

Validating Neck Circumference and Waist Circumference as Anthropometric Measures of Overweight/Obesity in Adolescents

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Objective: To measure neck circumference and waist circumference, to compare it between normal and overweight/obese adolescents, and to validate these with body mass index.

Methods: This cross-sectional study was conducted in 1800 school-going adolescents. Body mass index, waist circumference and neck circumference were measured. Independent samples *t*-test and Pearson's correlation were used as tests of significance to analyze quantitative data. **Results:** Positive correlation of neck circumference and waist circumference with body mass index was observed. The neck circumference and waist circumference in overweight/obese adolescents were significantly higher than adolescents with normal body mass index ($P<0.001$). Area under curve of waist circumference was more than area under curve of neck circumference. Cut-off values of neck circumference for screening adolescent obesity in boys and girls were 30.75 cm, and 29.75 cm, respectively, and waist circumference cut-off value were 70.75 cm for boys and 69.25 cm for girls at fairly good levels of sensitivity and specificity. **Conclusion:** Neck circumference and waist circumference may be used in clinical practice and epidemiological studies as an index of overweight/ obesity among school-going adolescents.

Keywords: Anthropometry, Body mass index, Diagnosis, Screening.

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Neck circumference (NC), a marker of upper body subcutaneous adipose tissue distribution, is a relatively new method of differentiating between normal and abnormal fat distribution. Central obesity being the main predictor of obesity-related disorders, body mass index (BMI) may not be the best indicator of functional consequences of obesity [1]. Calculating and interpreting BMI is also time consuming. On the contrary, measuring neck - and waist-circumference by a tape is relatively easy, and has not been explored adequately as anthropometric measure of overweight and obesity. We conducted this study to validate neck-and waist-circumference as anthropometric measures of overweight/obesity among adolescents, and to correlate these with BMI.

METHODS

This school-based cross-sectional study was conducted in 12 schools of Bhubaneswar city in Odisha, India from July to December 2013 among 1800 adolescents studying in class 6 to 10. For the selection of schools, the list of all schools (112) was obtained from the district education office. It was decided to cover about 10% (12) schools

that included six government and six private schools. From each school, 150 students were selected to reach the desired sample size of 1800. Thus a total of 900 students each from government and private schools were enrolled. Thirty students from each class were selected by systematic random sampling following the students list in the attendance register. In case, student of a selected roll number was absent on the day of survey, the next roll number was included.

Ethical clearance was obtained from Institutional Ethical Committee, and permission from Principal/Head masters of the schools was obtained prior to the study. Data were collected after obtaining assent from students. Healthy children were included in the study. Children with conditions likely to interfere with neck circumference, such as goiter, swellings or cysts in the neck and abnormalities of the cervical spine such as cranio-vertebral junction anomalies, were excluded. Children with Cushing syndrome, and those with exogenous steroid intake were excluded. Also, children with conditions like malnutrition, HIV, malignancies and acute or chronic illnesses were excluded.

Weight was measured with light clothing and without shoes. Height without shoes was measured by stadiometer. Children were categorized according to their BMI using BMI percentile curves for Indian boys and girls from 5–17 years with 3rd, 10th, 25th, 50th, 85th and 95th percentiles, along with two additional percentiles corresponding to a BMI of 23 and 28 kg/m² at 18 years [2]. Waist circumference (cm) was measured using plastic tape at midpoint between the costal margin and iliac crest in the mid-axillary line in standing position at the end of a gentle expiration [3]. Neck circumference was measured by using a flexible tape, with children in standing position; head held erect, at the level of the thyroid cartilage [4]. All anthropometric measurements were performed by two trained Medical Social Workers. Data were analyzed using SPSS version 20.0. Quantitative data were analyzed using independent samples *t*-test and Pearson's correlation. Receiver Operating Characteristic (ROC) analysis was done to find the optimal and maximal sensitivity and specificity for neck/waist circumference against BMI. The cut-off values for these in school going adolescents were determined by Youden index (Sensitivity + Specificity -1) [5]. A *P* value of <0.05 was considered to be statistically significant.

RESULTS

The age of adolescents included in this study (*n*=1800; 51.7% boys) varied from 10–16 years with a mean (SD) age 13.0 (1.4) years. The study sample consisted of 1213 (67.4%) with normal BMI, 501 (27.8%) with overweight/obesity and 86 (4.8%) underweight adolescents. The mean (SD) BMI of boys and girls were 18.5 (4.8) and 18.7 (4.4) kg/m², respectively. The mean (SD) waist circumference for boys and girls were 68.5 (12.3) and 66.2 (9.5) cm, respectively; and the mean (SD) neck circumference for boys and girls were 29.9 (3.2) and 28.9 (2.7) cm, respectively. There was significant difference (*P*<0.001) in waist circumference and neck circumference between adolescents with normal and high BMI for both genders (**Table I**).

BMI was positively correlated with neck circumference (*r*=0.642 for boys, 0.615 for girls) and waist circumference (*r*=0.693 for boys, 0.682 for girls) at significant level (*P*<0.001). For boys, 3rd percentile of neck circumference was 25 cm and 97th percentile was 36.0 cm, and for girls, 3rd percentile was 24.2 cm and 97th percentile was 35 cm.

Table II shows the values of area under the curve (AUC) and cut-off values for waist circumference and neck circumference with their respective sensitivity and specificity levels in identifying children with overweight/obesity. **Fig. I** shows the comparison of neck

TABLE I ANTHROPOMETRIC MEASUREMENTS AMONG SCHOOL-GOING ADOLESCENTS IN PRESENT STUDY

	With normal BMI	Overweight/ Obese	P value
<i>Boys</i>			
Height in cm	151.7 (13.1)	155.3 (13.07)	<0.001
Weight in kg	38.6 (9.9)	59.9 (14.2)	<0.001
Waist circumference	64.7 (8.6)	80.5 (12.7)	<0.001
Neck circumference	29.0 (2.6)	32.7 (2.8)	<0.001
<i>Girls</i>			
Height in cm	147.8 (8.4)	149.6 (9.4)	<0.05
Weight in kg	37.0 (7.07)	54.4 (10.2)	<0.001
Waist Circumference	63.1 (7.5)	74.6 (8.6)	<0.001
Neck circumference	28.2 (2.2)	31.1 (2.5)	<0.001

All values in Mean (SD); For normal BMI, *n*=620 for boys and *n*=593 for girls; and for overweight/obese *n*=250 for boys and *n*=251 for girls.

circumference as a tool for detection of overweight/obesity as compared to waist circumference and BMI.

DISCUSSION

In this study, we documented a significant difference in waist circumference and neck circumference among normal and overweight/obese children detected by BMI (*P*<0.001) in both boys and girls. Also, there was a strong positive correlation of neck circumference as well as waist circumference with BMI.

Limitations of present study include enrolment of adolescents from a small geographic area, sample size and lack of validation of these measurements with functional consequences of obesity.

We found that the cut-off value of neck circumference for screening adolescent obesity in boys and girls were 30.75 cm and 29.75 cm respectively, while cut-off values for waist circumference were 70.75 cm for boys and 69.25 cm for girls. These results were close to the

TABLE II PERFORMANCE OF NECK CIRCUMFERENCE IN DETECTING OVERWEIGHT/OBESITY

	AUC	95% CI	Cut-off (cm)	Sensitivity (%)	Specificity (%)
<i>Waist circumference</i>					
Boys	0.866	0.837, 0.894	70.75	82.8	77.3
Girls	0.850	0.821, 0.879	69.25	74.5	81.1
<i>Neck circumference</i>					
Boys	0.823	0.794, 0.853	30.75	79.2	68.7
Girls	0.816	0.785, 0.846	29.75	72.5	77.1

WHAT IS ALREADY KNOWN?

- Body mass index is the most commonly used tool for screening of overweight/obesity.

WHAT THIS STUDY ADDS?

- Neck circumference and waist circumference can also be used as tools for screening of obesity among adolescents with reasonable sensitivity and specificity.

estimates from previous studies, and small differences between the cut-offs could be explained by ethnic variation [4,6]. Correlation of neck circumference and waist circumference as with BMI, as observed in our study, has also been reported earlier [4,6,7]. We observed the area under the curve of more than 80% for both neck circumference and waist circumference among boys and girls, indicating accuracy in its ability to identify adolescents with a high BMI. Moreover, AUC for waist circumference was found to be more as compared to neck circumference in both boys (0.866 vs 0.823) and girls (0.850 vs 0.816) indicating that waist circumference may be a better measure of obesity in adolescents. However, several limitations have been documented in the literature, either related to its measurement [6], especially among the adolescents owing to body changes they experience during puberty or due to its variation throughout the day according to bowel function or

menstrual period [8]. Measurement of neck circumference may be relatively simple, convenient and non-intimidating, especially for the adolescents. As compared to BMI and waist-to-hip ratio, neck and waist circumference have been shown to have higher accuracy in predicting the risk of atherosclerosis in the middle-aged adults [9].

We conclude that both neck- and waist-circumference are useful screening tools for adolescent overweight/obesity, and have a potential to be used as a screening tool for adolescent overweight/obesity.

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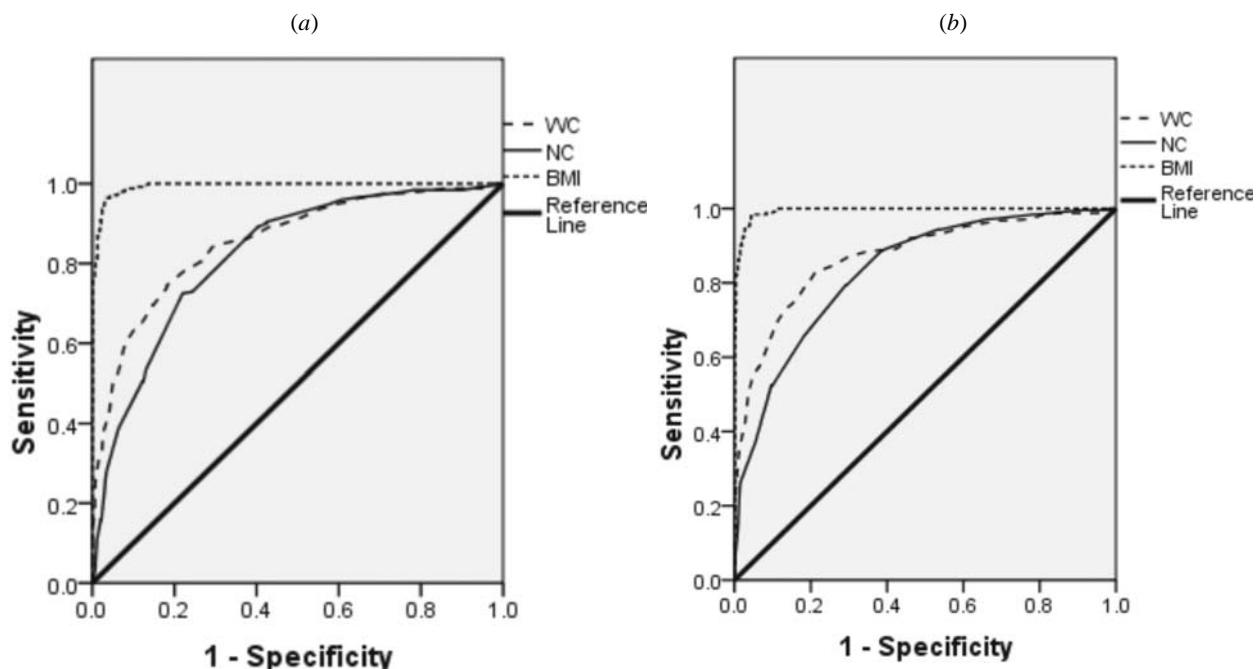


Fig. 1 ROC curve comparing neck circumference and waist circumference with body mass index (BMI) in boys (a), and girls (b). WC - waist circumference and NC - neck circumference.

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