ORIGINAL ARTICLE

NUREXUS

Journal of MedVerse Research & Practice

ISSN: 3107-4278

Correlation of Waist Indices with Body Mass Index in School-Aged Children

Dr. Joseph Vijay[1], Dr. Sangeetha [2]
Assistant Professor, Professor
Department of Paediatrics,
Faculty of Medicine, University of Colombo, Srilanka
Email ID: josephvijay@gmail.com,

Submission Date: 24.11.2025	Accepted Date: 21.12.2025	Published Date: 31.12.2025

Abstract

Background: Childhood obesity is a growing public health problem with significant short- and long-term health consequences. While body mass index (BMI) is commonly used to assess nutritional status, it does not adequately reflect central fat distribution, which plays a critical role in metabolic risk. Waist-based anthropometric indices have emerged as simple and effective measures for assessing central obesity.

Methods: A cross-sectional observational study was conducted among 300 school-going children aged 12–16 years. Anthropometric measurements, including weight, height, waist circumference, and hip circumference, were recorded using standardized procedures. BMI was calculated and classified using age- and sex-specific reference charts. Waist-to-hip ratio and waist-to-height ratio were derived using standard formulas. Correlation between BMI and waist indices was analyzed using appropriate statistical methods, with a p value <0.05 considered statistically significant.

Results: Of the total participants, 38% were classified as overweight or obese. Abnormal waist-to-height ratio was observed in a higher proportion of children compared to waist circumference and waist-to-hip ratio. Mean values of all waist indices increased progressively with rising BMI categories. BMI showed a strong positive correlation with waist-to-height ratio (r = 0.86) and waist circumference (r = 0.82), both of which were statistically significant (p <0.001). Notably, abnormal waist indices were also observed among children with normal BMI.

Conclusion: Waist-based anthropometric indices, particularly waist-to-height ratio, show a strong correlation with BMI and effectively identify central obesity among school children. Incorporation of waist indices along with BMI in school health screening programmes may improve early detection of obesity-related health risks and support preventive public health strategies.

Keywords: Body mass index; Waist circumference; Waist-to-height ratio; Waist-to-hip ratio; Childhood obesity; School children

Introduction

Childhood overweight and obesity have become major public health challenges worldwide, with a noticeable rise in prevalence over recent decades. Children from diverse socioeconomic and cultural settings are increasingly affected, largely due to rapid changes in lifestyle patterns. Increased consumption of energy-dense foods, declining levels of physical activity, prolonged screen exposure, and academic-related sedentary behaviour have collectively contributed to unhealthy weight gain during childhood and adolescence [1]. Excess body fat in childhood is associated with several adverse health outcomes. In the immediate term, affected children may experience reduced physical endurance, musculoskeletal discomfort, sleep-related problems, and psychosocial difficulties. More importantly, childhood obesity has a strong tendency to persist into adulthood, significantly increasing the risk of non-

communicable diseases such as type 2 diabetes mellitus, hypertension, cardiovascular disease, and cerebrovascular events later in life [2]. Early detection of children at risk is therefore crucial for preventing long-term health consequences.

Body mass index (BMI) is the most widely used anthropometric measure for assessing nutritional status among children and adolescents. Its simplicity, low cost, and ease of application make it suitable for large-scale screening and epidemiological studies [3]. However, BMI provides an estimate of overall body mass and does not differentiate between fat mass and lean mass. Furthermore, it fails to capture the distribution of body fat, particularly central adiposity, which plays a pivotal role in metabolic risk [4]. Growing evidence highlights the importance of abdominal obesity as a key determinant of cardiometabolic risk. Visceral fat is metabolically active and contributes to insulin resistance, systemic inflammation, and dyslipidaemia. Children with increased central fat accumulation may therefore exhibit metabolic abnormalities even when their BMI falls within the normal range [5]. This limitation necessitates the use of additional anthropometric indicators that better reflect fat distribution.

Waist-based anthropometric indices, including waist circumference, waist-to-hip ratio, and waist-to-height ratio, have gained attention as practical measures of central adiposity. Among these, waist-to-height ratio has been shown to be a reliable predictor of cardiometabolic risk, with the advantage of a single cut-off value applicable across age groups and sexes [6,7]. These indices are non-invasive, easy to measure, and feasible for implementation in school and community-based screening programmes. School-going children constitute an important target group for early screening, as lifestyle behaviours established during this period often track into adulthood. In South Asian countries, including India and Sri Lanka, the dual burden of undernutrition and rising childhood overweight presents a unique public health concern, particularly in urban and semi-urban populations [8,9]. Evaluating the relationship between BMI and waist-based indices may enhance the identification of children at risk and strengthen existing school health strategies. Therefore, the present study aims to assess the correlation between waist-based anthropometric indices and body mass index among school children [10].

Materials and Methods

Study Design

This observational cross-sectional study was conducted to evaluate the association between waist-based anthropometric indices and Body Mass Index (BMI) among school-aged children.

Study Setting and Duration

The study was carried out by the Department of Paediatrics, Faculty of Medicine, University of Colombo, Sri Lanka, in selected schools enrolling students aged 12–16 years. Schools were selected based on logistical feasibility and accessibility to facilitate systematic data collection during the study period.

Study Population

The study population consisted of school-going children aged 12–16 years studying in the selected schools. A total of 300 eligible students were enrolled using purposive sampling.

Sample Size

A total of 300 students were included in the study. The sample size was determined based on the expected number of eligible participants available during the study period and the feasibility of conducting anthropometric assessments within the selected schools.

Inclusion Criteria

Children aged 12–16 years who were enrolled in the selected schools, present on the day of data collection, and whose parents or legal guardians provided written informed consent along with assent from the child were included in the study.

Exclusion Criteria

Children with known chronic medical illnesses, endocrine disorders, congenital anomalies, or physical disabilities that could influence anthropometric measurements, as well as students whose parents declined consent or who were absent on the day of assessment, were excluded from the study.

Data Collection Tool

After obtaining written informed consent from parents or legal guardians and assent from participating children, data were collected using a pre-validated structured proforma. Sociodemographic information including age, sex, and relevant background characteristics was recorded. Dietary habits and physical activity levels were assessed using a standardized questionnaire. Consumption of junk food or sugar-sweetened beverages more than twice weekly was categorized as unhealthy dietary behaviour according to the recommendations of the American Academy of Pediatrics. A brief clinical examination was performed to identify obesity-related physical findings such as acanthosis nigricans. Anthropometric measurements were obtained by trained investigators following standardized protocols. Body weight was measured using a calibrated digital weighing scale and recorded to the nearest 0.1 kg, while standing height was measured using a portable stadiometer with participants standing barefoot in the Frankfurt horizontal plane and recorded to the nearest 0.1 cm. Body Mass Index (BMI) was calculated as weight in kilograms divided by height in meters squared and interpreted according to age- and sex-specific Centers for Disease Control and Prevention (CDC) growth reference charts. Waist circumference was measured using a non-elastic measuring tape at the midpoint between the lower border of the last palpable rib and the iliac crest at the end of normal expiration and recorded to the nearest 0.1 cm. Hip circumference was measured at the maximum circumference over the buttocks. Waist-to-Hip Ratio (WHR) was calculated by dividing waist circumference by hip circumference, with values greater than 0.90 in boys and 0.85 in girls considered abnormal. Waist-to-Height Ratio (WHtR) was calculated by dividing waist circumference by height, and a value greater than 0.5 was considered indicative of central obesity. Central adiposity was additionally defined using waist circumference values at or above the 70th percentile according to Khadilkar reference standards.

Ethical Considerations

The study protocol was reviewed and approved by the Institutional Ethics Committee of the Faculty of Medicine, University of Colombo, Sri Lanka, prior to commencement of the study. Permission to conduct the study was obtained from the respective school authorities. Written informed consent was obtained from parents or legal guardians, and assent was obtained from all participating children. Confidentiality and anonymity of participant information were strictly maintained throughout data collection, analysis, and reporting.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using the Statistical Package for the Social Sciences (SPSS) software version 26.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were summarized as frequencies and percentages. The association between Body Mass Index and waist-based anthropometric indices, including waist circumference, waist-to-hip ratio, and waist-to-height ratio, was assessed using Pearson's correlation coefficient. Comparisons between groups were performed using the independent sample *t*-test or one-way analysis of variance (ANOVA) for continuous variables and the Chi-square test for categorical variables, as appropriate. Multiple linear regression analysis was performed to identify independent anthropometric predictors of Body Mass Index after adjusting for age, sex, dietary habits, and physical activity. A *p*-value of less than 0.05 was considered statistically significant.

Results

Table 1:Age and Sex Distribution of Study Participants (n = 300)

Age group (years)	Boys n (%)	Girls n (%)	Total n (%)
12–13	48 (16.0)	42 (14.0)	90 (30.0)
14–15	66 (22.0)	54 (18.0)	120 (40.0)
16	45 (15.0)	45 (15.0)	90 (30.0)
Total	159 (53.0)	141 (47.0)	300 (100)

The age and sex distribution of the study participants demonstrates that the majority of children (40%) belonged to the 14–15-year age group, followed by equal proportions in the 12–13-year and 16-year groups (30% each). There was a slight male predominance, with boys constituting 53% of the total sample and girls accounting for 47%. This relatively uniform distribution across age groups ensures adequate representation of early to mid-adolescence, a critical period for rapid physical growth and changes in body composition. The near-equal sex distribution minimizes gender-related bias and enhances the generalizability of the findings across both sexes.

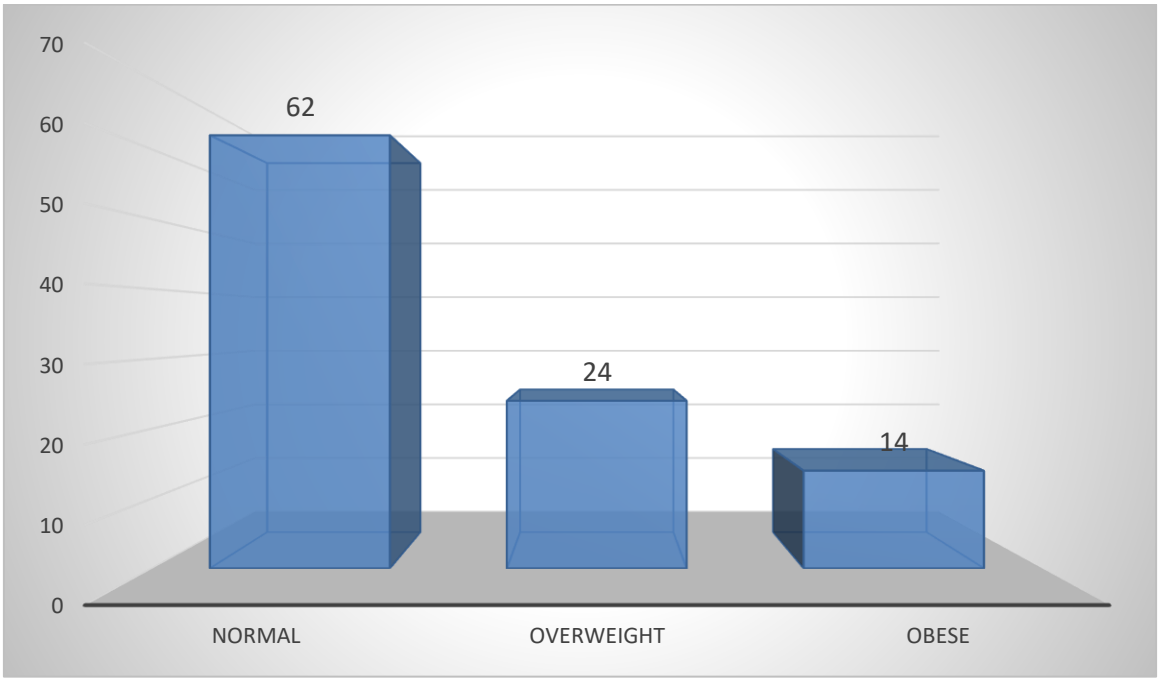

Figure 1: Distribution of BMI Categories among Study Participants

Based on BMI classification using age- and sex-specific reference standards, 62% of the children were found to have normal BMI, while 24% were overweight and 14% were obese. Thus, more than one-third (38%) of the study population exhibited excess body weight. This finding highlights a substantial burden of overweight and obesity among school-going children, reflecting the growing public health concern related to unhealthy weight gain during adolescence. The observed prevalence underscores the importance of early screening and preventive strategies in school settings.

Table 2: Distribution of Waist Indices among Study Participants

Waist index	Normal n (%)	Abnormal n (%)
Waist circumference	204 (68.0)	96 (32.0)
Waist-to-hip ratio	219 (73.0)	81 (27.0)
Waist-to-height ratio	195 (65.0)	105 (35.0)

Assessment of waist indices revealed that an abnormal waist-to-height ratio was present in 35% of participants, followed by an abnormal waist circumference in 32% and an abnormal waist-to-hip ratio in 27%. Among the three indices, waist-to-height ratio identified the highest proportion of children with central obesity. This suggests that waist-to-height ratio may be a more sensitive indicator of abdominal adiposity in children compared to other waist-based measures. The findings also indicate that a significant proportion of children with central obesity may not be identified using BMI alone.

Table 3: Mean Anthropometric Measurements by BMI Category

Parameter	Normal BMI (Mean ± SD)	Overweight (Mean ± SD)	Obese (Mean ± SD)
Waist circumference (cm)	66.2 ± 5.1	74.8 ± 4.6	82.5 ± 5.3
Waist-to-hip ratio	0.78 ± 0.05	0.84 ± 0.06	0.91 ± 0.07
Waist-to-height ratio	0.44 ± 0.04	0.52 ± 0.05	0.59 ± 0.06

Mean waist circumference, waist-to-hip ratio, and waist-to-height ratio showed a progressive increase from the normal BMI group to overweight and obese categories. Children classified as obese had markedly higher mean waist circumference and waist indices compared to their normal-weight counterparts. This graded rise in central adiposity parameters with increasing BMI demonstrates a clear association between overall adiposity and abdominal fat accumulation, reinforcing the biological plausibility of the observed correlations.

Table 4: Correlation between BMI and Waist Indices

Waist index	Pearson correlation coefficient (r)	p value
Waist circumference	0.82	<0.001
Waist-to-hip ratio	0.69	<0.001
Waist-to-height ratio	0.86	<0.001

Correlation analysis revealed a strong and statistically significant positive association between BMI and all waist indices. Waist-to-height ratio showed the strongest correlation with BMI ($r = 0.86$, $p < 0.001$), followed closely by waist circumference ($r = 0.82$, $p < 0.001$). Waist-to-hip ratio demonstrated a moderately strong correlation ($r = 0.69$, $p < 0.001$). These findings indicate that waist-based indices, particularly waist-to-height ratio, closely reflect overall adiposity as measured by BMI and may serve as reliable complementary screening tools.

Table 5: Prevalence of Abnormal Waist Indices across BMI Categories

BMI category	Abnormal WC n (%)	Abnormal WHR n (%)	Abnormal WHtR n (%)
Normal (n=186)	18 (9.7)	15 (8.1)	21 (11.3)
Overweight (n=72)	39 (54.2)	30 (41.7)	45 (62.5)
Obese (n=42)	39 (92.9)	36 (85.7)	39 (92.9)

The prevalence of abnormal waist indices increased markedly with rising BMI category. While a small proportion of children with normal BMI exhibited abnormal waist indices, more than half of overweight children and the vast majority of obese children demonstrated abnormal waist circumference and waist-to-height ratio. Notably, waist-to-height ratio detected central obesity in over 90% of obese children. This trend suggests that central adiposity worsens with increasing BMI and highlights the ability of waist indices to identify children at risk even within lower BMI categories.

Discussion

The present cross-sectional study evaluated the correlation between waist-based anthropometric indices and body mass index among school-going children aged 12 to 16 years. The findings demonstrate a substantial prevalence of overweight and obesity, along with a strong and statistically significant association between BMI and waist indices, particularly waist-to-height ratio. In the present study, 38% of participants were either overweight or obese, indicating a considerable burden of excess weight among adolescents. Similar trends have been reported globally and in South Asian settings. Gupta et al. observed an increasing prevalence of childhood overweight and obesity in urban Indian school children, attributing this rise to sedentary lifestyle patterns and dietary transitions [9]. Comparable findings were also reported by Wickramasinghe et al. among Sri Lankan school children, emphasizing the growing public health challenge of adolescent obesity in the region [10].

Waist-based indices revealed that waist-to-height ratio identified the highest proportion of children with central obesity compared to the waist circumference and waist-to-hip ratio. This observation aligns with findings by Ashwell and Gibson, who emphasized that waist-to-height ratio is a superior screening tool for central obesity across age groups and ethnicities [11]. McCarthy and Ashwell further suggested that waist-to-height ratio may be more effective than BMI in predicting metabolic risk in children [12]. The progressive increase in mean waist circumference, waist-to-hip ratio, and waist-to-height ratio across BMI categories observed in this study highlights the close relationship between general and central adiposity. Similar graded increases have been reported by Khadilkar et al., who demonstrated that central fat accumulation rises proportionately with increasing BMI in Indian children [13]. This reinforces the biological plausibility of using waist indices as complementary measures to BMI.

Correlation analysis in the present study revealed a strong positive correlation between BMI and waist-to-height ratio ($r = 0.86$), followed by waist circumference ($r = 0.82$). These findings are consistent with studies by Freedman et al., who reported strong correlations between BMI and waist circumference in paediatric populations [14]. A study by Savva et al. also demonstrated that waist-to-height ratio showed a stronger association with cardiometabolic risk factors compared to BMI alone [15]. An important observation from this study was the presence of abnormal waist indices even among children with normal BMI. Similar findings were reported by Lee et al., who noted that children with normal BMI but increased central adiposity had higher cardiometabolic risk profiles [16]. This underscores the limitation of BMI as a sole screening tool and highlights the importance of incorporating waist-based measurements in routine assessments. The markedly high prevalence of abnormal waist indices among overweight and obese children observed in the present study agrees with findings from the Bogalusa Heart Study, which demonstrated strong associations between central obesity and adverse cardiovascular risk factors in childhood [17]. Li et al. also reported that waist-to-height ratio was a reliable predictor of metabolic syndrome components in children and adolescents [18]. From a public health perspective, these findings have important implications for school health programmes.

Schools offer an ideal platform for early identification of children at risk of obesity-related complications. Studies by Daniels et al. have emphasized the need for simple, cost-effective screening tools that can be implemented in community and school settings [19]. Waist-to-height ratio, due to its simplicity and universal cut-off, may serve as a practical tool in such programmes. In the Indian subcontinent and Sri Lanka, where rapid urbanization and lifestyle changes are influencing child health, region-specific evidence is essential. Studies by Misra et al. have highlighted ethnic differences in body fat distribution, suggesting that Asian children may develop metabolic risk at lower levels of

adiposity [20]. Therefore, combining BMI with waist indices may improve early risk stratification. Overall, the present study supports the use of waist-based anthropometric indices, particularly waist-to-height ratio, as valuable adjuncts to BMI for assessing obesity and related health risks among school children.

Strengths

This study employed standardized anthropometric measurement techniques and internationally accepted reference standards for Body Mass Index, waist circumference, and waist-to-height ratio, thereby ensuring reliable assessment of central obesity among adolescents. The inclusion of dietary habits, physical activity, and clinical examination provided a comprehensive evaluation of factors associated with obesity.

Limitations

The cross-sectional design precluded assessment of causal relationships between anthropometric indices and Body Mass Index. Furthermore, the study was conducted in selected schools using purposive sampling, which may limit the generalizability of the findings to the wider adolescent population.

Conclusion

The present study demonstrates a strong and statistically significant correlation between body mass index and waist-based anthropometric indices among school-going children aged 12 to 16 years. A considerable proportion of participants were found to be overweight or obese, highlighting the growing burden of adolescent obesity. Waist indices, particularly waist-to-height ratio, showed a closer association with BMI and identified a higher proportion of children with central obesity, including those with normal BMI. These findings emphasize the limitation of relying solely on BMI for obesity screening and support the incorporation of waist-based measurements as complementary tools. Given their simplicity, cost-effectiveness, and ability to detect central adiposity, waist indices, especially waist-to-height ratio, can be effectively utilized in school health programmes for early identification of children at risk of obesity-related metabolic complications. Early screening and timely preventive interventions during school years may play a crucial role in reducing the future burden of non-communicable diseases.

Conflict of interest: Nil
Source Of Fund: Nil

Reference

1. World Health Organization. Childhood overweight and obesity. Geneva: World Health Organization; 2022.
2. Llewellyn A, Simmonds M, Owen CG, Woolacott N. Childhood obesity as a predictor of morbidity in adulthood. Obes Rev. 2016;17(1):56–67.
3. de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of WHO growth reference for school-aged children. Bull World Health Organ. 2007;85(9):660–667.
4. Daniels SR. The use of BMI in the clinical setting. Pediatrics. 2009;124(Suppl 1):S35–S41.
5. Weiss R, Dziura J, Burgert TS, Tamborlane WV, Taksali SE, Yeckel CW, et al. Obesity and the metabolic syndrome in children. N Engl J Med. 2004;350(23):2362–2374.
6. McCarthy HD, Ashwell M. Central obesity measurements in children. Int J Obes. 2006;30(6):988–992.
7. Ashwell M, Gibson S. Waist-to-height ratio for screening cardiometabolic risk. Nutr Rev. 2014;72(6):1–10.
8. Singh AS, Mulder C, Twisk JW, Van Mechelen W, Chinapaw MJ. Tracking of childhood overweight into adulthood. Obes Rev. 2008;9(5):474–488.
9. Gupta N, Goel K, Shah P, Misra A. Childhood obesity in developing countries: epidemiology,

determinants, and prevention. Endocr Rev. 2012;33(1):48–70.
10. Wickramasinghe VP, Lamabadusuriya SP, Atapattu N, Sathyadas G, Kuruparanantha S, Karunarathne P. Nutritional status of schoolchildren in an urban area of Sri Lanka. Ceylon Med J. 2004;49(4):114–118.
11. Ashwell M, Gibson S. Waist-to-height ratio as an indicator of "early health risk": simpler and more predictive than using a "matrix" based on BMI and waist circumference. BMJ Open. 2016;6(3):e010159.
12. McCarthy HD, Ashwell M. A study of central fatness using waist-to-height ratios in UK children and adolescents over two decades supports the simple message "keep your waist circumference to less than half your height". Int J Obes (Lond). 2006;30(6):988–992.
13. Khadilkar A, Ekbote V, Kajale N, Chiplonkar S, Khadilkar V. Waist circumference percentiles in 2–18-year-old Indian children. J Pediatr. 2014;164(6):1358–1362.
14. Freedman DS, Wang J, Maynard LM, Thornton JC, Mei Z, Pierson RN Jr, et al. Relation of BMI to fat and fat-free mass among children and adolescents. Int J Obes (Lond). 2005;29(1):1–8.
15. Savva SC, Tornaritis M, Savva ME, Kourides Y, Panagi A, Silikiotou N, et al. Waist circumference and waist-to-height ratio are better predictors of cardiovascular disease risk factors in children than body mass index. Int J Obes Relat Metab Disord. 2000;24(11):1453–1458.
16. Lee S, Bacha F, Gungor N, Arslanian SA. Waist circumference is an independent predictor of insulin resistance in black and white youths. J Pediatr. 2006;148(2):188–194.
17. Freedman DS, Dietz WH, Srinivasan SR, Berenson GS. The relation of overweight to cardiovascular risk factors among children and adolescents: the Bogalusa Heart Study. Pediatrics. 1999;103(6 Pt 1):1175–1182.
18. Li C, Ford ES, Mokdad AH, Cook S. Recent trends in waist circumference and waist-to-height ratio among US children and adolescents. Pediatrics. 2006;118(5):e1390–e1398.
19. Daniels SR, Jacobson MS, McCrindle BW, Eckel RH, McHugh Sanner B. American Heart Association childhood obesity research summit: executive summary. Circulation. 2009;119(15):2114–2123.
20. Misra A, Shah P, Goel K, Hazra DK, Gupta R, Seth P, et al. The high burden of obesity and abdominal obesity in urban Indian schoolchildren: a multicentric study of 38,296 children. Ann Nutr Metab. 2011;58(3):203–211.