ORIGINAL ARTICLE

Neck Circumference as A Screening Tool for Childhood Obesity: A Cross-Sectional Study

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ABSTRACT

Introduction: Obesity is found to be one of the most common modifiable risk factor for lifestyle diseases, its screening has become crucial to identify it at an early stage. This study aims to find whether neck circumference is a reliable indicator to measure childhood obesity. **Objectives**: To analyse neck circumference as a marker of abdominal obesity in children. **Methodology**: A cross sectional study was conducted among 220 children between 6-11 years of age group by visiting their school. Data was analysed using MS Excel and SPSS (version 20.0). **Results**: 220 students were included in the study. Age, waist circumference, hip circumference and BMI are positively correlated with Neck Circumference. **Conclusion**: Neck circumference is a reliable tool to measure childhood obesity.

KEYWORDS

Non Communicable Disease; Neck Circumference; Childhood Obesity; Screening; BMI

INTRODUCTION

Obesity is thought to be correlated with physical inactivity, and the current COVID-19 pandemic has exacerbated this trend. According to WHO, more than 34 crore school going children of age group 5-19 were having weight above normal limits according to data of 2016.(1-3) Obesity is defined by the CDC as a BMI that is at or above the 95th percentile for children and teenagers of the same age and sex.(4)International body mass index (BMI) criteria suggests that BMI for age group 5-19 is considered overweight if the value is more than +1 Standard Deviation (S.D) and obese if value is more than +2 S.D.(5-8)

Among adults and children, upper body fat is linked to non-communicable diseases.(9–15) Neck Circumference (NC) is a novel technique of measuring fat distribution.NC can be especially useful as a non-invasive, time-saving, easy to measure, remains constant and does not show variable value after consumption of food.(16,17)Also, there is dearth of literature which examine NC measurement from schools through idea of anthropometric data as a marker to corroborate central obesity assessment to

prevent diseases arising from sedentary lifestyle in children. Therefore, present study was planned in order to evaluate NC as a tool to measure central obesity.
Objective of this study was to evaluation of Neck Circumference as a tool to measure central obesity in school children

Material & Methods

Study design: This is a cross sectional study conducted at one point of time.
Study setting: Study was conducted in one school under Nagpur Municipal Corporation present in urban areas randomly selected out of 54 urban schools after permission from local education authorities.
Study population: Study was conducted among school going children of 6 to 11 years
Study duration: Study was conducted between July 2022 to August 2022

Sample size calculation: Sample of students calculated for the study was 220 based on previous study by Patil CR et al.(9)
Inclusion criteria: Students of 6 to 11 years of age attending school
Exclusion criteria: Students with any neck deformity or neck pathologies like Cushing's disease, torticollis, neck swelling, enlarged thyroid gland, discharging sinuses and earlier neck surgeries
Data collection: Data was collected using pre-tested, pre-validated and semi-structured questionnaire under domains of socio-demographic history, history of other illness, anthropometric measurements.

Anthropometric measurement procedures: The height was measured using standardized stadiometer available with school, weight was measured using a standard digital weighing scale and other parameters were noted using a non-stretchable plastic tape measure using overlapping technique. Neck circumference was measured in centimetres using a measuring tape with one-millimetres divisions. The child was made to stood upright with their head aligned in the horizontal Frankfurt plane. The upper edge of the measuring tape was placed just below the cricothyroid cartilage and positioned perpendicular to the neck axis.

Ethical issues & Informed consent: Permission for Institutional Ethics Committee was obtained. Students of 6 to 11 years of age were from the selected school were interviewed after permission from school principal, class teacher and assent from parents. Students were explained about the nature of study and what is expected from them. Students who were absent in the class for the interview on 1st visit were covered in the subsequent 2 visits. Letter No: NKPSIMS&RC and LMH/IEC/7/2022 dated 28-06-2022.

Data analysis software: Analysis of the data was done using SPSS version 24.0. Continuous variables are summarised using mean with standard deviation. Categorical variables were summarised using frequency with proportion with a 95% confidence interval. Pearson's correlation was utilised to assess relation between two continuous variables in the student t-test.

Results

Total 220 student's anthropometric data was collected to assess neck circumference as a screening tool in childhood obesity.

Out of 220 students, there were equal proportion of males and female students. Overall mean age of students was 8 years with SD of 1.57 years. Maximum proportion of students were Hindu (89.6%) followed by Buddhist (6.8%) and Muslim (3.6%) religion. Average number of members in family of students were 5(±1). Using the Modified Kuppuswamy Scale for year 2022(18), the families of children were grouped into 5 different classes of which 65% were belonging to lower middle class. Five percent students had a history of low birth weight and the rest had normal birth weight. Out of total participants, 71.8% were delivered normally and 28.2% were delivered by caesarean-section. (Table 1)

Table 1: Distribution of Sociodemographic profile of students of 6-11 years of age. (N=220)

Sr.	Variable	Frequency	Percentage (%)
1	Gender:		
	Male	110	50 %
	Female	110	50%
2	Religion:		
	Hindu	197	89.6%
	Buddhist	15	6.8%
	Muslim	8	3.6%
3.	Socioeconomic class		
	Upper (1)	0	0%
	Upper Middle (2)	5	2.2%
	Lower Middle (3)	143	65%
	Upper Lower (4)	68	31%
	Lower (5)	4	1.8%
4.	Birth history		
	Low birth weight	11	5%
	Normal	209	95%
5.	Delivery		
	Normal	158	71.8%
	Caesarean section	62	28.2%

Mean BMI values for males are 14.67cm +2.06 and for females are 14.45cm + 1.93, Waist to Hip ratio for males and females are similar (0.86) and neck circumference is 27.60cm +2.20 among males and 27.80cm +2.60 among females. (Table 2)

Table 2: Gender wise distribution of Anthropometric Data of students (6-11 yrs.)

Gender	**Male (N=110)**		**Female (N=110)**	
Anthropometry	Mean	S.D	Mean	S.D
Height (in cm)	122.60	12.82	121.80	11.80
Weight (in kg)	22.52	7.45	21.80	6
B.M.I* (in kg/m²)	14.67	2.06	14.45	1.93
W.C* (in cm)	54.9	6.85	55.70	6.15
H.C* (in cm)	63	7.60	64.70	7
Waist-Hip Ratio	0.86	0.04	0.86	0.03
N.C* (in cm)	27.60	2.20	27.80	2.60
Age (in yrs.)	8.6	1.76	8	1.57

** W.C: Waist Circumference, B.M.I: Body Mass Index, N.C: Neck Circumference, HC: Hip Circumference,S.D: Standard Deviation*

Table 3 depicts that neck circumference mean is significantly higher in age group of 9 to 11 years of age (28.36 cm + 3.38, p value=0.0003) than in 6 to 8 years of age group. Mean values of neck circumference do not significantly vary as per sex and religions.

Table 3: Mean Values of Neck circumference based on various socio-demographic variables

Variables		**Neck circumference**				
		Mean	SD	Min	Max	P value
Age(year)	6 to 8	26.95	2.36	21	35	0.0003*
	9 to 11	28.36	3.38	2.41	37	
Sex	Male	27.58	2.20	24	37	0.96
	Female	27.60	3.55	2.41	35	
Religion	Hindu	27.64	2.43	24	32	0.80#
	Muslim	28	2.72	25	33	
	Buddhist	26.73	2.43	24	32	

**t test #ANOVA*

On calculating the z scores of BMI values, it was observed that, for the values more than 2, i.e. considered overweight/obese, mean neck circumference is significantly higher (31.88+ 2.66, p value=0.0008). On comparing waist to hip (WHR)ratio, with BMI z scores, WHR does not significantly different in normal and overweight children. (Table 4)

Table 4: Classification of obesity based on Body Mass Index z score values

BMI Z Score	N	Mean	SD	P value*
Neck Circumference				
-2 SD to 2 SD	211	27.40	2.82	0.0008
>2	9	31.88	2.66	
Waist to hip Ratio				
-2 SD to 2 SD	211	0.86	0.04	0.45
>2	9	0.87	0.03	

**t test*

It was observed that there is strong positive correlation for neck circumference and overweight and obesity. Other anthropometric variables which are significantly correlated with overweight/obesity and neck circumference are weight, height, waist circumference and hip circumference.(Table 5)

Table 5: Correlation of other Anthropometric tools with Neck Circumference for all Children (with p value).

Sr.	Anthropometric Measurements	Mean (n=220)	Standard Deviation (S.D)	R	P value
1	Height (in cm)	122.20 cm	12.30 cm	0.59	<0.00001*
2	Weight (in kg)	22 kg	6.77 kg	0.67	<0.00001*
3	B.M.I (in kg/m²)	14.56 kg/m²	2 kg/m²	0.75	<0.00001*
4	W.C (in cm)	55.30 cm	6.50 cm	0.67	<0.00001*
5	H.C (in cm)	63.85 cm	7.30 cm	0.67	<0.00001*
6	Waist-Hip Ratio	0.86	0.04	0.01	0.86
7	Age (in yrs.)	8.15 yrs.	1.63 yrs.	0.48	<0.00001*

*Key (B.M.I: Body Mass Index, W.C: Waist Circumference, H.C: Hip Circumference, N.C: Neck Circumference, S.D: Standard Deviation, r: Pearson's coefficient, P: probability value) * Significant Correlation found.*

DISCUSSION

Present study has evaluated the neck circumference and its variations according to age, gender, religion and also correlated the neck circumference with anthropometric measurements used for diagnosing obesity.It was observed in the pre sent study, neck circumference is significantly higher in age group of 9 to 11 years of age than in 6 to 8 years of age group indication the role growth spurt leading to increase in muscle mass, weight and height physiologically. But study done by Kuciene R et al suggested that higher values in adolescents age group increases risk of early development of non-communicable diseases among adolescents.(19)

Also, present study has found significant association and between overweight/obesity and higher values of neck circumference. Strong positive correlation also found between overweight/obesity, neck circumference and other anthropometric indices values, indicating and validating neck circumference as a reliable indicator for measuring obesity. Ashok et al (20) in their study depicted a very substantial positive association between NC and weight, BMI, HC, and WC in both the sexes. Also study conducted by Valencia-Sosa E et al (21) in Mexican children's depicted a strong positive relation between NC and other tools of anthropometry used to measure obesity.

Previous research suggests that neck adipose tissue should be considered an ectopic fat depot under certain conditions. This concept stems from the hypothesis that when triglyceride (TAG) levels exceed the capacity of metabolically favourable fat depots to expand,

excess fat infiltrates tissues that typically store only minimal amounts of fat. Ectopic fat, in particular, is believed to exhibit characteristics of dysfunctional adipose tissue and is closely linked to metabolic disturbances.(22) Also, several studies such as those done by Da silva et al, Grammatikaki and Moschonis, Kelishadi, Heidari-Beni and Qorbani have suggested that NC as a metabolic syndrome indicator for pre-school and school children, as well as adolescents and also it can be related to the non-alcoholic fatty liver disease.(23–26)

Thus, Neck circumference (NC) presents for the literature and as per the findings of present study, is a viable, non-invasive, and cost-effective screening tool for assessing obesity, particularly in environments where traditional metrics such as Body Mass Index (BMI) may not be readily applicable. The ease with which NC can be measured makes it especially suitable for large-scale epidemiological studies, school-based health assessments, and routine clinical practice, providing an accessible method for early detection and intervention in obesity-related health issues (27) It can also be used in use in marginalized communities where often there is no access to anthropometric equipment such as a scale or stadiometer, thus can overcome some drawbacks.

Added advantage of using NC is, BMI does not take into consideration the lean muscle mass, bone density and age and W.C and H.C often show diurnal variation and varies after intake of food or bloating. NC has a positive correlation with age, so it can give proper value for specific age group after further research studies.

In this study, NC also has a few drawbacks as it cannot be used in children with underlying neck deformity or neck pathologies like Cushing's disease, torticollis, neck swelling, enlarged thyroid gland, discharging sinuses and earlier neck surgeries. But the benefits of using NC overweight the drawbacks, therefore it is a much more reliable tool for screening of childhood obesity. Using NC, obese children can be effectively and efficiently identified and sent for further clinical evaluation

CONCLUSION

Study suggests that the robust correlation between NC and other anthropometric indices, such as BMI, waist circumference (WC), and hip circumference (HC), highlights its potential utility in standardized obesity screening protocols. This is particularly pertinent in resource-constrained settings, where more complex or expensive methods may be impractical. The evidence suggests that NC could be integrated into existing protocols, enhancing the capacity for early identification of individuals at risk of obesity and related comorbidities.

RECOMMENDATION

Based on the findings of this study, it is recommended that future research should expand to include multiple schools across different regions to ensure generalizability of results and refine its accuracy across demographics. Neck circumference is a very useful measurement to use in epidemiological studies, it is advised to use NC for greater masses, including it into routine school health checkups particularly in relation to nutritional disease as it is easy, non-expensive, non-invasive technique , time saving to measure potential obesity. Additionally, training school health staff in proper measurement techniques and raising community awareness about its significance could enhance early detection and intervention for childhood obesity.

LIMITATION OF THE STUDY

This study was constrained to single geographic area and thus could not give generalizable cut-offs for NC and as dietary history was not a part of the study proforma, dietary recommendations for obesity could not be given.

RELEVANCE OF THE STUDY

Present study identifies neck circumference it as a practical and reliable marker for assessing obesity-related health risks in line with other anthropometric measures. It offers a simple alternative to traditional measures like BMI, particularly in indicating upper body obesity, which is closely linked to non-communicable

diseases. Additionally, neck circumference has the potential to serve as an independent predictor of metabolic risk factors and could be particularly useful in populations where other markers may not be that effective. Its ease of measurement makes it an accessible tool in clinical and community settings, especially in resource-limited environments. Further research for setting cut off values for wider range of population is required.

Authors Contribution

All authors have contributed equally.

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Nil

Conflict of Interest

There are no conflicts of interest.

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Declaration of Generative AI and AI Assisted Technologies in the Writing Process

The authors haven't used any generative AI/AI assisted technologies in the writing process.

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