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Body Mass Index (BMI), Waist Circumference (WC) and Waist to Height Ratio (Whtr) as a Screening Tool for Detection of Cardio Metabolic Risk Factors among Adolescents in Kerala

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Abstract:
Central obesity is a cardio metabolic risk factor. A comparative study was done to assess the effectiveness of BMI, WC and WHtR and blood pressure as a screening tool to detect cardio metabolic risk factors among adolescents and identify their relationship using a descriptive comparative research design. The sample consisted of 518 adolescents from 9 urban schools from two districts in Kerala by a multistage random sampling. Height, weight, waist circumference as well as Blood Pressure was collected using validated and reliable instruments. Demographic details were collected using a questionnaire. Ethical clearance from IRB and administrative permission besides subjects' consent were obtained prior to data collection. Data was analyzed using SPSSvs.18 in accordance with objectives laid down.
The study found substantial number of adolescents as overweight, obese as well as hypertensive as ear marked by their BMI, WC and WHtR. The WHtR and WC showed highly significant positive correlation (r= .916, p<0.001). The WC showed the same with SBP (r-.433, p<0.001) as well as DBP (r=.339, p<0.001). Highly significant positive correlation (r=.313, p<0.001) was found between WHtR and SBP as well as with DBP (r=.210, p<0.001). Systolic and diastolic BP showed highly significant positive correlation (r=.739, p<0.001). BMI was found to have significant weak positive correlations with WC (r= 0.146, p = 0.001) and with WHtR (r=137, p=0.002). A stepwise linear regression analysis done with blood pressure (SBP & DBP) as dependent variables indicated WC, and WHtR to be predictive of systolic and diastolic BP (p<0.001) followed by BMI (p=0.007) for systolic BP. The results indicate WC (p<0.001) being superior to WHtR (p<0.001) BMI (p<0.01) in predicting hypertension. The study affirms WC and WHtR as a convenient, cost effective and discriminative tool for predicting cardio metabolic risk.

Keywords: *Adolescents, Cardio metabolic risk, BMI, Waist circumference, Waist: Height*

1. Introduction

Obesity is associated with many of the cardio metabolic disorders. BMI represents whole body obesity status, while waist to height ratio (WHtR) is an indicator of central adiposity or abdominal obesity and has a significantly greater discriminatory power compared with BMI. [i, ii]

2. Background

Ravikumar et.al.reported both overweight and obesity are prevalent at early adolescence in urban compared to rural areas. Prevalence of hypertension is significantly higher in this group than those with normal BMI. An Iranian survey of 13486 Childhood and Adolescent population aged 6-18 years reported substantially high prevalence rate of high BP (pre-HTN together with HTN) among the participants.

AnjanKumar (2015) in a study in Andhra Pradesh among 1000 children reported 53 children as being overweight and 32 as being obese; having their SBP and DBP significantly higher compared to non obese group. Patel (2014) reported 5.36% prevalence of hypertension and 8.74% pre hypertension, higher in males (10.35%) than females (7.14%) with high prevalence of 24.07% in obese against non-obese (5.56%) from a study on school children aged 11 to 18 years.

Khoury M (2013) conducted a cross-sectional analysis of 14,493 children between 8 to 18years of age to determine the utility of waist/height ratio (WHtR) in the specification of cardio metabolic risk in children already stratified by BMI. Analysis showed overweight and obese subjects with a WHtR ≥ 0.5 had a cardio metabolic risk parallel to subjects with a normal BMI. Increasing

WHtR was significantly associated with increased cardio metabolic risk in overweight and obese subjects (WHtR ≥ 0.6), and 32% had metabolic syndrome.

Ashwell M (2012) did a systematic review and meta-analysis of 31 studies to assess the discriminatory power of waist-to-height ratio (WHtR) and waist circumference (WC) in adults with cardio-metabolic outcomes and found WHtR had significantly greater discriminatory power compared with BMI. Compared with BMI, WC improved discrimination of adverse outcomes by 3% ($p < 0.05$) and WHtR improved discrimination by 4–5% over BMI ($p< 0.01$). Hence Waist-to-Height ratio was recommended as a screening tool for cardio metabolic risk factors in both sexes.

A cross-sectional study from Brazil on 8,019 adolescents aged 10 to 15 years from 43 schools found boys had higher mean WHtR than girls (0.45±0.06 vs. 0.44±0.05; p=0.002) and higher WHtR at the 95th percentile (0.56 vs. 0.54; p<0.05). The WHtR cutoffs according to the WHO criteria ranged from 0.467 to 0.506 and 0.463 to 0.496 among girls and boys respectively, with high sensitivity (82.8-95%) and specificity (84-95.5%). The WHtR was significantly associated with body adiposity measured by BMI.

A study from Han on 1665 adolescents aged 13-15 years evaluated the relationship between waist-to-height ratio (WHtR) and glucose and lipid metabolism, reported the waist-to-height ratio to be an appropriate measure to assess dyslipidemic-diabetic adolescents and a useful guide for early intervention of future prevention of these linked diseases.

Although Body mass index (BMI) is used to identify obesity, waist circumference to height ratio (WHR) is considered a better index for predicting metabolic abnormalities associated with obesity such as hypertension and impaired glucose tolerance. A study on correlation of blood pressure to height ratio with BMI and WHR in 264 adolescents was done in rural Bangalore. Waist circumference to height ratio appeared to better correlate with risk of elevated blood pressure than body mass index in adolescents (Rajanish, 2014)

In a study of 772 Chinese subjects, BMI, waist circumference, waist-hip ratio (WHR) and waist-height ratio (WHtR) were used to predict the risk of obesity related diseases and found BMI, waist circumference and WHtR values were all significantly associated with blood pressure, glucose, and triglyceride and also with the number of metabolic risk factors in both male and female subjects (all of $p < 0.05$). Lui et al reported that blood pressure to height ratios were accurate and feasible diagnostic tool for hypertension in adolescents and proposed optimal thresholds for systolic BP to height ratio, and diastolic BP to height ratio (Klein, 2007).

Waist circumference (WC) is a perimeter of body girth at the level of the abdomen. It is a surrogate marker of abdominal fat mass, because WC correlates with subcutaneous and intra abdominal fat mass and is a reliable indicator of cardio metabolic risk.WC is a stronger predictor of diabetes than BMI, having a direct correlation with the risk of developing cardiovascular disease. Men and women who have WCs ≥ 40 in (102 cm) and 35 in (88 cm), respectively, are considered to be at increased risk for cardio metabolic disease. Men should strive to maintain a waist circumference of 94 cm or less, and for women the corresponding goal is 80 cm. A healthy waist to height ratio: Waist circumference / Height = ≤ 0.5. The message in the formula is clear: men and women should strive to keep their waist circumference to no more than half their height.

A Cross-sectional school-based study on a random sample of 6380 children (6-18 yr old, 3501 boys) from five major cities in India examined the relationship of body mass index (BMI), waist circumference (WC), waist to height ratio (WHtR) with blood pressure in children and adolescents. The reported prevalence of overweight and obesity was 23.5% and 9.7%, respectively. Hypertension was observed in 5.6%. Higher WC and WHtR exhibited 1.5 times higher risk of hypertension (P<0.001). WHtR may offer reputed markers for early detection of hypertension.

Literature review threw light on WHtR as superior to BMI and WC in screening for abdominal adiposity and predicting cardio metabolic risk among adolescent age group. In the present scenario of the global increase in obesity among children leading to childhood NCD, the advantage of WHtR as a simple tool for screening the population is significant.

2.1. Statement of the Problem

A Comparative study of Body Mass Index (BMI), Waist Circumference (WC) and Waist to Height Ratio (WHtR) as a screening tool for detection of cardio metabolic risk among adolescents in Kerala

2.2. Objectives

i. To assess the effectiveness of BMI, WC, WHtR and Blood pressure (systolic and diastolic) measurements as a screening tool to detect the cardio metabolic risk among adolescents in a selected urban community in Kerala.
ii. To compare the relationship between BMI, WC and WHtR with SBP and DBP for prediction of hypertension among adolescents.

3. Methodology

Using a quantitative approach and descriptive correlation design, 518 adolescents in 13 to 16 age group was selected from 9 urban schools in two districts by multistage random sampling. Ethical clearance and administrative permission was obtained along with assent from students after ensuring confidentiality. The investigator- prepared, validated tool was used to collect demographic data. Height, weight, waist circumference as well as systolic and diastolic BP were collected using valid and reliable instruments. Height was measured from head to foot in standing position without shoes. WC was measured at the umbilical level above the iliac crest at the narrowest part using a tape measure. Waist to Height Ratio was calculated as: Waist circumference / Height = ≤ 0.5. Data was collected in the class room of respective schools. Blood pressure was measured manually in sitting position using sphygmomanometer and stethoscope. The apparatus was calibrated before data collection. The collected data was analyzed using SPSS vs.18.

4. Results

The data collected from all 518 adolescents of 9th standard who met the inclusion criteria was organized, analyzed and interpreted using descriptive and inferential statistics on SPSS version 18 in accordance with the objectives laid down for the study. The statistical tests like mean, standard deviation and Pearson Correlation Coefficient were used to find out relationship between BMI, WC and WHtR and Systolic and Diastolic BP measurements among subjects. The significant findings of the study are presented in tables and graphs.

4.1. Section I. Demographic characteristics of the sample

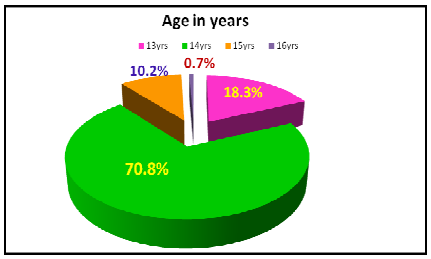


Figure 1: Distribution of subjects by age

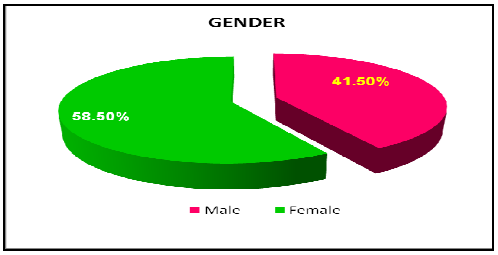


Figure 2: Distribution of sample by gender

The sample consisted of 518 adolescents with a mean age of 13.90± 0.82 years; 215(41.5%) males and 303(58.5%) females, majority from nuclear families 432(83.4%) and the rest 82 (15.8%) were from joint families. Subjects were Christian (51.5%), Hindu (30%) and Muslim (20.5%).

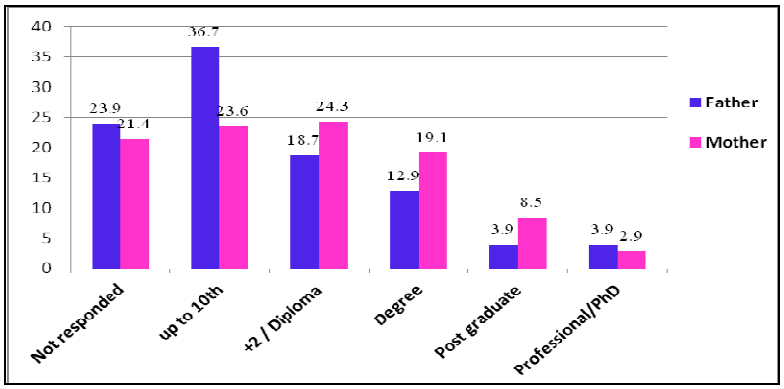


Figure 3: Sample distribution (%) by parental education

Majority parents were educated up to high school or plus 2, while less than 20% were graduates and postgraduates.

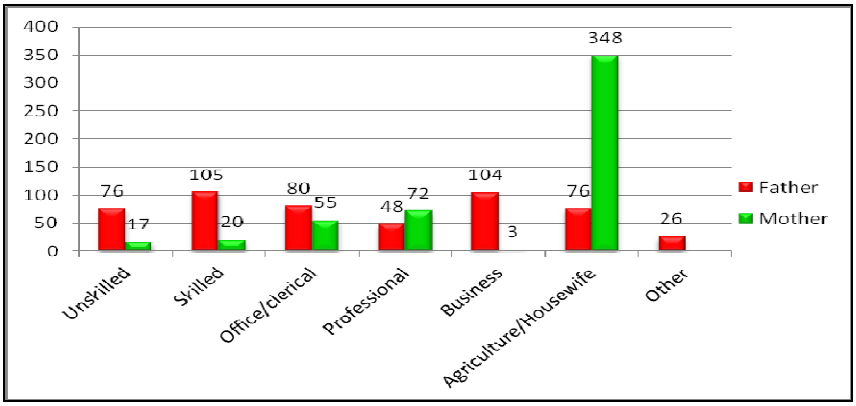
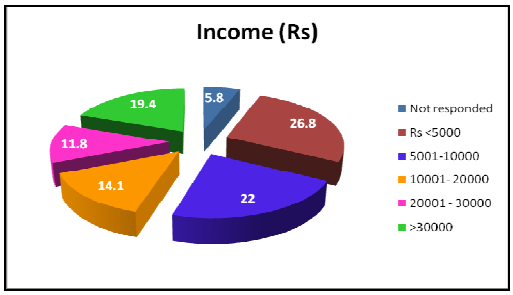


Figure 4: Sample distribution (%) by parental occupation

Majority 348(67.6%) mothers were housewives while 20% fathers were unskilled workers or doing business.

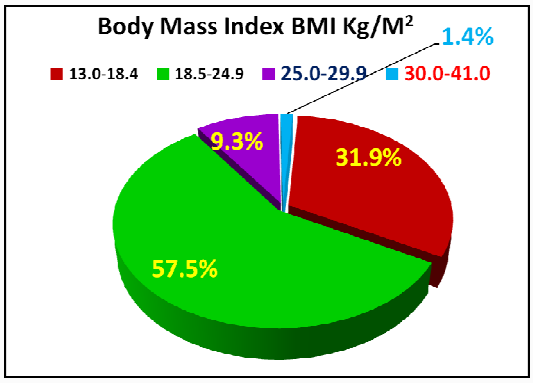


The corresponding WHtR was found to be 0.51 - 0.60 for 60 (11.6%) and 0.61 - 0.70 for 6 (1.2%) subjects respectively (Fig-8).

Figure 5: Percentage distribution of adolescents by family incor

The average family income varied between Rs. 5000 to 20,000 mostly (48.9%), while 20% had income >30,000/- month.

4.2. Section II: Findings related to BMI, WC and WHtR among adolescents in a selected urban community in Kerala.



Overweight was found among 48(9.3%) subjects and obesity among 7 (1.4%) subjects.

Figure 6: Distribution of Adolescents according to BMI

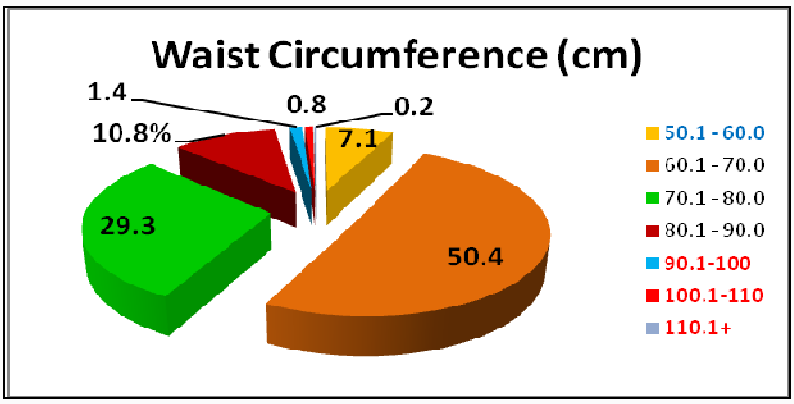


Figure 7: Percentage distribution of subjects according to WC

Majority 450 (86.9%) subjects had WC within normal limits, while 68 (13.1%) had WC above normal (Fig- 7). Gender wise analysis showed girls 259(50%) and boys 211(40.7%) had WC against the recommended normal values; (WC- for boys 90 cm and girls 80cm or less).

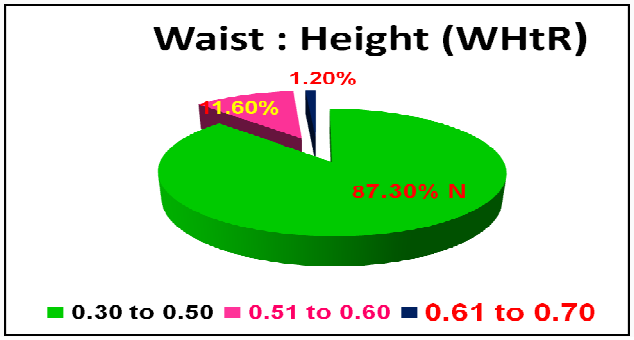


Figure 8: Distribution of adolescents by Waist: Height Ratio (WHtR).

Variables	Characteristics	Frequency	Percentage
Systolic Blood Pressure (mmHg)	<= 60	2	0.4
	61 - 70	9	1.7
	71 - 80	42	8.1
	81 - 90	138	26.6
	91 - 100	120	23.2
	101 - 110	108	20.8
	111 - 120	78	15.1
	121 - 130	12	2.3
	131 - 140	6	1.2
	141 - 150	3	0.6
Diastolic Blood Pressure (mmHg)	<= 40	19	3.7
	46 - 50	66	12.7
	56 - 60	184	35.5
	66 - 70	147	28.4
	71 - 75	1	0.2
	76 - 80	89	17.2
	86 - 90	11	2.1
	96+	1	.2

Table 1: Distribution of Blood Pressure readings among Adolescents

Blood pressure readings both systolic (SBP) and diastolic (DBP) were elevated; 12 (2.3%) subjects had SBP 121-130 and 6 (1.2%) had 131-140 while 3 (0.6%) had SBP in 141- 150 mmHg ranges. The diastolic BP (DBP) also showed elevated readings; 11(2.1%) in 86-90 range and one subject had DBP >96mmHg (Table 1)

			BMI	WC	WHtR	SBP	DBP
	BMI	Pearson Correlation	1				
		Sig. (2-tailed)					
	WC	Pearson Correlation	.146**	1			
		Sig. (2-tailed)	.001				
	WHtR	Pearson Correlation	.137**	.916**	1		
		Sig. (2-tailed)	.002	.000			
	SBP	Pearson Correlation	-.041	.433**	.313**	1	
		Sig. (2-tailed)	.353	.000	.000		
	DBP	Pearson Correlation	.012	.339**	.210**	.739**	1
		Sig. (2-tailed)	.793	.000	.000	.000	
		N	518	518	518	518	518

Table 2: Correlation on BMI, WC and WHtR with SBP and DBP among adolescents
***Correlation coefficient is significant at 0.01 levels*

The WHtR and WC showed highly significant positive correlation (r= .916, p<0.001***) while WC and SBP (r-.433, p<0.001) as well as with DBP (r=.339, p<0.001). Highly significant positive correlation (r=.313, p<0.001) was recognized between WHtR and SBP as well as with DBP (r=.210, p<0.001). Systolic and diastolic BP showed highly significant positive correlation (r=.739, p<0.001). BMI was found to have significant weak positive correlations with WC (r= 0.146, p = 0.001**) and with WHtR (r=137, p=0.002**) (Table 2).

Variable	Characteristics	Male (215) Frequency (%)	Female(303) Frequency (%)	χ^2,df (p-value)
WC (cm)	50.1 - 60.0	23 (4.4)	14 (2.7)	χ^2 = 13.686 df = 6 p =.033*
	60.1 - 70.0	114 (22.0)	147 (28.4)	
	70.1 - 80.0	54 (10.4)	98 (18.9)	
	80.1 - 90.0	20 (3.9)	36 (6.9)	
	90.1 - 100.0	1 (0.2)	6 (1.2)	
	100.1 - 110.0	2 (0.4)	2 (0.4)	
	110.1+	1 (0.2)	0	

Table 3: Association of Waist circumference with gender among urban adolescents

A significant association was found between gender and WC (χ^2 = 13.686, df=6, p<0.05*) (Table 3.).

Variables		Beta Coefficient	p-value	Model Significance	p-value
Systolic BP	WC	.936	0.001	55.04	0.001
	WHtR	.505	0.001		
	BMI	.105	0.007		
Diastolic BP	WC	.926	0.001	38.99	0.001
	WHtR	.563	0.001		

Table 4: Stepwise Linear Regression Model showing predictive values with BP

A stepwise linear regression analysis was done with blood pressure (systolic and diastolic) as dependent variables and study variables at (WC, WHtR, WHR and BMI) were entered in to the model. Regression analysis indicated WC, and WHtR to be predictive of systolic and diastolic BP (p<0.001) followed by BMI (p=0.007) for systolic and WHR (p=0.046) for diastolic BP. The results show that WC is superior to WHtR and is followed by BMI in predicting cardio metabolic risk factors such as hypertension, overweight and obesity among adolescents.

5. Summary

The study of 518 adolescents from two selected urban community in Kerala was done to assess the BMI, WC, WHtR and Blood pressure (Systolic and diastolic) measurements and to find any relationship between the same for prediction of cardio metabolic risk factors. Substantial number of adolescents is having overweight, obesity as well as hypertension as ear marked by their BMI, WC, WHtR and BP. The study found WC (p<0.001) being superior to WHtR (p<0.001) and BMI (p<0.01) in predicting cardio metabolic risk factors such as overweight, obesity and hypertension among adolescents. Thus WC and WHtR can be used as a convenient and cost effective tool for predicting cardio metabolic risk factors.

6. Discussion

Obesity is associated with many of the cardio metabolic disorders like diabetes, hypertension, polycystic ovarian disease and metabolic syndrome. Its presence among adolescents and children are alarming globally and at home. Present study found substantial number of adolescents having overweight, obesity as well as hypertension as ear marked by their BMI, WC and WHtR. Gender wise, WC showed girls exceeding boys for central obesity. This is contradictory to the findings by Isa de Pádua Cintra1et.al.

In the present study, highly significant (p<0.001) positive correlation was found between WC, SBP and DBP as well as between WHtR, SBP and DBP. A stepwise linear regression analysis showed WC, and WHtR to be predictive of systolic and diastolic BP (p<0.001) followed by BMI (p=0.007) for systolic and WHR (p<0.05) for diastolic BP. Several studies have supported that WHtR and WC are superior to BMI for prediction of cardio metabolic risk factor determination. BMI had shown correlation with WC and WHtR only and not with SBP or DBP in the present study. Findings agree with conclusion from systematic review and meta-analysis by Ashwell M et.al.

7. Conclusion

The findings that substantial number of adolescents are among the cardio metabolic high risk category is alarming and calls for parents and concerned authorities to visualize and initiate realistic solution for this grave crisis before we lose our young generation succumb to early demise from preventable NCDs. Family centered awareness program, availability and accessibility of healthy food items in restaurants and institutions, curtailing the availability of calorie dense foods at school premises, encouraging physical activity through eco friendly environment, building public parks in urban along with mass health awareness camps can help to control the obesity epidemic.

- Limitations: The study is limited to adolescents from two districts among urban community; hence generalization with represent the rest of the state or country is limited.
- Recommendations: Irrespective of the food habits and socio economic status, all individuals including adolescents and children should engage in physical exercise and activities to keep their waist line to half of their heights to achieve cardio metabolic fitness.
- Acknowledgement: The author wishes to thank all the young participants and their contributions for the successful study.
- Conflict of interest: Nil
- Financial resource: Self

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