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Neck Circumference as a Screening Tool for Overweight and Obesity in Children

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Authors' contributions

This work was carried out in collaboration among all authors. Author AKN designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors VKG and BSN managed the analyses of the study. Author CRV managed the literature searches. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Introduction: Obesity is an emerging epidemic worldwide causing serious public health concern. The upper part of the body as Neck circumference (NC) can be used as a simple and time saving screening tool to evaluate it.

Materials and Methods: From January 2018 to June 2019, this school-based prospective observational study was conducted in schools of rural and urban areas near Jaipur taking 1000 children between age group of 6 to14 years. Children with conditions likely to interfere with neck circumference measurement were excluded. All anthropometric measurements were taken with standard techniques, and children were divided as normal, overweight or obese.

Results: Out of 1000 subjects, 364 males and 428 females were normal weight, 44 males and 68 females were overweight and 41 males and 19 females were found obese.

Intra group comparison of neck circumference in male & females showed significant correlation between normal, overweight & obese children. There was a good positive correlation between BMI and NC for all children.

Conclusion: Neck circumference can be used with great reliability to screen overweight and obesity in children.

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Keywords: Neck circumference; BMI; obese; overweight.

1. INTRODUCTION

The presence of obesity worldwide has led to the use of the term 'Globesity' to describe the epidemic trend towards increased body weight [1]. The emerging epidemic of obesity is causing serious public health concern and contributes to 2.6 million deaths worldwide every year [2].

Neck circumference (NC) has been suggested as an index of upper body fat distribution as subcutaneous fat releases more free fatty acids in the upper part of the body than its lower part, a fact that strengthens the relevance of measuring upper body subcutaneous adipose tissue [3].

NC is also favoured in large-scale public health projects for its reasonable accuracy, higher predictive power with ease of measurement and low cost. It can be used as a simple and time-saving screening measure to identify overweight and obesity [4].

The purpose of this study was to compare normal, overweight, and obese school-going children in relation to neck circumference and body mass index.

2. MATERIALS AND METHODS

This is a school-based prospective observational study that was conducted in the schools of rural and urban areas near Jaipur taking 1000 children of age 6-14 years from January 2018 to June 2019.

Inclusion criteria were all children aged between 06 to 14 years and consent taken by parents or legal guardian.

Exclusion criteria included 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. Children with Cushing syndrome, and those with exogenous steroid intake were excluded. Children with conditions like malnutrition, HIV, malignancies and acute or chronic illnesses were also excluded.

2.1 Anthropometric Measurements Technique

Height was measured by using a portable plastic stadiometer. The child was made to stand barefoot and head held in Frankfurt horizontal plane to the nearest 0.1 cm.

Weight was recorded using a standard electronic weighing machine. Measurement of weight was done in light clothing and without shoes, with the same instrument and to the same degree of accuracy to the nearest 0.1 kg.

BMI was calculated by dividing weight in kilograms (kg) by the square of their height (m^2).

$$BMI = Weight(kg) / [Height(meter)]^2$$

BMI Percentile is the most commonly used indicator to assess the size and growth patterns of individual children in many countries. After BMI is calculated for children and adolescents, the BMI number was plotted on the Revised IAP 2015 Growth Charts for BMI (for either girls or boys) to obtain a percentile ranking. Children were classified into three categories as per the IAP recommendation as normal, overweight and obese.

BMI cut off lines as per the Revised IAP 2015 Growth Chart:

- Below 23rd AE (Adult Equivalent): No overweight/No obese between 5th to 84th percentile.
- 23rd to below 27th AE (Adult Equivalent): Overweight between 85th to 94th percentile.
- 27th AE (Adult Equivalent) and above: Obese above 95th percentile.

Neck circumference (cm) was measured by using a plastic tape, with the child in standing position, head held erect and eyes facing forward and the neck in a horizontal plane at the level of most prominent portion that is the thyroid cartilage.

Waist circumference (cm) was measured by using plastic tape to the nearest 0.1 cm with the child standing at the midpoint between the inferior margin of the lowest rib and the iliac crest at the end of normal expiration.

2.2 Statistical Analysis

SPSS version 21 software was used for calculations and the results were considered statistically significant with $P \leq 0.05$. Categorical and continuous measurements were computed as presented in number (%) and Mean±SD

respectively. To study the significance of parameters on a continuous scale between two groups, two tailed student t-test was used. To study the association between various anthropometric measurements, Pearson correlation was used to find the degree of relationship. The ROC (receiver operating characteristic) curves analyzed the cutoff values of neck circumference to identify overweight and obesity.

3. RESULTS

In this study a total of1000 school-going children from 6 to 14 years were included, out of which we observed that 79.2% were normal weight I, 11.2% overweight and 9.6% obese according to IAP guidelines.

Out of 1000 students, 364 males and 428 females were of normal weight, 44 males and 68 females were overweight, 41 males and 19 females were obese.

Normal weight males had mean BMI 16.73±2.03 cm, mean neck circumference 28.53±2.15 cm and mean waist circumference 60.89±10.02 cm, while females had mean BMI 17.44±2.31 cm, mean neck circumference 28.58±1.87 cm, and mean waist circumference 60.54±9.62.

Overweight males had mean BMI 20.01±2 kg/m^2, mean neck circumference 30.49±2 cm, and mean waist circumference 67.31±12.9 cm while overweight females had mean BMI 21.19±2.55 cm, mean neck circumference 29.65±2.1 cm, mean waist circumference 62.21±12.03 cm.

Obese males had mean BMI 23.22±2.61 kg/m^2, mean neck circumference 30.22±1 cm and mean waist circumference 68.16±11.76 cm while obese females had mean BMI 24.67±2.51 kg/m^2, mean neck circumference 30.44±1.77 cm and mean waist circumference 65.71±10.35 cm.

The normal weighted males had mean neck circumference 28.53±2.15 cm and females had 28.58±1.87 cm. Overweight males had mean neck circumference 30.49±2.36 cm, females had 29.65±1.93 cm. Obese males had mean neck circumference 30.22±1.7 cm, females had 30.44±1.77 cm respectively (Table 1).

Tables 2 & 3 showing the intra group comparison of neck circumference in male & females which had a significant correlation between normal weight, overweight & obese children.

According to Karl Pearson's correlation 'r', there was a good positive correlation between Body Mass Index and Neck Circumference for male children as well as there was a high positive correlation between BMI and Neck Circumference for female children (Table 4 & Figs. 1,2).

The sensitivity of cut off value for neck circumference of male (boys) was 75% to 100% while the specificity was 78.9% to 97.6% for different age groups from 6-14 years.

The sensitivity of cut off value for neck and waist circumference of female (girls) was 76.82% to 100% while the specificity was 78.02% to 93.8% for different age groups from 6-14 years.

Table 1. Inter group comparison of neck circumference

BMI	Neck circumference		P value
	Male (Mean ± SD)	Female (Mean ± SD)	
Normal	28.53±2.15 cm	28.58±1.87 cm	0.71
Overweight	30.49±2.36 cm	29.65±1.93 cm	0.04
Obese	30.22±1.7 cm	30.44±1.77 cm	0.54

Table 2. Intra group comparison of neck circumference (male)

Male	Normal	Overweight	Obese
Normal		P<0.01	P<0.01
Overweight			P<0.01

Table 3. Intra group comparison of neck circumference (female)

Female	Normal	Overweight	Obese
Normal		P<0.01	P<0.01
Overweight			P<0.05

Table 4. Correlation between BMI and neck circumference

Karl Pearson's correlation 'r'	Males	Females
BMI vs NC	0.73 (Good positive correlation)	0.76 (High positive correlation)
P value	<0.001	<0.001

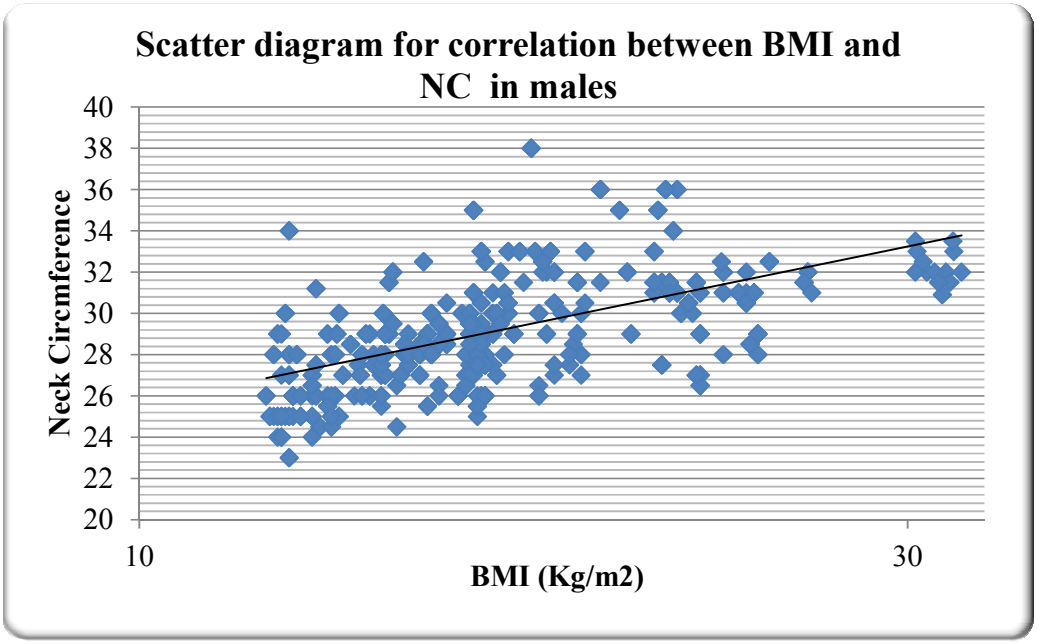

Fig. 1. Correlation between BMI and NC in males

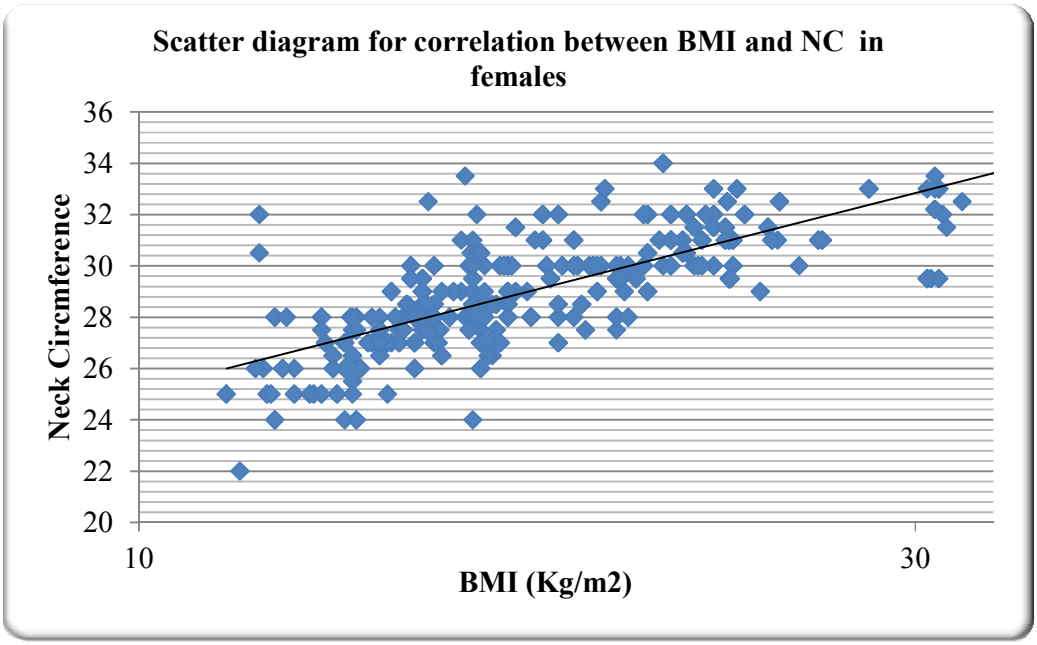

Fig. 2. Correlation between BMI and NC in females

Table 5. Comparison of cut off value of neck circumference of our study with others

Study	Country/year	Age	Number	Cut off value	
				Boys	Girls
This study	India, 2019	6-14	1000	27.25-32.42	24.26-30.22
Mehri Taheri [5]	Iran,2013	6-17	864	27.50-38.3	26.7-33.4
Olubukola [6]	USA, 2010	6-18	1102	28.5-39.0	27.0-34.6
Hatipoglu [7]	Turkey, 2010	6-18	976	28.0-38.0	27.0-34.5
Lou [8]	China, 2012	7-12	2874	27.4-31.3	26.3-31.4
Atwa [9]	Egypt, 2012	12-15	2762	29.3-31.7	28.6-31.4

4. DISCUSSION

This observational study was conducted at the National Institute of Medical Science, Jaipur to compare normal weight, overweight, and obese school-going children to demonstrate a relation between neck circumference and body mass index.

The result of this study, together with those of the nearly identical prior studies in USA, Iran, Turkey, China, Egypt indicate that neck circumference and waist circumference increases with the age of the child and both both these parameters are strongly correlated with BMI [5,6,7,8,9] (Table 5).

Thus our study is in agreement with the observation made by Mehri Taheri et al. [5], Nafiu et al. [6] and Hatipoglu et al. [7] in which similar sample size and age group were included.

In our study the best cut off value of neck circumference to identify boys with high BMI was 27.25-32.42 cm, and for females, it was 24.26-30.22 cm.

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 32 cm with sensitivity of (81.82%), specificity (89.06%), and for girls was 30 cm with sensitivity of (84.85%), specificity (87.5%) by Yashoda et al. [10]. Neck circumference had a strong positive correlation with other anthropometric measures BMI, WC, the waist-hip ratio in both boys and girls ($p<0.001$).

5. CONCLUSION

We concluded that 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 thus be considered as a simple, time saving and inexpensive clinical tool for detection of obesity in large population-based studies in children and adolescents.

CONSENT AND ETHICAL APPROVAL

Ethical clearance was obtained from the Institutional Ethical Committee, and permission from the Principal/Head masters of the schools was obtained and consent taken by parents or legal guardian of students.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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