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NECK CIRCUMFERENCE AS A SCREENING TOOL FOR OBESITY IN ADOLESCENT GIRLS IN NAVI MUMBAI

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A clinical study was conducted in Navi Mumbai on 150 adolescent girls from mixed community aged 13-18 years, to find the correlation between Neck Circumference and BMI percentile in adolescent girls, and to examine if Neck Circumference is a valid measure of fat distribution. Anthropometric markers of obesity measured, included Body Mass Index (BMI), BMI-for-age Percentage, Waist Hip Ratio, and compared with Neck Circumference of the same subjects. Correlation between Neck Circumference and other obesity indices were obtained statistically. There was statistically significant positive correlation between Neck Circumference and other anthropometric measurements namely BMI and BMI-for-age Percentage, while there was a moderate correlation between Neck Circumference and Waist Hip Ratio. The study found limitations of Neck Circumference measuring cut-offs for assessing fat distribution of adolescent girls. The average Neck Circumference varies for different geographical locations, since the average body structure itself differs from location to location. There definitely is a correlation between Obesity Indices and Neck Circumference, but to use Neck Circumference as an independent tool to assess Body Fat, the Neck Circumference Cut-offs need to be reviewed and practical cut-offs for each geographical area need to be defined.

Keywords: Neck circumference, Adolescent girls, Waist hip ratio, Body mass index percentile

INTRODUCTION

Childhood overweight and obesity is rapidly increasing and remains a worldwide public health concern (World Health Organisation, 1997). Childhood overweight/obesity is associated with health risk factors both during childhood (Friedemann *et al.*, 2012; Weiss *et al.*, 2004) and adulthood. Freedman *et al.* (2008) and The *et al.* (2010) excess body weight, when due to the accumulation of body fat, is closely related to the incidence of obesity and many other diseases, so early detection is important (Whitaker *et al.*, 1997; and Barlow, 2007).

Consequently, identification of overweight/obese children early in life may be an important part of an overall health screening process that could be used to improve well-being in this population (Kuczmarski *et al.*, 2000; and August *et al.*, 2008).

The most commonly used screening tool for detecting childhood overweight/obesity is the Body Mass Index (BMI; weight (kg)/height (m) squared). The standard method used in the United States relies on the use of gender and age specific BMI growth charts from the Centers for Disease Control and Prevention (CDC) (Kuczmarski *et al.*, 2010).

Youth above the standard 85th percentile are considered overweight while youth above the 95th percentile are considered obese. While the BMI is widely used and

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accepted, there has been recent interest in the use of Neck Circumference (NC) as an alternative screening method.

Age- and gender-specific cut-offs for NC were established using receiver operating characteristics curve (ROC curve) on a large sample of children (n = 1102, 52% boys, aged 6 to 18 yrs). The analyses were designed to maximize both sensitivity and specificity of NC cut-offs in relation to the overweight/obesity categorization using the CDC growth charts for BMI (i.e., values above the 85th percentile). This methodology resulted in a set of age- and gender-specific NC cut-offs that ranged from 28.5 cm to 39.0cm for boys and from 27.0 cm to 34.6 cm for girls (Vivian Siqueira Santos GONÇALVES *et al.*, 2014).

Despite the simplicity and universal use of BMI, it is not the perfect scale to assess central obesity, which is the main predictor for obesity-related disorders. Due to the limitations of BMI, alternative scale indicators such as Waist Circumference (WC) and Waist-to-Hip Ratio (WHR) have been introduced, but each has its limitations. For instance, measuring WC may be time-consuming and problematic in terms of cultural and environmental issues. Similarly, after eating, WC may be affected by abdominal distention. Given the limitations of these criteria, new strategies are required to find a better scale to measure overweight and obesity, particularly focusing on visceral obesity. Very few investigators have attempted to use neck circumference to screen for high BMI in children.

Objectives

Therefore, the objectives of the study were to find the correlation between Neck Circumference and BMI PERCENTILE in ADOLESCENT GIRLS, to examine if Neck Circumference is a valid measure of fat distribution in a group of adolescent girls aged 13-18 years.

METHODOLOGY

A study was conducted in Navi Mumbai, Nerul, in a clinical setting. 150 adolescent girls aged 13 to 18 yrs. participated with various socio-economical and educational backgrounds.

Inclusion Criteria: Adolescents girls aged between 13 to 18 years were included.

Exclusion Criteria: Children with goiter, cervical lymphadenopathy or other neck masses, neck deformity, diabetes, Cushing disease, medication use (steroids, etc.) or procedures like tracheostomy or use of cervical collar were excluded.

Anthropometric Measurements: Measurements were taken by self, height was measured by using a stadiometer, child standing barefoot and head held in Frankfurt horizontal plane to the nearest 0.1 cm. Weight was measured by using an 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). Waist Circumference 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 measuring 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 $\geq$27.5 kg/m^2.

BMI-for-age percentile was calculated using the CDC BMI chart for girls 2 to 20 yrs. Continuous measurements were computed as Mean ± SD, categorical measurements were presented in Frequency & Percentage.

The calculations was performed, a Correlation was established using CORRELATION Function of Microsoft Excel between Neck circumference measurement and BMI for-age Percentile, between Neck Circumference measurement and BMI for age Percentile and Neck Circumference measurement and Waist/Hip Ratio.

A Correlation Coefficient Value >= 0.5 can be taken as a strong Correlation, while the sign indicates whether the fields are Positively or Negatively Correlated.

RESULTS AND DISCUSSION

A total number of 150 samples from the Navi Mumbai clinical setting, who met the inclusion criteria, were included in the analysis.

Anthropometric Measurements: The Weight, Height, Waist Hip Ratio and BMI of the samples were taken and the means were found to be as follows: Weight - 59.3 Kg (with a minimum of 35.5 Kg to a maximum of 96.3 Kg), Height - 155.3 cm (with a minimum of 142.0 cm to a maximum of 175.0 cm), Waist Hip Ratio - 0.82 (with a minimum of 0.67 to a maximum of 1.14),

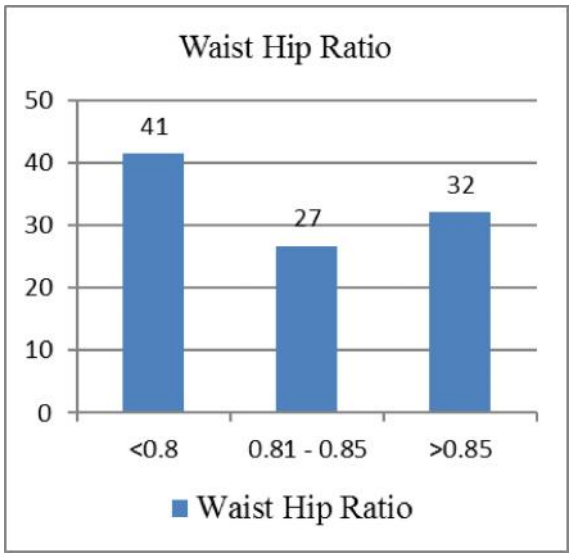
BMI - 24.60 Kg/m^2 (with a minimum of 15.80 Kg/m^2 to a maximum of 37.50 Kg/m^2).

As seen in Table 1 and Figure 1, 41% of the samples were found to be with normal Waist Hip Ratio, i.e., <0.80, while 27% were found to be in the 0.81 to 0.85 range and 32% were found to be in the >0.85 range indicating increased health risks due to excess fat in the abdominal region. Anthropometric measurements were used in other studies to assess the nutritional status of adolescent girls (Pelegrini *et al.*, 2015). The trend observed is in line with the study of anthropometric indicators of obesity in the prediction of high body fat in adoloscents. Anthropometric indicators like BMI and WHR were conclusively found that it can be used as screening methods for identification of body fat in adoloscents, because are simple, low cost and non-invasive (Anju Sood *et al*., 2007).

Table 1: Anthropometrical Measurements of Samples

SR	Anthropometrical Measurements (n=150)		
	Anthropometry Variables	**Frequency**	**Percentage**
1	Waist Hip Ratio		
1a	< 0.80	62	41
1b	0.81 to 0.85	40	27
1c	> 0.85	48	32

Figure 1: Waist/Hip Ratio of Samples



The CDC BMI Chart for Girls 2 to 20 Years was used to plot the Body Mass Index-for-age percentile for each sample. The mean BMI-for-age percentile was 74.23 with a Standard Deviation of +/- 28.5. This BMI-for-age percentiles 0% to 5%, 5.01% to 85%, 85.01% to 95% and >95.01% were categorised into Underweight, Healthy, Overweight and Obese categories respectively.

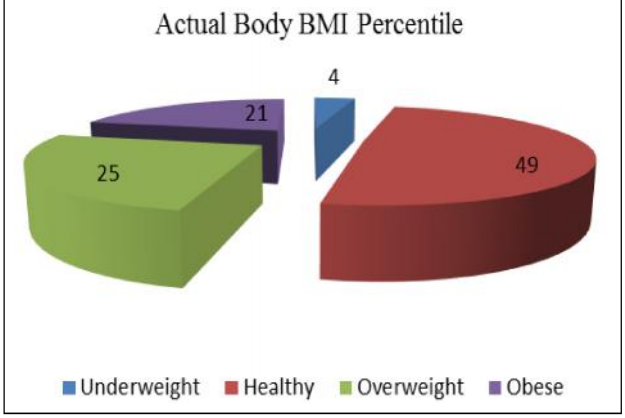
As seen in Table 2 and Figure 2, 49% of the samples were found to be Healthy, 25% Overweight, 21% Obese and 4% Underweight. The CDC BMI Chart was used to assess the BMI and Body Fat Percent among affluent adolescent girls. With regards to using BMI-CDC charts, in 1997, an international conference convened by International Obesity Task Force concluded that BMI is a reasonable measure for assessing overweight in children and adolescents world-wide.

Some of the practical features of using Neck Circumference measurements are that this is easy, simple, inexpensive to use, has no requirement to remove upper clothes and is less susceptible to harsh weather, than other measures (ex., Waist Circumference measurement). Neck

Table 2: Actual Body BMI Percentile

SR	Actual Body BMI Percentile (n=150)		
	Body Image Perception	**Frequency**	**Percentage**
1	Underweight	6	4
2	Healthy	74	49
3	Overweight	38	25
4	Obese	32	21

Figure 2: Actual Body BMI Percentile



Circumference and BMI was found to have a correlation of 0.7 and it was recommended to use Neck Circumference measurements to screen overweight and obesity in children as shown in Table 3 (Vivian Siqueira Santos GONÇALVES *et al.*, 2014). The mean Neck Circumference of Normal/ Underweight girls was found to be 28.71+/- 1.5 cm, while that of Overweight / Obese girls was found to be 31.50 +/- 1.4 cm. The present study sample of 150 subjects consisted of a mix of Adolescents girls aged between 13 years to 18 years. The Mean NC was 29.0 ± 1.6 cm SD.

As shown in Table 4 and Figure 3, 23% of the samples were found to be Underweight, 50% to be Healthy, 16% to be Overweight and 11% to be Obese. This data was Statistically Correlated to other anthropometric measurements.

There was statistically significant positive correlation between NC and other anthropometric measurements namely BMI (0.7) and BMI-for-age Percentage (0.62), while there was a moderate correlation between NC and Waist/Hip Ratio (0.49) as shown in Table 5.

Table 3: Cut-Offs of Neck Circumference in Classification of Samples

Cut-Offs (Neck Circumference in cm)	Classification of Samples
`<27.21	Underweight
`>27.21	Healthy
`>30.1	Overweight
`>31.5	Obese

Table 4: Classification of Samples Using NC Cut-Offs

Classification of Samples	Percentage	Frequency
Underweight	23	34
Healthy	50	75
Overweight	16	24
Obese	11	17

Figure 3: Classification of Samples Using NC Cut-Offs

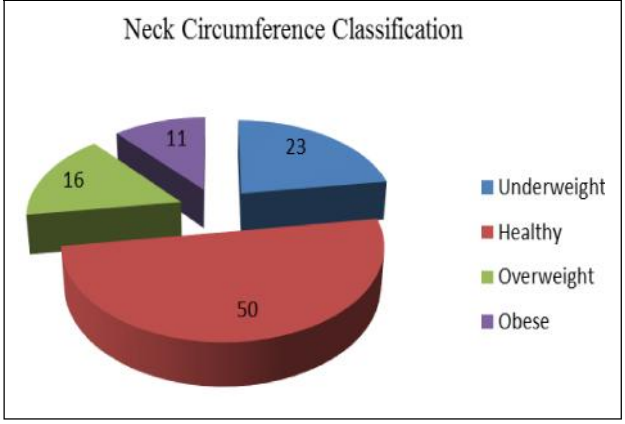


Table 5: Statistical Correlations of Neck Circumference with Other Anthropometric Measurements

Statistical Correlations	Correlation Coefficient
Correlation between Neck Circumference and Waist/Hip Ratio	0.49
Correlation between Neck Circumference and BMI	0.7
Correlation between Neck Circumference and BMI for-age Percentile	0.62

This study, conducted on adolescent girls aged 13-17 years has shown a significant association between Neck Circumference and other anthropometric measurements of obesity like BMI and Waist Hip Ratio. Adolescent is a period of physical, behavioural and emotional changes that marks the transition between childhood and adulthood, individuals are consolidating food habits and so are more vulnerable both to nutritional deficiencies and obesity, because of excessive energy dense foods. The prevalence of obesity in children has increased worldwide and is associated with risk factors for cardiovascular and metabolic disorders, which, due to their chronic and insidious nature, require careful monitoring in childhood, aimed at early detection and the establishment of interventions to prevent complications in adulthood (Nayera Hassan *et al.*, 2014). The most commonly used screening tool for detecting childhood overweight/obesity is the body mass index (BMI; weight (kg)/height (m) squared). The standard method used in the United States relies on the use of gender and age specific BMI growth charts from the Centers for Disease Control and Prevention (CDC).

Several methods are available for assessing obesity in children including Weight, WC, WHR, BMI and Weight Height ratio. BMI may not reflect body fat distribution

and Waist Circumference measurement, though reflecting central obesity, 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. Due to the limitations of BMI, alternative scale indicators such as Waist Circumference (WC) and Waist-to-Hip Ratio (WHR) have been introduced, but each has its limitations. For instance, measuring WC may be time-consuming and problematic in terms of cultural and environmental issues. Similarly, after eating, WC may be affected by abdominal distention. Given the limitations of these criteria, new strategies are required to find a better scale to measure overweight and obesity, particularly focusing on visceral obesity. 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 intra reliability and various studies had found an association between Neck Circumference with other obesity indices.

To date, a relatively large number of studies have been conducted to examine the associations between NC and varying health indicators in children (i.e., cardiovascular risk factors (Ben-Noun and Laor, 2006; Kurtoglu *et al.*, 2012; and Guo *et al.*, 2012), prehypertension (Nafiu *et al.*, 2011) and perioperative adverse respiratory events (Youngwon Kim *et al.*, 2014). However, a limited body of scientific evidence has been established to determine whether or not NC measurement can serve as a useful tool for classifying childhood overweight/obesity. NC measurement may not be precise enough to serve as a stand-alone alternative to BMI. In support, BMI showed better (or comparable) classification accuracy of overweight/obesity for boys and girls, respectively, in comparison with NC. Moreover, BMI has been recommended by numerous previous studies as a useful screening tool to identify childhood overweight/obesity. In contrast, it has also been found that Neck Circumference was not better than BMI in classifying childhood overweight/obesity. Pediatricians or pediatric researchers need to be cautious or wary about incorporating Neck Circumference measurements on their pediatric care or research. The accuracy of Neck Circumference measurement was not so reasonably high, hence Pediatricians/Pediatric educators may not be able to capitalize on the good practicability per se (Mehri Taheri *et al.*, 2016).

Therefore, it has become a tradition in nearly all pediatric clinical settings that Height and Weight are routinely measured as part of their basic check-ups for a child to yield his or her corresponding BMI value.

For these reasons, unless classification accuracy of Neck Circumference measurement for childhood overweight/obesity is strongly supported with scientific evidence, NC measurement may not be broadly used in clinical practice, despite its high practicality. Neck Circumference significantly correlates with overweight and obesity. Hence Neck Circumference could definitely be used with great reliability to screen overweight and obesity in children, and to identify those with high BMI. The best cut-off values for Neck Circumference to identify boys with high BMI were 27.5 to 38.3 cm and for girls it was 26.7 to 33.4 cm (Varun Gaiki and Vasant Wagh, 2015).

We will now probe further by relating to other studies on this subject to see if Neck Circumference can be conclusively used as a screening tool to indicate obesity in children. The Weight, Height, Waist Hip Ratio and BMI of the samples were taken and the means were found to be as follows: Weight - 59.3 Kg (with a minimum of 35.5 Kg to a maximum of 96.3 Kg), Height - 155.3 cm (with a minimum of 142.0 cm to a maximum of 175.0 cm), Waist Hip Ratio - 0.82 (with a minimum of 0.67 to a maximum of 1.14), BMI - 24.60 Kg/m^2 (with a minimum of 15.80 Kg/m^2 to a maximum of 37.50 Kg/m^2). 41% of the samples were found to be with normal Waist Hip Ratio, i.e., <0.80, while 27% were found to be in the 0.81 to 0.85 range and 32% were found to be in the >0.85 range indicating increased health risks due to excess fat in the abdominal region. The CDC BMI Chart for Girls 2 to 20 Years was used to plot the Body Mass Index-for-age percentile for each sample. The mean BMI-for-age percentile was 74.23 with a Standard Deviation of +/- 28.5. This BMI-for-age percentiles 0% to 5%, 5.01% to 85%, 85.01% to 95% and >95.01% were categorized into Underweight, Healthy, Overweight and Obese categories respectively.

The present study sample of 150 subjects consisted of a mix of Adolescents ranging from 13 years to 18 years. The Mean NC was 29.0 ± 1.6 cm SD. 23% of the samples were found to be Underweight, 50% to be Healthy, 16% to be Overweight and 11% to be Obese.

CONCLUSION

There was statistically significant positive correlation between Neck Circumference and other anthropometric

measurements namely BMI and BMI-for-age Percentage, while there was a moderate correlation between Neck Circumference and Waist/Hip Ratio. The present study has several limitations that need to be addressed in future research. The sample size was small consisting of young adolescent girls and, therefore, the results cannot be generalized over the whole population. Further, the findings need to be confirmed and extended in further larger or collaborative studies among children of wider age group.

The study finds limitations in the Neck Circumference measuring cut-offs for assessing fat distribution of adolescent girls. The average Neck Circumference varies for different geographical locations, since the average body structure itself differs from location to location. There definitely is a correlation between Obesity Indices and Neck Circumference, but to use Neck Circumference as an independent tool to assess Body Fat, the Neck Circumference Cut-offs need to be reviewed and practical cut-offs for each geographical area need to be defined.

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