International Journal of Contemporary Pediatrics
Yashoda HT et al. Int J Contemp Pediatr. 2017 Mar;4(2):426-430
http://www.ijpediatrics.com
pISSN 2349-3283 | eISSN 2349-3291

DOI: http://dx.doi.org/10.18203/2349-3291.ijcp20170538

Original Research Article

Neck circumference measurement as a screening tool for obesity in children

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Received: 05 February 2017
Accepted: 10 February 2017

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ABSTRACT

Background: Childhood obesity is a rising epidemic and a major public health problem with the risk for type 2 diabetes mellitus, hypertension and cardiovascular disorders in later life. Neck circumference (NC), a marker of upper body subcutaneous adipose tissue distribution can predict higher metabolic risk. The aim of the present study was to evaluate the association between neck circumference (NC) and obesity.
Methods: This cross-sectional prospective observational study was conducted in Bangalore in the month of October 2016. 172 male and 161 female students, aged 13-17 years were screened. Anthropometric markers of obesity measured included body mass index (BMI), waist circumference (WC), hip circumference (HC), waist-to-hip ratio (WHR), and compared with neck circumference (NC) of the same subjects. Pearson's correlation coefficient was calculated between neck circumference and other obesity indices, and receiver operating characteristic curve analysis was used to determine the best cutoff value of neck circumference in predicting high BMI.
Results: Overall, 13.2% boys and 9.9% girls were found overweight/obese. The mean BMI was 25.27±2.09kg/m^2 and25.17±2.23kg/m^2, mean neck circumference was 33.43±2.3cm and 31.50±1.4 in overweight/obese boys and girl respectively. All of the anthropometric parameters were found to be significantly higher in overweight/obese children than with their normal weight peers and higher in boys compared to girls. The neck circumference in boys was significantly greater than girls and higher in overweight/obese with P<0.001. The best cut-off value of neck circumference by ROC to identify boys with a high BMI was 32cm with sensitivity of (81.82%), specificity (89.06%), and for girls was 30cm with sensitivity of (84.85%), specificity (87.5%). Neck circumference had a strong positive correlation with other anthropometric measures BMI, WC, waist hip ratio in both boys and girls (p <0.001).
Conclusions: Neck circumference significantly correlated with other indices of obesity. It can be used with great reliability to screen overweight and obesity in children. NC can be considered as a simple, time saving and inexpensive clinical tool for detection of obesity in large population-based studies in children and adolescents.

Keywords: Body mass index, Neck circumference, Overweight, Obesity, Waist Circumference, Waist hip ratio

INTRODUCTION

The prevalence of childhood obesity is rapidly increasing worldwide. Obesity is associated with increased risk of cardiovascular and metabolic disturbances in later life. In children, the prevalence of obesity increased 300% over approximately 40 years. The National Health and Nutrition Examination Survey (2009-2010) found 32% of children between 2-19 year-old to be overweight or obese.[1]

BMI is the most widely used tool for defining overweight and obesity in both adults and children. But BMI is a suboptimal marker for total body fat and less suitable to

assess body fat distribution. Regional deposition of fat, especially in the upper body segment, is a better predictor of obesity related complications, such as hypertension, diabetes, and cardiovascular diseases.[2]

In assessing central obesity, anthropometric measures used are waist circumference (WC), waist/hip ratio (WHR), sagital abdominal circumference, etc, and skinfold thickness like triceps/subscapular skinfold thickness are measures of subcutaneous adiposity. But these measurements may not be of practical to use in winter and busy primary day to day practice. Other techniques like DEXA (dual-energy X-ray absorptiometry), USG, CT and MRI imaging procedures are expensive procedures to measure visceral/subcutaneous adiposity and are limited to research purposes. So there is a need to develop a simple, quick and reliable method of assessing obesity in primary care practices, to control obesity and related metabolic consequences. Free fatty acids release from upper body subcutaneous fat was found to be larger than that from lower body subcutaneous fat, a fact that further strengthens the relevance of measuring upper body subcutaneous adipose tissue depot.[3] Neck circumference measurement has been suggested as an index of the upper body fat distribution and can be used as a simple and time-saving screening measure to identify overweight/obesity.

The purpose of this study was to determine whether neck circumference alone can be used to identify overweight and obese children and to find out the correlation between neck circumference and BMI, WC, WHR to evaluate obesity.

METHODS

The present study was a prospective cross sectional observational study conducted in 2016 in the month of October in an urban school in Bangalore. After institutional ethical committee approval, we screened 333 children who were aged between 13 to 17 years. Parents were informed and consent was taken from the adolescent children in this study. Inclusion criteria were all adolescents aged between 13 to 17 years and who gave consent. Exclusion criteria were children with goiter, cervical lymphadenopathy or other neck masses, neck deformity, diabetes, cushings disease, medication use (like steroids etc) or procedures like tracheostomy or use of cervical collar were excluded from this study.

Anthropometric measurements

Measurements were taken by trained research assistant, height was measured by using a stadiometer, child standing with barefoot and head held in Frankfurt horizontal plane to the nearest 0.1 cm. Weight was measured by using a calibrated electronic weighing scale, to the nearest 0.1 kg. BMI was calculated by dividing weight in kilograms (kg) by the square of their height in meters (kg/m^2). WC was measured by using flexible measuring tape to the nearest 0.1 cm with the child standing, and at the end of normal expiration at a point midway between the inferior margin of the lowest rib and the iliac crest. Hip circumference (HC) was measured at the maximum circumference around the buttocks. WHR was calculated by dividing WC by HC. Neck circumference was measured by using a flexible tape, with the child in the standing position, head held erect and eyes facing forward and the neck in a horizontal plane at the level of most prominent portion, the thyroid cartilage.

Classification of BMI (WHO -2004): Underweight < 18.5 kg/m^2, normal 18.5 - 22.9 kg/m^2, over weight- 23 - 27.4 kg/m^2, Obese >_27.5 kg/m^2.[4] WHR values (WHO) for males was 0.9 and for females was 0.85.[5]

According to this classification 77 (23.1%) were with BMI >23kg/m^2 and 256 (76.9%) were with BMI <23kg/m^2.

Descriptive statistical analysis has been carried out in the present study. Continuous measurements were computed as Mean±SD, categorical measurements were presented in number (%).The calculations were performed by SPSS version 21 software and the results were considered statistically significant with $P \leq 0.05$. Student t-test (two tailed) has been used to find the significance of study parameters on continuous scale between two groups. Pearson correlation was used to study association between various anthropometric measurements to find the degree of relationship. Cutoff values of neck circumference to identify overweight and obesity were obtained by analyzing the ROC (receiver operating characteristic) curves. A perfect score will have an AUC of 1, whereas AUC of 0.5 means that test performs no better than chance. The best cutoff values were established for male and female children separately.

RESULTS

A total of 333 children who met the inclusion criteria were included in this study. Based on BMI, 44(13.2%) boys and 33(9.9%) girls were identified as overweight/obese. Table 1 shows mean anthropometric measurement values in both boys and girls. The mean weight, height, BMI, WC, HC, WHR were 63.16±10.03 kg, 158.33±8.2 cm, 25.27±2.09 kg/m^2, 81.05±10.41 cm, 88.14±10.4 cm, 0.92±0.05 cm respectively in obese/overweight boys. The mean weight, height, BMI, WC, HC, WHR were 59.00±7.3 kg, 153.14±7.1, 25.17±2.23 kg/m^2, 78.36±10.07 cm, 87.03±10.3cm, 0.90±0.10 respectively in obese/overweight girls. All of the anthropometric parameters were found to be significantly higher in overweight/obese children than with their normal weight peers and higher in boys compared to girls. The mean neck circumference in overweight/obese boys and girls was 33.43±2.3 and 31.50±1.4 cm respectively. The neck

circumference in boys was significantly greater than girls and higher in overweight/obese with P <0.001. Table 2 presents the Pearson's correlation coefficients between neck circumference and other anthropometric parameters for boys and girls. Neck circumference showed a strong positive correlation with BMI, WC and waist hip ratio in both boys and girls.

Table 1: Comparison of anthropometric measurements between controls and overweight/obese in boys and girls.

Boys (mean)	controls(normal/underweight)	Over weight-obese	P value
Age (years)	14.84±1.1	15.23±1.4	0.065
WT(kg)	44.48±7.0	63.16±10.03	<0.001
HT(cm)	157.11±7.5	158.33±8.2	0.366
BMI (kg/m^2)	17.89±2.0	25.27±2.1	<0.001
HC(cm)	80.29±7.0	88.14±10.4	<0.001
WC(cm)	67.02±7.4	81.05±10.4	<0.001
WHR	0.83±0.1	0.92±0.1	<0.001
NC(cm)	29.53±3.2	33.43±2.3	<0.001
Girls (mean)			
Age (years)	14.93±1.3	14.97±1.2	0.889
WT(kg)	42.91±5.6	59.00±7.3	<0.001
HT(cm)	153.26±5.9	153.14±7.1	0.918
BMI(kg/m^2)	18.32±2.0	25.17±2.2	<0.001
HC(cm)	81.95±5.9	87.03±10.3	<0.001
WC(cm)	65.93±6.1	78.36±10.1	<0.001
WHR	0.80±0.0	0.90±0.1	<0.001
NC(cm)	28.71±1.5	31.50±1.4	<0.001

Table 2: Pearsons correlation(r) between neck circumference and other anthropometric parameters.

	NC-BMI (r)	NC-WHR (r)	NC-WC (r)	BMI-WHR (r)	P value
Boys	0.57	0.39	0.55	0.64	<0.001
Girls	0.7	0.46	0.66	0.55	<0.001

Table 3: ROC curve analysis for neck circumference.

Neck circumference	ROC results to predict obesity				Cut-off	AUROC	SE	P value
	Sensitivity	Specificity	LR+	LR-				
Boys	81.82%	89.06%	7.48	0.20	>32	0.885	0.032	<0.001
Girls	84.85%	87.50%	6.79	0.17	>30	0.912	0.028	<0.001

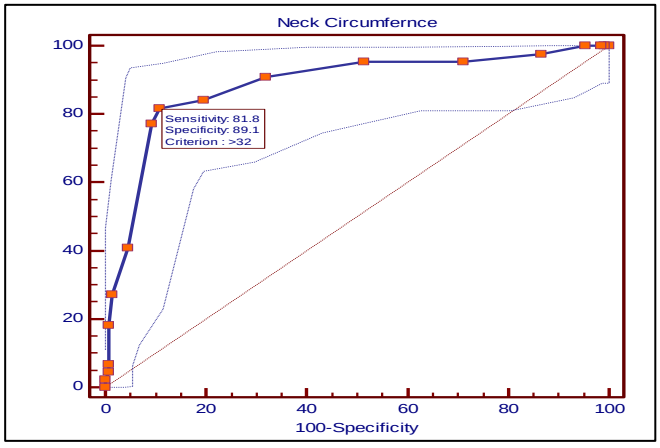

Figure 1: ROC for NC in boys

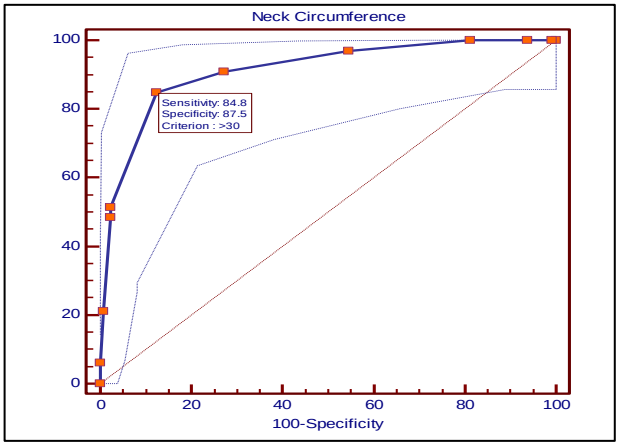

Figure 2: ROC for NC in girls.

Table 3 shows the AUC (area under curve) including the optimal NC cutoffs. Neck circumference cutoff value in boys was 32cm with the corresponding sensitivity of (81.82%), specificity (89.06%), positive LHR (7.48) and negative LHR (0.20). Neck circumference cutoff value in girls was 30cm and the corresponding sensitivity was (84.85%), specificity (87.5%), positive LHR (6.79) and negative LHR (0.17)

DISCUSSION

The present study conducted on children aged 13 - 17 years had shown a significant association between neck circumference and other anthropometric measurements of obesity in both boys and girls.

Childhood obesity has become a major public health problem in children. Many studies had shown increased adverse health outcomes of childhood obesity both short-term as well as long-term consequences.[6,18] Controlling the epidemic of childhood obesity, detection, early prevention and treatment of childhood obesity are important priorities that need accurate diagnostic measures. Screening and monitoring tools must be low-cost, quick and easy to use, and generally acceptable to both patients and health practitioners.

Several methods are available for assessing obesity in children and include weight, WC, WHR, BMI and weight height ratio. BMI may not reflect body fat distribution and waist circumference measurement though reflect central obesity it is time consuming, cumbersome and may be effected by post prandial abdominal distension, bowel dysfunction etc. Direct measurement of body fat by USG, DEXA, CT etc are expensive and not feasible and hence anthropometric measures which are reliable and easy to perform at point of care should be used.

Studies conducted in adults had shown that neck circumference can be used as a simple screening tool for identifying individuals with high BMI with good inter and intrarater reliability and various studies had found an association between neck circumference with other obesity indices.[7-9] However, there are limited studies on the neck circumference measurement as an index of obesity in the paediatric age group.

Vague J was the first person to suggest that different body morphology and type of fat distribution are associated with the health risk of obesity and used a neck skin-fold to assess upper body fat distribution.[10]

Hatipoglu et al suggested NC can be used as an additional measure to screen children with overweight and obesity and also found a positive correlation between NC and BMI, WC. The cut-off values that showed higher sensitivity and specificity for NC to detect overweight in pre-pubertal and pubertal period were 28 -31 cm for girls and 29-32.5cm for boys respectively.[11]

A study conducted by Nafiu et al on 1102 children aged between 6-18 years had shown that NC correlated with age, BMI, and waist circumference in both boys and girls and NC cutoff values were given according to age, optimal NC cutoff indicative of high BMI in boys ranged from 28.5-39 cm, in girls 27-34.6 cm respectively.[12] Similar results were also found in other studies by Roberta de et al and Mozaffer et al.[13,14]

Some studies shown association between neck circumference and increased risk of adverse health consequences of excess weight. Renata et al shown association of neck circumference and high blood pressure in children and adolescents.[15] Katz et al had shown that neck to waist ratio, an index of body fat distribution predicts obstructive sleep apnoea in overweight/obese children.[16] Another study conducted in 324 Greek children aged 9 - 13 years found that NC was associated with most cardiovascular disease (CVD) risk factors. The study showed that the association of NC and CVD was comparable to the observed co-relations of BMI, WC, hip circumference (HC), waist-to-hip ratio (WHR) and WHtR with CVD.

The present study had similar results with other studies. Neck circumference cutoff value in boys was 32 cm with sensitivity of (81.82%), specificity (89.06%), in girls was 30cm with sensitivity was (84.85%), specificity (87.5%). Neck circumference is a reliable and inexpensive, quick and easy to measure than other indexes of adiposity.

The study had some limitations that it was a cross-sectional observation study with small sample size and limits its interpretation as to causality of associations. Although neck circumference had a strong correlation with various obesity parameters there is a need to derive and validated neck circumference cutoff for different pubertal stages, different BMI catagories and different age groups for our Indian population.

CONCLUSION

The findings of the present study are consistent with other studies in children and adolescents, so we conclude that neck circumference could be a useful, simple screening measure for identifying overweight/obese children.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Yashoda HT, Swetha B, Goutham AS. Neck circumference measurement as a screening tool for obesity in children. Int J Contemp Pediatr 2017;4:426-30.