# **Original Research Article**

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# Evaluation of anthropometric measurements of central obesity as screening tools in children: multi receiver operating characteristic analysis

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# ABSTRACT

**Background:** Obesity in children is often expressed by indicators like Body Mass Index, Waist Circumference, Waist-to-Hip ratio etc. Each of these has its own merits and demerits. Among these, BMI is commonly used to assess overweight/obesity but the central obesity is more important than the body mass as it has shown strong association with risk for coronary heart disease, adverse lipid profile and hyper insulinaemia in children. The objectives were to assess the validity of waist-hip ratio, waist-to-height ratio, conicity index as indicators of central obesity in children as measured by waist circumference.

**Methods:** This is a cross sectional study conducted on 4663 students who were enrolled in 8<sup>th</sup> to 10<sup>th</sup> standard of government and private schools of Mandya city. Weight, height, waist and hip circumference are measured following WHO guidelines. The data was analyzed using mean, standard deviation, proportion, cut off, sensitivity, and specificity. ROC curves were drawn to assess the validity of the anthropometric measurements.

**Results:** Using the WC percentiles given by Kuriyan R, the prevalence of overweight/obesity was found to be 7.59% with 8.85% in girls and 6.03% in boys. Waist-to-Height ratio performed significantly better than waist-to-hip ratio and conicity index in identifying central obesity in both girls and boys as indicated by the AUCs.

**Conclusions:** The age and sex specific cut off points for waist-to-hip ratio, waist-to-height ratio and conicity index can be used to detect overweight/obesity in Indian Children aged 11-16 years.

Keywords: Conicity index, Cut off values, Childhood obesity, ROC, Waist circumference, Waist-to-hip ratio, Waist-to-height ratio

# **INTRODUCTION**

Obesity along with malnutrition and infectious diseases is becoming one of the most prevalent nutritional problems in the world. It is emerging as the most significant contributor to ill health and mortality and is affecting not only adults but also children and adolescents.<sup>1</sup> Excess fat in childhood is a risk factor for later adult disease and is associated with impaired health during childhood itself which may continue untreated for many years. Once established, obesity in children (as in adults) is hard to reverse.<sup>2</sup> Obesity is often expressed by indicators like Body Mass Index, Waist Circumference (WC), Waist-to-Hip ratio and Skin fold thickness. Other indices used are

Corpulence Index, Conicity Index, total body water, total body potassium, body density, percentage body, Dual Energy X ray Absorptiometry (DEXA).<sup>3-5</sup> Each of these has its own merits and demerits. Among these, BMI is commonly used to assess overweight/obesity but the central obesity is more important than the body mass as it has shown strong association with risk for coronary heart disease, adverse lipid profile and hyperinsulinaemia in children.<sup>6,7</sup> Screening of regional fat distribution on a wide scale requires methods that are simpler, easy and cost effective. However, studies conducted on assessing the validity of anthropometric techniques for identifying central obesity in children are scarce.<sup>2,8-10</sup> Therefore, the aim of the study was to assess the validity of waist-hip ratio (WHR), Waist-to-Height Ratio (WHtR), conicity index (CI) as indicators of central obesity in children as measured by waist circumference.

#### **METHODS**

This is a cross sectional study conducted on 4663 students who were enrolled in 8<sup>th</sup> to 10<sup>th</sup> standard of government and private schools of Mandya city. Socio demographic details of the study subjects were obtained with the use of semi structured pre tested questionnaire. The study was conducted after obtaining the ethical clearance from the Institutional Ethics Committee of Mandya Institute of Medical Sciences, Mandya. Permission from Deputy Director Public Instruction (DDPI) and school heads were obtained. Verbal consent of the study subjects was taken before enrolling them in the study.

The anthropometric measurements were taken following WHO guidelines. The weight was measured in kilograms using standardized bathroom weighing machine to the nearest 0.5 kg, the height was measured with stadiometer to the nearest 0.1 cm. Waist circumference was taken at the midpoint between the top of the iliac crest and the lower margin of the last palpable rib in the mid axillary line. Hip circumference was measured at a level parallel to the floor at the largest circumference of the buttocks. Both waist and hip circumference were measured to the

nearest 0.1 cm.<sup>11</sup> Waist and hip circumference were measured under secured privacy.

The standard cut off values to assess central obesity using waist circumference in children are lacking in India<sup>12</sup>. As WC is considered a simple tool to detect central obesity, it was used in the present study to detect obesity in children aged between 11 and 16 years using WC percentiles calculated for urban Indian children aged 3-16 years as the reference.<sup>7</sup>

Study period: June 2012 to May 2013.

Study setting: High schools of Mandya city.

*Inclusion criteria:* Students of high schools (Government and Private) of Mandya city.

*Exclusion criteria:* Study subjects who did not give consent to participate and who were not available in the school during two visits.

#### Statistical analysis

Waist circumference values of 75th percentile developed by Kuriyan for urban Indian children was taken as reference for cut off values. The data was analyzed using mean, standard deviation, proportion, cut off, sensitivity, and specificity. ROC curves were drawn to assess the validity of the anthropometric measurements (Waist-Hip Ratio, Waist-to-Height Ratio, Conicity Index) with area under curves.

#### RESULTS

The data were analyzed in 4663 study subjects (girls - 2589, boys - 2074). The descriptive characteristics of the study subjects are mentioned in table 1. Using the WC percentiles given by Kuriyan R, the prevalence of overweight/obesity was found to be 7.59% (354/4663) with 8.85% (229/2589) in girls and 6.03% (125/2074) in boys.<sup>13</sup> The characteristics of the study participants are described in Table 1.

Characteristics	Boys	Girls	Total
Age (years)	13.76 ( <u>±</u> 1.07)	13.49 ( <u>+</u> 0.98)	13.65 ( <u>+</u> 1.03 )
Height (mt)	1.53 ( <u>+</u> 0.11)	1.51 ( <u>+</u> 0.08)	1.52 ( <u>+</u> 0.94)
Weight (kg)	40.95 ( <u>+</u> 9.77)	42.23 ( <u>+</u> 9.08)	41.66 ( <u>+</u> 9.41)
Waist circumference (cm)	62.30 ( <u>+</u> 8.27)	64.14 ( <u>+</u> 7.92)	63.33 ( <u>+</u> 8.13)
Hip circumference (cm)	75.12 ( <u>+</u> 7.72)	78.47 ( <u>+</u> 8.32)	76.98 ( <u>+</u> 8.23)
BMI $(kg/m^2)$	17.28 ( <u>+</u> 3.52)	18.57 ( <u>+</u> 3.90)	17.99 ( <u>+</u> 3.79)
Waist to Hip ratio	0.83 ( <u>+</u> 0.07)	0.82 ( <u>+</u> 0.08)	0.83 ( <u>+</u> 0.75)
Waist to Height ratio	0.41 ( <u>+</u> 0.05)	0.43 ( <u>+</u> 0.06)	0.42 ( <u>+</u> 0.05)
Conicity Index <sup>a</sup>	1.12 ( <u>+</u> 0.09)	1.12 ( <u>+</u> 0.11)	1.11 ( <u>+</u> 0.10)

#### Table 1: Characteristics of the study participants.

<sup>a</sup>Calculated as waist girth in meters / (0.109 x square root of weight in kg/height in meter).



Figure 1: Receiver Operating Characteristic curves for central obesity in girls and boys; (a): ROC Curve of anthropometric indices – girls; (b) ROC curve of anthropometric indices – boys.

Correlation between waist circumference and waist-toheight ratio was higher in both girls (r - 0.79, p < 0.0001)and boys (r - 0.73, p < 0.0001) than correlations between WC and CI [(girls - r - 0.56, p<0.0001) (boys - r - 0.60, p<0.0001)] or between WC and Waist-to-Hip ratio [(girls - r - 0.42, p<0.0001) (boys - r - 0.53, p<0.0001)].

#### Table 2: Comparison of areas under ROC Curve - Girls

Anthropometric index and waist circumference	Area	95 % CI	<i>p</i> value
Girls			
Waist-to-Height ratio	0.906	0.892 - 0.920	0.000
Conicity Index	0.766	0.737 - 0.796	0.000
Waist-to-Hip ratio	0.747	0.712 - 0.781	0.000
Boys			
Waist-to-Height ratio	0.937	0.919 - 0.956	0.000
Conicity Index	0.801	0.768 - 0.835	0.000
Waist-to-Hip ratio	0.811	0.778 - 0.845	0.000

#### Table 3: Suggested cut-off points for identifying central obesity with WHtR, WHR and CI.

Age group	Waist-to- Height ratio			Conicity Index			Waist-to-Hip ratio		
	Cut off	Se (%)	Sp (%)	Cut off	Se (%)	Sp (%)	Cut off	Se (%)	Sp (%)
Girls									
11 years $(n = 16)$	0.464	100	100	1.215	100	79	0.835	100	64
12 years (n=393)	0.457	92	89	1.224	63	80	0.856	75	76
13 years (n=823)	0.461	99	88	1.115	94	57	0.844	77	75
14 years (n=971)	0.484	99	92	1.136	89	63	0.861	69	84
15 years (n=344)	0.473	96	89	1.141	78	66	0.840	67	70
16 years (n=42)	0.540	100	100	1.132	100	69	1.024	67	99
Boys									
11 years <sup>a</sup> (n=12)	-	-	-	-	-	-	-	-	-
12 years (n=218)	0.447	100	91	1.173	100	74	0.890	88	88
13 years (n=594)	0.457	89	98	1.166	83	72	0.854	90	68
14 years (n=705)	0.439	100	84	1.142	88	65	0.839	97	63
15 years (n=434)	0.460	100	89	1.149	93	66	0.868	86	75
16 years (n=111)	0.461	100	91	1.224	80	88	0.890	80	92

Se – Sensitivity, Sp – Specificity; <sup>a</sup>Obese children in this age group was not found in the present study. Cut off values cannot be calculated.

The ROC curves for central obesity in girls and boys are shown in Figure 1a and 1b. Waist-to-Height ratio performed significantly better than Waist-to-Hip ratio or Conicity Index in identifying central obesity in both girls and boys as indicated by the AUCs (Figure 1a and 1b and Table 2). The cut off values, sensitivity and specificity for detecting obesity using different anthropometric measurements are given in Table 3.

#### DISCUSSION

Waist circumference has been suggested as the most useful simple measure of fat distribution in children and adolescents as it has shown strong association with risk for coronary heart disease, adverse lipid profile and hyperinsulinaemia in children.<sup>6,7</sup> However, there are no accepted cut-off values for the classification of overweight and obesity in children based on WC. So in the present study, WC percentiles calculated for urban Indian children aged 3-16 years was taken as the reference to compare the anthropometric indices (WHtR, WHR, CI).<sup>12,13</sup>

#### Waist-to-height ratio (W/Ht)

Currently, waist-to-height ratio of 0.5 is suggested for all age groups and different ethnic groups as a tool to determine risk for obesity. Standardization is yet to be done to draw a perfect relation between waist-to-height and overweight/obesity status.<sup>14-16</sup>

In the present study, waist-to-height ratio is found to be less than 0.5 to detect overweight/obesity in both sex and different age groups. Similar observation was found in a study done by Panjikkaran ST, where waist-to-height ratio of 0.45 was the cut-off observed to detect overweight/obese among school going Indian children.<sup>14</sup> But in a study done by K. Rebecca, W/Ht ratio was found to be greater than 0.5, which decreased with increasing age in boys and girls.<sup>7</sup> In the present study, Waist-to-Height Ratio performed well as an index of central obesity in children and adolescents of both sexes.

#### Waist-to-hip ratio (WHR)

The WHR has been used extensively in adults; however, studies published in the 1990s suggest that WHR may be a more useful and accurate tool in children to access the risk of ill health patterns but another study concludes that the use of ratios such as WHR to assess obesity in children may not be appropriate because of factors like age dependence, separate circumference measurements, different skeletal structures which may confound the results.<sup>17</sup>

Currently, the WHO recognizes WC  $\geq$ 90 cm (men) and  $\geq$ 80 cm (women) in Asian adults as a measure to detect central obesity and no cut-offs are mentioned for WHR in asian adults.<sup>18</sup>

Even there is lack of such cut –off values of waist circumference and WHR for children and adolescents of Asian origin. In the present study, WHR ranged from 83-89 in both sex and age group except in girls of 16 years age group.

### Conicity index (CI)

A conicity index of 1.25 means, a person has a waist circumference which is 1.25 times larger than the circumference of a cylinder with height and weight of that person.

The values of conicity index range between 1.00 (perfect cylinder) and 1.73 (perfect double cone). The closer to 1.73, the greater the accumulation of abdominal fat.<sup>19</sup> In the present study, cut off values in both sex varied from 1.1 to 1.2 which is nearer to perfect cylinder value. Conicity index is considered as one of the good indicators of central obesity but due to lack of cut off points, it is limitedly used.<sup>20</sup>

# CONCLUSION

This study determines age and sex specific cut off points for waist-to-hip ratio, waist-to-height ratio and conicity index in Indian Children aged 11-16 years. ROC demonstrated that Waist-to-Height ratio performed significantly better than Waist-to-Hip ratio or Conicity Index in identifying central obesity in both genders. These cut off values can be used to detect overweight/obesity in children

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