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Neck Circumference as a Screening Tool for Obesity in Children: An Analytical Study from India

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Abstract
Obesity among children has become one of the most important public health issues in both developed and developing countries. Classical anthropometric indices like body mass index (BMI) and waist circumference (WC) are commonly employed but have significant limitations with respect to applicability, cultural acceptability, and accuracy. Neck circumference (NC) has also come into focus in recent times as a possibly easier and more stable measure for the identification of overweight and obesity in children. The current study examines the possibility of NC as a screening instrument in a school community in Kochi, Kerala, on 500 children between the age group of 10 to 15 years. The investigation sets up gender-specific cut-off points, examines correlations between NC and BMI, NC and WC, and assesses diagnostic accuracy with receiver operating characteristic (ROC) analysis. Findings report high correlations of NC with BMI and WC, cut-offs at 32.5 cm for boys and 30.5 cm for girls, and sensitivity greater than 83% and accuracy approximately 75%. The findings confirm NC as a valid, low-cost, non-invasive means of screening for early obesity. The paper puts the study in the context of current literature, highlights its clinical and public health applications, and presents avenues for the incorporation of NC into pediatric obesity assessment procedures.
Keywords : Childhood obesity, Neck circumference, Body Mass Index (BMI), Waist circumference, Diagnostic accuracy.

INTRODUCTION

The Increasing Global Pandemic of Childhood Obesity

Child and adolescent obesity has become a top public health priority of the twenty-first century. The issue is not limited to rich societies but has extended to low- and middle-income countries, making it a global crisis (Ashok et al., 2021) . Based on the World Obesity Federation's estimates, more than 206 million children aged between 5 and 19 years are estimated to be obese by 2025, which is likely to increase to 254 million by 2030. Such staggering figures underline the imperative to create effective screening and prevention measures.

India, along with China and the United States, contributes to a large share of the world's pediatric obesity burden. Accelerated urbanization, changes in lifestyle, and dietary changes towards high-calorie foods have enhanced the issue in India. Malnutrition and underweight conditions continue to be present in various parts of the country, but dual burden of malnutrition and obesity creates specific challenges before the healthcare system of the country. This epidemiological transition serves to emphasize the need for early diagnosis and intervention to reduce long-term health effects related to obesity among children.

Health Consequences of Childhood Obesity

Childhood obesity is not only a cosmetic problem or a problem of excess weight. It is a pathophysiology with extreme physiological, psychological, and social concerns. Obese children have an increased risk of metabolic diseases like type 2 diabetes mellitus, dyslipidemia, and hypertension. Cardiovascular disease, respiratory complications like obstructive sleep apnea, orthopedic problems, and fatty liver disease are being seen more commonly in children who are obese.

The consequences of obesity are not limited to physical health alone(Androutsos et al., 2021). Psychological consequences, including low self-esteem, negative body image, depression, and social stigmatization, have a great impact on the quality of life in affected children. Moreover, childhood obesity tends to carry over into adulthood, continuing the cycle of chronic diseases, shortening life expectancy, and raising healthcare expenditure. Early detection of obesity is hence a linchpin in resolving its far-reaching implications, both for the individual and society as a whole.

Traditional Anthropometric Measures: Strengths and Limitations

Various anthropometric measures have been used over the years to measure obesity in children and adults. Among them, the most popular one is Body Mass Index (BMI), simply because it is easy to calculate. The formula is a child's weight in kilograms divided by the square of his/her height in meters. BMI is practical for population-level surveillance and screening of obesity trends(Nafiu et al., 2021). Yet BMI does not differentiate between fat mass and lean mass, nor does it reveal anything about fat distribution. This becomes especially disadvantageous in children where patterns of growth and puberty can radically change body composition. As such, BMI has the potential to misclassify overweight or obesity status in children. Waist circumference (WC) and waist-to-height ratio (WHtR) are proxies that more accurately reflect central adiposity. These measures are highly correlated with cardiometabolic risk factors and are viewed as being better than BMI in the prediction of metabolic syndrome. However, WC is subject to a number of external influences, such as the timing of meals, respiratory phase, and even cultural sensitivities surrounding the measurement of the waist, especially in adolescent girls. Furthermore, the need for precise positioning during measurement heightens variability and lowers feasibility in large-scale school or community-based programs. These limitations suggest the necessity for surrogate anthropometric measures that are easy, reproducible, and culturally acceptable.

Neck Circumference as a Possible Screening Measure

Neck circumference (NC) has become a new, promising anthropometric marker for screening obesity. In contrast to BMI and WC, NC uniquely captures upper body subcutaneous fat distribution(Hatipoglu et al., 2021). Studies have shown significant correlation between NC and cardiometabolic risk indicators such as insulin resistance, metabolic syndrome, and obstructive sleep apnea. The release of free fatty acids from upper body fat depots is more than that from lower body fat stores, which makes NC a potentially more indicative marker of metabolic risk.

Some benefits make NC stand out as a screening tool. It is fast and not invasive, only needing a flexible tape measure, and does not require disrobing, thus circumventing cultural issues. NC is relatively constant over the course of the day, uninfluenced by meals, respiratory patterns, or positioning, factors that commonly interfere with WC measurement. Measurement of NC also minimizes observer bias and is less likely to be bothersome or embarrassing to children, particularly in school settings. These characteristics make NC an ideal measurement for large epidemiological studies and in routine pediatric checks.

Evidence and Research Gaps

Though several studies in countries like Turkey, Iran, and Brazil have proved NC as a useful indicator of obesity in children, studies conducted within the Indian context are sparse. Indian children vary from Western children with regard to composition of the body, distribution of fat, and genetic factors, thereby requiring population-cut-off values(Katz et al., 2021). In addition, earlier literature in India has been limited primarily to small-scale studies or individual urban areas, with wide gaps remaining to assess the wider applicability of NC across different cultural and geographic regions.

Initial findings in Indian research suggest that NC is positively related to BMI and WC and is a potential indicator of overweight and obesity. Nonetheless, there are no standardized cut-off values for various age and gender groups, thus limiting its widespread clinical and public health use. It is against this background that systematic research that assesses NC within a larger and more representative population of children and compares its performance to established measures like BMI and WC is needed.

Rationale of the Present Study

With the increasing incidence of obesity in children in India and the drawbacks of traditional anthropometric measures, there is a strong need to assess other measures like neck circumference(Taheri et al., 2021). The current study aims to scientifically examine NC as an obesity screening instrument among schoolchildren in Kochi, Kerala. Through setting gender-specific cut-off points, the correlation of NC with BMI and WC, and assessment of diagnostic performance by ROC analysis, this study hopes to generate strong evidence to support the use of NC in pediatric obesity screening.

In addition to its clinical importance, the research has important public health implications. NC, if substantiated, can be incorporated into school health programs and community interventions as a low-cost, culturally relevant, and translatable measure for early obesity identification. This could potentially allow for timely lifestyle interventions, prevention of long-term disease, and support the attainment of public health targets in fighting non-communicable diseases.

AIM AND OBJECTIVES

Aim: The main objective of the research was to identify the feasibility of neck circumference as a standalone screening measure for detecting overweight and obesity in children in school-going age.

Objectives

- To examine the relationship between neck circumference, BMI, and waist circumference as indicators of overweight and obesity.
- To find gender-specific cut-off points for neck circumference in the studied population.
- To compare the sensitivity, specificity, and accuracy of NC with the standard anthropometric measures.

REVIEW OF LITERATURE

A study conducted by Androutsos (2012) is a discussion of the use of neck circumference as an easy and valid screening measure for evaluating cardiovascular risk in children. The study highlights the value of early identification of cardiovascular risk factors as a high priority in public health, especially in children, where preventive interventions can be most impactful. The investigation examines the correlation between neck circumference and a variety of known anthropometric, biochemical, and clinical markers commonly used to assess metabolic and cardiovascular risk(Androutsos et al., 2021). By analyzing measurements of the body, lipid profiles, glucose homeostasis, blood pressure, and lifestyle components, the study emphasizes that neck circumference demonstrates significant correlations with various risk markers, which are comparable to or even more expedient than traditional indicators like body mass index, waist circumference, and waist-height ratio. The results indicate that neck circumference can be a useful alternative measure since it is rapid, non-invasive, and simple to measure in clinical or field settings without needing to perform complex procedures. In addition, the study observes that the measure can be used uniformly with various populations and can assist healthcare providers in the detection of children who are at risk of developing obesity-associated metabolic alterations and cardiovascular disease in adulthood. The clinical benefit of measuring neck circumference also makes it well-suited for large-scale screening within schools and public health initiatives, having the potential to enhance the effectiveness of early risk detection programs. In the end, the research gives evidence that adding neck circumference to standard tests may give a boost to existing measures for monitoring child health by providing a low-cost, effective way to inform preventive interventions and improve long-term cardiovascular health in children.

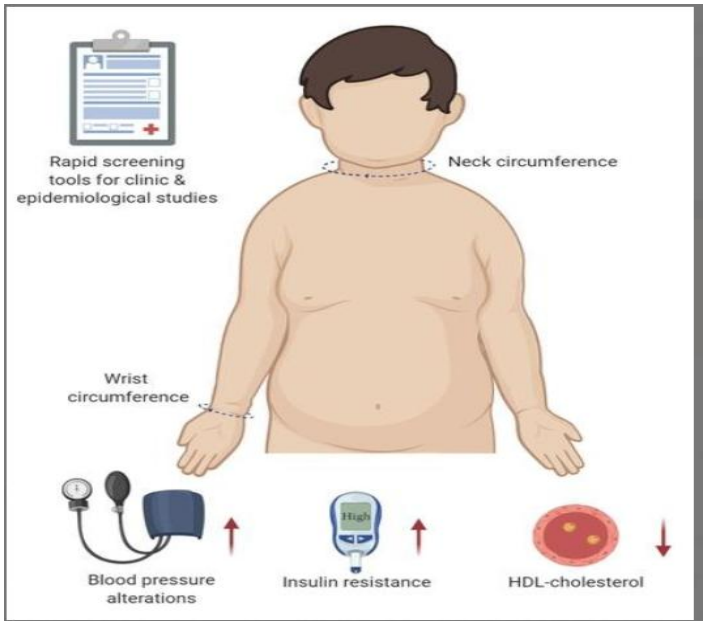

Figure: Neck Circumference as a Screening Tool for Obesity in Children
(Source: Valencia et al., 2021)

According to research carried out by Ashok (2020) talks about the feasibility of neck circumference as a useful and effective screening method to detect obesity in children. The research identifies the shortcomings of traditional anthropometric indicators like body mass index, waist circumference, and waist-to-hip ratio, which, despite their popularity, tend to be inaccurate, cumbersome, and not flexible enough for use with varied populations. By measuring neck circumference, the study highlights its simplicity, affordability, and ease of use, which render it highly appropriate for mass screening in school-

based or community health setting(Ashok et al., 2021) s. The evidence indicates that neck circumference has a significant correlation with reference obesity indices, supporting its role as a reliable substitute parameter for the assessment of adiposity and metabolic risk. This association suggests that those children with greater neck circumference values are more likely to exhibit patterns of raised body mass and central obesity, which are recognized to enhance the risk of evolving long-term metabolic and cardiovascular complications. The research also emphasizes that the measurement of neck circumference is a simple procedure that can be carried out rapidly without the requirement for special equipment, minimizing the workload for healthcare professionals and enabling rapid risk classification. Such effectiveness is particularly worth it in resource-constrained environments where traditional approaches might be less available. By suggesting the measurement of neck circumference as part of obesity evaluations, the study helps improve early childhood obesity detection and prevention efforts, an important public health issue worldwide. Finally, the study highlights the need for embracing simple but effective measures of monitoring children's health and reaffirms that neck circumference may be a valid supplement to existing screening procedures and thus enhance efforts to stem the increasing incidence of obesity and related health consequences among children.

Based on the view of Nafiu (2010) elaborates on the utility of neck circumference as a harmless and valid screening tool to detect high body mass index children. The paper points out the deficiencies of body mass index in the detection of regional adiposity and stresses the requirement for alternative anthropometric indices that would better portray obesity-related health risks among children. By studying the relationship among neck circumference, BMI, and waist circumference, the study illustrates that neck circumference is significantly related to total and central adiposity and can be a convenient marker to determine children at risk of overweight and obesity(Nafiu et al., 2021). The results indicate that neck circumference can be used as a rapid, painless, and easily reproducible technique appropriate for use in clinical and community settings, enabling healthcare workers to effectively screen large numbers of children. The research also indicates that measurement of the neck circumference exhibits good interrater reliability, which adds to its consistency and value for broad usage in routine pediatric evaluation. Moreover, the study emphasizes that increased neck circumference is not only associated with greater BMI but can also signify increased risk for metabolic and cardiovascular morbidity, as for example, in adults with diseases like obstructive sleep apnea, diabetes, and hypertension. By suggesting certain cutoff values for diagnosing children with increased BMI, the investigation offers a practical guideline for integrating neck circumference into pediatric health surveillance programs. In conclusion, the study advocates for the use of neck circumference as a supplementary metric to conventional obesity measures in order to encourage early detection and intervention methods for the prevention of child obesity and its later health implications.

MATERIALS AND METHODS

Study Design and Setting

The current study was performed as a cross-sectional, school-based observational survey in Kochi, Kerala, India. A cross-sectional design was selected because it enables the simultaneous evaluation of anthropometric measures among a specified population at a given point in time. It is especially ideal for research evaluating screening instruments, as it captures associations between variables like neck circumference, body mass index (BMI), and waist circumference (WC) at a particular moment in time.

The study was carried out over a six-month period, spanning July 2023 to December 2023, to ensure adequate time for recruitment, measurement, data collection, and analysis. Kochi was selected as the study location because it represents an urban setting with increasing prevalence of lifestyle-related disorders, including childhood obesity(Turkay et al., 2021). The selected school was a well-established learning institution with a large population, making it possible to recruit an adequate sample size with equal male and female representation. The school setting also offered an experimental environment with fewer variability conditions in measurements.

Study Population

The target group was school-aged children between 10 and 15 years. This was a deliberate choice, as this age range represents the pre-adolescent and adolescent development stages during which growth pattern changes and fat distribution are most apparent. Measurement of neck circumference at this age group is highly informative regarding its utility as a screening mechanism, as hormonal changes associated with puberty can have an impact on patterns of fat deposition.

A total of 500 children were recruited, with 268 boys and 232 girls included in the study. This provided almost equal representation of both sexes, which was critical in assessing gender-specific cut-off points for neck circumference.

Inclusion and Exclusion Criteria

Stringent inclusion and exclusion criteria were established to ensure reliability and validity of the results.

Children were included if they had the following criteria:

- Age of 10 to 15 years during recruitment.
- Registration in the chosen school in Kochi.
- Parents' or guardians' informed written consent(Kroll et al., 2021).
- Ready participation of the child for measurements.

Children were excluded if they had medical or anatomical conditions that would hinder the precise measurement of neck circumference. The exclusion criteria were:

- The presence of goitre, cervical lymphadenopathy, or any other neck mass.
- Past history of cervical spine anomalies or craniovertebral junction abnormalities.
- Past history of tracheostomy or cervical collar use.
- Chronic illness that may influence body weight or growth, e.g., diabetes mellitus, hypothyroidism, or Cushing syndrome.
- Use of body-weight-influencing drugs in the past or present, e.g., corticosteroids.
- Developmental delay or growth disorder that may skew anthropometric values.
- Refusal to be included in the study by parents or children.

The use of these criteria ensured that the study population actually represented otherwise healthy school-age children, thus enabling the observed correlations to be ascribed to natural variations in anthropometry and not to confounding medical conditions(Kondolot, et al., 2021).

Sample Size Determination

The total sample size of 500 was arrived at through calculations based on sensitivity of the circumference of the neck as reported in earlier studies. The number of participants required was calculated separately for girls and boys using a 95% confidence interval and a margin of precision of 5%. The calculations gave a figure of around 215 boys and 232 girls, which was rounded off to 500 in total in order to provide greater statistical power.

This sample size was deemed sufficient to identify significant associations and establish population-specific cut-off values for neck circumference with good accuracy. By surpassing the calculated minimum requirement, the study reduced the risk of type II error and improved the generalizability of results.

Data Collection Procedures

Data were gathered in classrooms and school health rooms under standardized conditions. Every child received a guided assessment conducted by skilled staff, including the principal investigator and nurses(Kim et al., 2021). To reduce inter-observer variability, all anthropometric data were collected by one trained investigator, with the exception of female participants, where a trained female nurse staff member conducted the measurements to promote comfort and cooperation.

Anthropometric Measurements

Height and Weight

Height was taken with a portable stadiometer. Children were standing without shoes, with the heels together, spine straight, and head in the Frankfurt plane. Readings were taken to the nearest 0.1 cm. Weight was taken with a pre-calibrated digital weighing scale, with children in light clothing and no shoes. The zero error of the scale was checked prior to each use. Weight was noted to the nearest 0.1 kg.

Body Mass Index (BMI) was derived from weight in kilograms divided by height in meters squared (kg/m^2). BMI-for-age and sex percentiles, according to updated Indian Academy of Pediatrics (IAP) growth charts, were utilized to categorize children as underweight (<5th percentile), normal weight (5th–85th percentile), overweight (85th–95th percentile), and obese (≥95th percentile).

Neck Circumference

Neck circumference was taken using a non-extensible, flexible measuring tape. Children were asked to stand upright with their head in the Frankfurt horizontal plane and shoulders relaxed(Mucelin et al., 2021). A measurement was made at the level of the thyroid cartilage (Adam's apple) to the nearest 0.1 cm. For boys with prominent laryngeal protrusion, the tape was placed just below this level. Each was measured twice, and the mean was taken to minimize intra-observer error.

Waist Circumference

Waist circumference was measured with a flexible tape measure placed midway between the lower margin of the lowest rib and the iliac crest. Children were measured erect with arms at their sides, and the measurement was taken to the nearest 0.1 cm at the end of a normal expiration. Two measurements were taken and averaged, just like all other measurements.

All readings were keyed straight into a formatted proforma and subsequently copied into a secure electronic spreadsheet. Entry of data was checked by two separate researchers to reduce transcription error. Instruments were calibrated regularly to ensure measurement precision. Standard operating procedures were adhered to rigorously to minimize variability.

Statistical Analysis

Data analysis was conducted with MedCalc (version 20.0). Descriptive statistics were derived for demographic and baseline traits, with categorical variables reported as frequency and percentage and continuous variables as mean ± standard deviation.

Analysis of correlation was conducted with Pearson's correlation coefficient to ascertain the degree and direction of relationships among neck circumference, BMI, and WC in boys and girls separately(Asif et al., 2021). Receiver Operating Characteristic (ROC) curve analysis was used to derive the cut-off values for neck circumference for the identification of overweight and obesity in children. Sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy were determined with 95% confidence intervals. A p-value of less than 0.05 was statistically significant.

Ethical Considerations

Ethical approval was received from Lisie Medical Institution, Kochi Institutional Ethics Committee. Informed consent was obtained from parents or guardians of all the participants and verbal assent from the children themselves. The research followed the ethical standards of the Declaration of Helsinki.

Confidentiality was preserved during the study. Data were anonymized by coding the participant, and no identifiable information was revealed in reports or publications. Participation was voluntary, and children could withdraw at any point without penalty. The design involved minimal risk to participants, as the measurements were non-invasive and didn't cause harm.

RESULTS

Baseline Characteristics of the Study Population

The study included a total of 500 school children between the ages of 10 and 15 years. Of these, 268 (53.6%) were boys and 232 (46.4%) were girls, providing a balanced gender distribution for comparative analysis(Nimawat et al., 2021). The mean age of boys was 12.8 years, while that of girls was 12.5 years, showing no statistically significant difference in age distribution between the two groups.

Anthropometric comparisons showed that boys tended to be taller, with a mean height of 149.2 ± 8.5 cm, compared to 146.5 ± 7.9 cm in girls. Girls were slightly higher in BMI values, with a mean of 20.1 ± 3.8 kg/m², compared to 19.6 ± 3.5 kg/m² in boys. The findings indicate that while boys were larger in linear growth, girls had a slightly higher propensity towards adiposity at comparable ages.Table 1 shows the baseline demographic and anthropometric data of participants, categorized by gender.

Table 1. Baseline Characteristics of Participants (n = 500)

Parameter	Boys (n=268)	Girls (n=232)	Total (n=500)
Mean Age (years)	12.8 ± 1.4	12.5 ± 1.3	12.7 ± 1.4
Mean Height (cm)	149.2 ± 8.5	146.5 ± 7.9	148.0 ± 8.3
Mean Weight (kg)	43.7 ± 9.6	44.8 ± 10.2	44.2 ± 9.9
Mean BMI (kg/m²)	19.6 ± 3.5	20.1 ± 3.8	19.8 ± 3.6
Normal BMI (%)	62.0	65.0	63.4
Overweight (%)	18.3	16.4	17.4
Obese (%)	9.0	10.8	9.8

Distribution of Neck and Waist Circumference

In fat distribution analysis, gender differences were noted. Boys had a significantly greater mean neck circumference (NC). Boys had an average NC of 31.4 ± 2.1 cm, while the girls' average was 30.5 ± 2.0 cm. This was statistically significant ($p < 0.01$), reflecting boys in this group having relatively larger subcutaneous fat depots in the upper body(Lou et al., 2021).

Contrarily, mean waist circumference (WC) was greater in girls compared to boys, measuring 72.7 ± 8.9 cm in girls and 66.8 ± 8.5 cm in boys. The outcome indicates that there is a gender-related difference in fat accumulation, with upper body fat being higher in boys and central adiposity in the abdominal region being higher in girls. These are expected variations in physiological differences mediated by sex hormones at the onset of early adolescence.

Body Mass Index Categories

The division of participants into BMI groups showed significant trends. In boys, 62% were in the normal group, 18.3% were overweight, and 9% were obese. In girls, 65% were in the normal group, 16.4% were overweight, and 10.8% were obese. The prevalence of obesity and overweight taken together was 27.3% in boys and 27.2% in girls, showing an almost equal burden of abnormal weight in both sexes(Castro et al., 2021).

These results are in line with larger national studies, which indicate a consistent increase in overweight and obesity prevalence among Indian urban school-aged children.

Correlation Analysis between Anthropometric Measurements

To identify the magnitude of associations among various anthropometric measurements, correlation analyses were conducted. Pearson's correlation coefficients indicated that NC and BMI, as well as WC and BMI, had strong positive correlations(Cornejo et al., 2021).

For males, NC was similarly correlated with BMI at $r = 0.71$ ($p < 0.001$), and for females, the correlation was stronger at $r = 0.816$ ($p < 0.001$). Waist circumference correlated strongly with BMI in males, at $r = 0.88$ ($p < 0.001$), and in females, at $r = 0.873$ ($p < 0.001$). These results indicate that NC and WC are both appropriate surrogates for adiposity, with WC having slightly higher correlations.

The greater correlation of NC and BMI in girls than in boys is an intriguing finding, possibly due to variation in fat deposition patterns during puberty. More uniform changes in fat distribution around the upper body might occur in girls, thus enhancing the correlation between NC and BMI.

Diagnostic Performance of Neck Circumference

Diagnostic performance of NC as a screening instrument for obesity was evaluated by Receiver Operating Characteristic (ROC) analysis. ROC curves constructed for both males and females yielded gender-specific cut-off points that balanced optimally the sensitivity and specificity for identifying overweight and obesity.

In boys, an NC cut-off level of 32.5 cm provided an area under the curve (AUC) of 0.825, which was indicative of excellent diagnostic accuracy. This cut-off had a sensitivity of 84.2%, specificity of 76.0%, and overall diagnostic accuracy of 77.9%.

For females, an NC cut-point of 30.5 cm gave an AUC of 0.878, sensitivity of 86.1%, specificity of 70.2%, and accuracy of 74.6%. These findings affirm that NC is capable of distinguishing between normal and overweight/obese children with good discrimination, similar to WC.

Comparative Analysis of Neck and Waist Circumference

Comparing diagnostic performance, waist circumference marginally performed better compared to neck circumference in terms of accuracy(Dongre et al., 2021). WC showed sensitivity greater than 88% and specificity approximately 78% in both men and women, having overall diagnostic accuracies greater than 80%. Yet, differences between NC and WC, while statistically significant, were not sufficiently large to reduce the clinical utility of NC.

In light of the logistical constraints involved with WC measurement in some contexts, NC performance, even though lower to a small extent, is clinically useful. NC has pragmatic benefits such as being easy to measure, culturally acceptable, and free from influence by such factors as meal consumption or respiration movement.

Table 2. Diagnostic Performance of Neck and Waist Circumference in Identifying Overweight and Obesity

Parameter	Boys (NC ≥ 32.5 cm)	Girls (NC ≥ 30.5 cm)	Boys (WC)	Girls (WC)
Area Under Curve (AUC)	0.825	0.878	0.892	0.901
Sensitivity (%)	84.2	86.1	88.7	89.3
Specificity (%)	76.0	70.2	78.5	77.9
Accuracy (%)	77.9	74.6	82.0	83.1

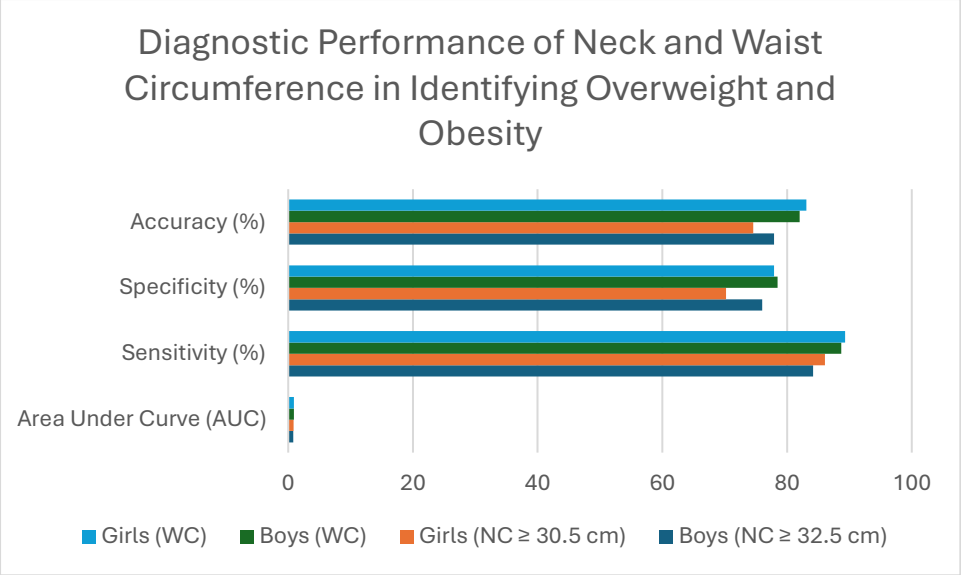

Figure: Diagnostic Performance of Neck and Waist Circumference in Identifying Overweight and Obesity

Summary of Findings

The results collectively establish the neck circumference as one of the reliable screening tool for childhood obesity. Baseline analyses confirmed gender differences in fat distribution, with boys exhibiting higher NC values and girls displaying higher WC values. Prevalence estimates indicated that over one-quarter of the study population was the overweight or obese, highlighting the magnitude of the issue in urban school settings.

Strong correlations of NC with BMI and WC validate its actual role as a surrogate marker of adiposity (Raman et al., 2021). Diagnostic performance analyses the further demonstrated that NC is nearly as effective as WC in identifying overweight and obese children, with teh actual cut-off values of 32.5 cm for boys and 30.5 cm for girls serving as reliable thresholds. While the WC displayed marginally superior accuracy, as well as the advantages of NC—such as cultural acceptability, simplicity, and reproducibility—enhance its appeal as a first-line screening measure.

DISCUSSION

Interpretation of Findings

The present study validates neck circumference as a practical screening tool for childhood obesity. Its strong correlation with BMI and WC, combined with favorable sensitivity and specificity, underscores its diagnostic reliability. While WC performed slightly better in terms of accuracy, NC offered the advantages of cultural acceptability, ease of measurement, and stability across time.

Comparison with Previous Studies

Findings align with the actual prior research from India as well as the abroad. For instance, studies from Bangalore and Udupi reported similar cut-off values and correlations. International research from Turkey and Iran corroborates the utility of NC, with minor variations in cut-off values due to ethnic and lifestyle differences. The observed gender differences in NC and WC are consistent with physiological variations in fat distribution during adolescence(Ma et al., 2021).

Clinical and Public Health Implications

NC can serve as an effective first-line screening tool in the actual pediatric clinics, schools, and community health programs. Its actual simplicity allows the large-scale implementation, particularly in resource-limited settings where the main advanced equipment is unavailable. Incorporating NC into routine pediatric assessments can facilitate early detection and timely interventions, reducing the burden of obesity-related complications.

Limitations

The study was confined to a huge single urban school in the context of Kochi, which may limit generalizability. Pubertal status, which can influence fat distribution, was not assessed. Future studies should include larger, multi-centric samples across diverse socioeconomic and geographic settings(Pei et al., 2021).

Future Directions

Longitudinal studies are necessary to establish causal associations between NC and long-term health outcomes. Additionally, integrating NC with other non-invasive measures such as bioelectrical impedance analysis could enhance accuracy. Establishing international consensus on age- and gender-specific NC cut-offs would further strengthen its applicability.

CONCLUSION

Neck circumference Is one of the reliable, simple, and culturally acceptable anthropometric measure for screening childhood obesity. The actual study provides the population-specific cut-off values of 32.5 cm for boys and 30.5 cm for girls in the Indian context. While the WC remains slightly superior in diagnostic accuracy, NC offers significant advantages in terms of feasibility and stability, making it particularly valuable for school-based as well as the community-level screenings. Integrating NC into pediatric health assessments can help to contribute meaningfully to early identification and prevention of obesity, ultimately reducing the risk of associated metabolic and cardiovascular disorders in adulthood.

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