Print ISSN: 2321-6379
Online ISSN: 2321-595X
DOI: 10.17354/ijss/2018/111

Original Article

Study on Relationship between Waist Circumference and Blood Pressure among School-Going Adolescents

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Abstract

Background: Hypertension is on the raise among schoolchildren. Overweight and obesity, especially in childhood and adolescents, play an important role in the development of insulin resistance, diabetes mellitus, and hypertension. Obesity indicators such as body mass index (BMI), waist circumference (WC), and waist-to-height ratio play an important role in predicting children with high blood pressure (BP).

Aim and Objective: The aim is to study the relationship between WC and BP among school-going adolescents and to examine the utility of WC as an indicator of elevated BP compared to BMI.

Methodology: A total of 1392 school-going children were included in the study. Their height, weight, WC, and BP were recorded. BMI was calculated.

Results: In this cross-sectional study carried out on 1392 adolescents in Madurai, the incidence of pre-hypertension and hypertension was 3.4% and 1.8%, respectively. Nearly 6% were overweight and 3% were obese. About 6.6% of the children had increased WC. Prediction of pre-hypertension and hypertension among children was found to be statistically significant with sensitivity: 90.41%, specificity: 98.03%, ppv: 71.74%, and npv: 99.46%. Prediction of children with high BP by BMI was also found to be statistically significant with sensitivity: 89.04%, specificity: 95%, ppv: 49.62%, and npv: 99.37%.

Conclusion: Obesity indicators such as WC and BMI because of its ease of measurement can be used as a screening tool to identify children with high BP.

Key words: Blood pressure, Body mass index, Waist circumference

INTRODUCTION

"Hypertension, i.e., elevated systolic blood pressure (SBP) and/or diastolic BP (DBP) is now considered to be on the raise among school-going children in recent times.[1-4] In India, it has been noted that children are on the verge of obesity-associated elevated BP.[5] It has been known that BP tracks over time; children with increased values are now at an elevated chance of acquiring hypertension in older age group."[6]

Access this article online

www.ijss-sn.com

Month of Submission : 02-2018
Month of Peer Review : 03-2018
Month of Acceptance : 03-2018
Month of Publishing : 04-2018

"BP readings for children require trained doctors to identify and take out the appropriate values. Since this is difficult to be carried out in schools, utilization of anthropometric measures which are being carried at school physical examination is found to be beneficial and early identification of those young children and adolescents who are at the verge of having elevated BP. Usually, waist-to-height ratio (WHtR), body mass index (BMI), and waist circumference (WC) which are used as obesity indicators among adults, children, and adolescents can also be utilized as an indicator of high BP."[7-11]

WC is considered as a good predictor of central adipose tissue deposition and is noted to be a strong predictor of hypertension in Indian adolescents.[12,13] WC is predictive of such adverse outcomes as abnormal lipid profile and insulin resistance and is a component of pediatric metabolic syndrome.

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The National Health and Nutrition Examination Survey (NHANES) has proposed the 90th percentile as the cutoff for identifying central adiposity.[14,15]

Aim and Objective

1. To study on the relationship between WC and BP among school-going adolescents
2. To examine the utility of WC as an indicator of elevated BP when compared to BMI.

Study Design

This was a cross-sectional observational study.

Period of Study

The study duration was 5 months (April 2016–August 2016).

Study Subject

Schoolchildren aged 11–17 years, numbering 1392 (50.5% boys and 49.5% girls), formed the study group.

Inclusion Criteria

Healthy school-going children aged 11–17 years in Madurai were included in the study.

Exclusion Criteria

- Children already diagnosed to have secondary hypertension
- Children having any acute illness
- Present history suggestive of cardiovascular, chronic respiratory, or any
- Other systemic illness
- Children on chronic drugs such as steroids were excluded from the study.

Ethical Clearance

It was obtained from the Institutional Ethical Committee.

Method of Collection of Data

The details of the students were collected in a pre-structured pro forma. Anthropometric indices of the children such as height, weight, and WC were measured. BP was measured for all children after 5 min of rest in seated position with the right arm supported at the level of the heart.

For children whose BP was above the 90th percentile, reading was repeated twice at 5–10 min interval in the same visit and average BP was recorded. BP consistently between 90 and 95th percentile was considered to be pre-hypertensive. For children whose BP was above the 95th percentile, BP recordings were repeated at weekly intervals twice, and BP reading that was found to be consistently above the 95th percentile was considered as hypertensive. Height for each student was measured, and non-elastic measuring tape fastened to a vertical wall was used. For weight measurement, an electronic weighing scale was used to measure weight. From these values, "BMI was calculated using this formula BMI = weight (kg)/height (m^2)."WC measurements were performed in accordance with methodology used in the NHANES. WC for the children was measured with the child standing erect using a stretch-resistant tape. The tape was applied horizontally just above the upper lateral border of the right ilium. Each measurement was made at the end of a normal expiration and recorded to the nearest 0.1 cm.

Statistical Analysis

For statistical analysis, the data were entered in MS Excel and analyzed using SPSS v20. Qualitative data were summarized as frequencies and percentages. Quantitative data were checked for normality. Normally distributed data were summarized using mean and standard deviation. Median and interquartile range was used for summarizing non-normally distributed data. Association between qualitative variables was tested using Chi-square tests. Difference in distribution of quantitative variables across the two groups was tested using independent *t*-test and Mann–Whitney U-test using normal and non-normally distributed variables, respectively. Difference in distribution of quantitative variables across more than two groups was tested using analysis of variance. Statistical significance was interpreted using an arbitrary cutoff of $P = 0.05$.

RESULTS AND ANALYSIS

In this study, a total of 1392 children were screened out of which 50.5% ($n = 703$) were boys and 49.5% ($n = 689$) were girls [Tables 1-15].

DISCUSSION

This study was done among 1392 school-going adolescents in Madurai with the objective to study the relationship between WC and BP among school-going adolescents and to examine the utility of WC as an indicator of elevated BP when compared to BMI.

From our observational study, it was noted that the incidence of pre-hypertension was noted to be 3.4% ($n = 48$) and hypertension 1.8 % ($n = 35$). Another study which was conducted by Goel *et al.* among students in the age group 14–19 years in New Delhi found that 6.4% of adolescents to be among the hypertensive range.[16]

In another study conducted by Jitendra Kumar *et a*l. among school-going adolescents at Karad, Maharashtra, it was noted that 1.89% of the children had elevated BP.[17]

The incidence of overweight in this study was found to be 6.5% (n = 95) and that of obesity was found to be 2.9% (n = 40). Screening study done in nearby Pondicherry state showed that the prevalence of obesity was 3.8% and that of overweight to be around 7.8%. In the study conducted by Jitendra Kumar *et al.*,[17] it was noted that 10.1% of children had high BMI.

Table 1: Profile of study participants

Gender distribution gender	*n* (%)
Male	703 (50.5)
Female	689 (49.5)
Total	1392 (100)

Table 2: Anthropometry of study participants

Anthropometry	Male	Female	Total
Height	153.9±12.36	151.34±10	152.65±11.32
Weight	41.86±12.13	42.08±8.96	41.97±10.67
WC	65.84±9.35	66.5±8.65	66.17±9.01
BMI	17.31±3.21	18.11±2.67	17.71±2.98

WC: Waist circumference, BMI: Body mass index

Table 3: Nutritional status of study participants using BMI

BMI category	Frequency (%)
Normal	1261 (90.6)
Overweight	91 (6.5)
Obese	40 (2.9)
Total	1392 (100)

BMI: Body mass index

Table 4: Age-wise distribution of BMI

Age	Measure	Normal	Overweight	Obese
11	*n* (%)	176 (87.6)	17 (8.5)	8 (4)
12	*n* (%)	189 (93.6)	11 (5.4)	2 (1)
13	*n* (%)	188 (93.1)	13 (6.4)	1 (0.5)
14	*n* (%)	151 (87.8)	15 (8.7)	6 (3.5)
15	*n* (%)	187 (91.2)	11 (5.4)	7 (3.4)
16	*n* (%)	186 (91.2)	13 (6.4)	5 (2.5)
17	*n* (%)	184 (89.3)	11 (5.3)	11 (5.3)
Total	*n* (%)	1261 (90.6)	91 (6.5)	40 (2.9)

BMI: Body mass index

Table 5: Mean and SD for BMI in each age group

Age in years	Frequency	Mean±SD
11	201	16.79±2.71
12	202	16.38±2.43
13	202	17.62±2.33
14	172	17.83±3.41
15	205	17.94±2.76
16	204	18.33±2.82
17	206	19.04±3.46

SD: Standard deviation, BMI: Body mass index

It was noted that among the 1392 children screened, 6.7% of the children had increased WC which indicated the presence of central adiposity. In the study done by Jitendra Kumar *et al.*,[17] 106 out of 951 children (11.14%) were having increased WC.

Table 6: Age-wise distribution of WC in study population

Age	Measure	<70th percentile	70–90th percentile	>90th percentile
11	*n* (%)	184 (91.5)	12 (6.0)	5 (2.5)
12	*n* (%)	190 (94.1)	11 (5.4)	1 (0.5)
13	*n* (%)	191 (94.6)	10 (5.0)	1 (0.5)
14	*n* (%)	159 (92.4)	9 (5.2)	4 (2.3)
15	*n* (%)	193 (94.1)	5 (2.4)	7 (3.4)
16	*n* (%)	191 (93.6)	8 (3.9)	5 (2.5)
17	*n* (%)	192 (93.4)	7 (4.5)	7 (2.1)
Total	*n* (%)	13000 (93.4)	62 (4.5)	30 (2.1)

WC: Waist circumference

Table 7: Mean and SD of WC in study population

Age	WC	
	n	Mean±SD
11	201	63.27±8.44
12	202	63.62±8.42
13	202	67.90±8.37
14	172	68.20±9.91
15	205	65.45±8.47
16	204	66.68±9.01
17	206	68.32±9.14

SD: Standard deviation, WC: Waist circumference

Table 8: Age-wise distribution of BP

Age	Normal	Pre-hypertension	Hypertension
11	189	9	3
	94	4.5	1.5
12	195	5	2
	96.5	2.5	1.0
13	192	9	1
	95	4.5	0.5
14	164	5	3
	95.3	2.9	1.7
15	191	9	5
	93.2	4.4	2.4
16	194	7	3
	95.1	3.4	1.5
17	194	4	8
	94.2	1.9	3.9
Total	1319	48	25
	94.8	3.4	1.8

BP: Blood pressure

Table 9: BP distribution

BP percentile	No of children (%)
Normal<90	1319 (94.8)
Pre-hypertension 90–95	48 (3.4)
Hypertension>95	25 (1.8)
Total	1392 (100

BP: Blood pressure

Table 10: Association between SBP and BMI among study participants

BMI	Normal	Pre-hypertension	Hypertension	"*P*" value
Normal	1254 (99.4)	7 (0.6)	0	<0.001
Overweight	56 (61.5)	28 (30.8)	7 (7.7)	
Obese	10 (25)	12 (30)	18 (45)	

SBP: Systolic blood pressure, BMI: Body mass index

Table 11: Association between DBP and BMI among study participants

BMI	Normal	Pre-hypertension	Hypertension	"*P*" value
Normal	1259 (99.8)	2 (0.2)	0	<0.0001
Overweight	66 (72.5)	22 (24.2)	2 (3.3)	
Obese	17 (42.5)	14 (35)	9 (22.5)	

DBP: Diastolic blood pressure, BMI: Body mass index

Table 12: Association between SBP and WC

WC	Normal	Pre-hypertension	Hypertension	"*P*" value
<70 percentile	1294 (99.5)	5 (0.4)	1 (0.1)	<0.0001
70–90 percentile	22 (35.5)	36 (58.1)	4 (6.5)	
>90 percentile	4 (13.3)	6 (20)	20 (66.7)	

SBP: Systolic blood pressure, WC: Waist circumference

Table 13: Association between DBP and WC

WC	Normal	Pre-hypertension	Hypertension	"*P*" value
<70 percentile	1298 (99.8)	2 (0.2)	0	<0.0001
70–90 percentile	36 (58.1)	25 (40.3)	1 (1.6)	
>90 percentile	8 (26.7)	1 (36.7)	11 (36.7)	

DBP: Diastolic blood pressure, WC: Waist circumference

Table 14: Correlation between SBP, WC, and BMI

Parameter	Total BP correlation coefficient, *P* value	BP male correlation coefficient, *P* value	BP female correlation coefficient, *P* value
BMI	0.563, <0.0001	0.562, <0.0001	0.544, <0.001
WC	0.578, <0.0001	0.578, <0.0001	0.543, <0.0001

SBP: Systolic blood pressure, WC: Waist circumference, BMI: Body mass index, BP: Blood pressure

Table 15: Correlation between DBP, WC, and BMI

Parameter	Total BP correlation coefficient, *P* value	BP male correlation coefficient, *P* value	BP female correlation coefficient, *P* value
BMI	0.201, <0.0001	0.201, <0.0001	0.122, <0.001
WC	0.187, <0.0001	0.25, <0.0001	0.098, <0.010

DBP: Diastolic blood pressure, WC: Waist circumference, BMI: Body mass index, BP: Blood pressure

In this study, it was found that the prediction of pre-hypertension and hypertension by WC and BMI was found to be statistically significant. When WC was used to predict pre-hypertension and hypertension, it was found that the sensitivity: 90.41%, specificity: 98.03%, ppv: 71.74%, and npv: 99.46%.

When BMI was used as a parameter to predict hypertension, it was noted that sensitivity: 89.04%, specificity: 95%, ppv: 49.62%, and npv: 99.37%. It was also significant. The prediction of detecting hypertension was found to be higher when WC was used as an indicator when compared to BMI.

In study conducted by Bahl *et al.*,[18] it was noted that the prevalence of hypertension among overweight participants (BMI >85 percentile) was 13.2% and among obese participants (BMI >95 percentile) was 18.75% which was found to be statistically significant. Moreover, there was a statistically significant correlation noted between WC and BMI with both SBP and DBP in their study.

In study conducted by Mishra *et al.*,[19] it was noted that high obesity indicators were associated with elevated BP. Their results showed statistically similar AUCs for BMI and WC and WHtR in detecting risk of high BP,

indicating similar discriminatory ability for all three obesity indicators.

CONCLUSION

1. The incidence of hypertension among school-going adolescents in Madurai was found to be 1.8 %
2. The incidence of obesity among the adolescents was found to be 2.9%
3. There was a strong correlation noted between increased WC and BMI with high BP among adolescents
4. Prediction for hypertension by WC was found to be higher compared to BMI in this study
5. Family history of hypertension had no relationship to predict high BP in children in this study.

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How to cite this article: Murugalatha P, Guna P. Study on Relationship between Waist Circumference and Blood Pressure among School-Going Adolescents. Int J Sci Stud 2018;6(1):47-51.

Source of Support: Nil, **Conflict of Interest:** None declared.