significantly higher (p<0.05) than in children with normal BMI (101.26±10.15, 158.81±7.52, 117.73±5.79 respectively).

Serum Apo-A1 values in obese children (116.28±6.62) and overweight children (123.88±61.58) was lower than in children with normal BMI (125.66±71.3).This difference was statistically significant(p<0.05) Blood levels of total cholesterol in overweight children were significantly higher (p<0.001) than in children with normal BMI , Apo-B overweight children (100.65±9.70, 164.74±15.48 and 117.93±5.97 respectively). However, there was no statistically significant difference in serum LDL cholesterol and Apo –B values in children with normal BMI and overweight children.

Table 3: Comparison of blood pressure and different lipid parameters in children with normal BMI and overweight children.

Parameter	Normal BMI (N=200)	Overweight(N=270)	t	p value	Inference
Age	13.05±2.01	13.32±1.86	0.27	>0.05	Non -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
BMI	16.84±1.55	23.80±1.74	6.96	<0.001	Highly significant
TCHL	158.81±7.52	164.74±15.48	5.93	<0.001	Highly significant
LDL	101.26±10.15	100.65±9.70	0.6	>0.05	Non- significant
Apo-A	125.66±71.3	123.88±61.58	1.78	<0.05	Significant
Apo-B	117.73±5.79	117.93±5.97	0.20	>0.05	Non -significant
SBP	108.94±7.84	111.12±7.4	3.06	<0.05	Significant
DBP	67.19±3.73	69.99±4.18	2.80	<0.05	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).

In children with high waist circumference, all lipid parameters (LDL cholesterol: 104.73±14.64; Total cholesterol: 167.84±23.79 and APO –B: 119.77±6.55) were significantly higher(p<.001) than in children with normal waist circumference (LDL cholesterol- 100.15±9.16 ; total cholesterol- 160.45±10.54 and APO-B: 117.64±5.69). APO- A1 in children with high waist circumference (116.45±7.4) was lower than in children with normal waist circumference (125.45±9.18) which was statistically significant.

DISCUSSION

Epidemiological and clinical investigations have shown that relationship between obesity and cardiovascular risk factors begins early in life.[6,7,22] It is well known that body fat distribution affects development of metabolic disturbances in children. Waist circumference being a sensitive marker of cardiovascular risk factors can be used in identifying obese children at higher metabolic risk.

Gillian S. et al studied effect of obesity and high blood pressure on plasma lipid levels in children and adolescents and found that abnormal plasma lipid levels were high among overweight children with both normal BP and hypertension.[23] The prevalence of elevated BP was much greater in severely obese boys and girls (46.5% and 39%) than moderately obese boys and girls (28.1% and 23.1%).Their results included S. cholesterol >200 mg/dl in 5.4% of obese boys and 18% of obese girls, S. HDL cholesterol <40 mg/dl in 40.3% of obese boys and 32.5% of obese girls. LDL-C> 130 mg/dl was present in 12.2% and 20.0% obese boys and girls respectively while TG>150 mg/dl was seen in 29.7% and 11.1% of obese boys and girls respectively.

Cai-Xia Z et al showed that overweight and/or obese children screened by both Chinese new BMI and weight-for-height criterion are associated with increased levels of cardiovascular risk factors (e.g., elevated serum TG, LDL, Apo- B, and reduced HDL-C, Apo -A levels).[24]

A central or abdominal distribution of body fat was related to adverse concentrations of triacylglycerol, LDL cholesterol, HDL cholesterol, and insulin; these associations were independent of race, sex, age, weight, and height. Compared with a child at the 10th percentile of waist circumference, a child at the 90th percentile was estimated to have, on average, higher concentrations of LDL cholesterol (0.17 mmol/L), triacylglycerol (0.11 mmol/L), and insulin (6 pmol/L) and lower concentrations of HDL cholesterol (−0.07 mmol/L). These differences, which were independent of weight and height, were significant at the 0.001 level and were consistent across race-sex groups.

Maffeis C et al showed that ApoA1/ApoB, HDL cholesterol, total cholesterol/HDL cholesterol, and systolic as well as diastolic BP are significantly associated with waist circumference and triceps and subscapular skinfolds, independently of age, gender, and body mass index.[11] Waist circumference has several advantages over other anthropometric measures like skinfold measurement. Waist circumference is easy to measure, has good inter individual reproducibility and offers more accurate results than skin fold measurement. Goran et al. found that waist circumference strongly correlated with subcutaneous adipose tissue .[25] De Ridder et al. also demonstrated that waist circumference is a good measure for truncal fat in girls.[26] Therefore, measurement of waist circumference may be a good choice in clinical practice to facilitate the detection of individuals with cardiovascular risk factors in childhood.

Few studies are available on the relationship between waist circumference and cardiovascular risk factors in children.[27,28] Our results were similar to those of the Bogalusa Heart Study which showed that waist circumference has consistent association with cardiovascular risk factors. Chan et al. showed that in adults, the best determination of cardiovascular risk can be achieved by using waist circumference as a measure of body-fat distribution.[29] In children, waist circumference, adjusted for age and gender, significantly contributed the explanation of interindividual variability of cholesterol and SBP.

Waist circumference measurement does not discriminate between Intra-abdominal adipose tissue (IAAT) and subcutaneous adipose tissue[7]. However, Taylor.et al. recently found that waist circumference correctly identified a high proportion of children and adolescents with high trunk-fat mass as measured by a state-of-the-art measurement. They concluded that waist circumference is a simple technique that could be used to screen for high central obesity in children.[30]

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