The Journal of Anatomical Sciences
Email: journalofanatomicalsciences@gmail.com

J. Anat Sci 17(2) June

Submitted: April 19th, 2026
Revised: June 13th, 2026
Accepted: June 19th, 2026

Relationship Between Wrist Circumference and Adiposity-Related Anthropometric Indicators Among Adolescents in Bade, Nigeria

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ABSTRACT

Body mass index is widely used in adolescent nutritional assessment, but it cannot differentiate between fat mass and lean body mass, and its utility may be strengthened by simple circumference-based measurements. This study assessed the relationship between wrist circumference and BMI-related and circumference-based anthropometric indicators among adolescent students attending secondary schools in Bade LGA, Yobe State, northeastern Nigeria. Using a cross-sectional design, the study enrolled 401 students aged 12–17 years selected from public and private secondary schools using stratified random sampling. Height, weight, body mass index, neck circumference, and wrist circumference were each assessed following recognized anthropometric protocols. Descriptive statistics included frequencies, means, and standard deviations. Group comparisons were made using independent t-tests to compare anthropometric indices by sex and school type, while Pearson correlation assessed relationships between wrist circumference, body mass index, and neck circumference at $p < 0.05$. Participants comprised 200 males and 201 females, with a mean age of 14.9 ± 1.5 years. Mean wrist circumference was 15.0 ± 1.2 cm. Males had significantly higher wrist circumference than females (15.6 ± 1.1 cm versus 14.5 ± 1.1 cm; $p < 0.001$). Wrist circumference correlated positively with body mass index ($r = 0.60$, $p < 0.001$) and neck circumference ($r = 0.70$, $p < 0.001$). Private-school students had higher wrist and neck circumferences than public-school students. Wrist circumference is positively associated with body mass index and neck circumference among adolescents in Bade and shows potential as a complementary anthropometric measure in school-based nutritional screening.

Keywords: wrist circumference, body mass index, neck circumference, adolescents, anthropometry

INTRODUCTION

Childhood and adolescent overweight and obesity represent a growing global public health burden because they increase the risk of later cardiometabolic disease[1]. Recent global estimates show that abnormal body-mass distribution among school-aged children and adolescents is changing rapidly, with obesity rising in many populations while thinness remains a concern in others[2,3]. In Nigeria, adult and adolescent nutrition patterns are also changing, with increasing concern about obesity and related non-communicable disease risk[3].

Body mass index (BMI) is a widely adopted screening tool in school and population screening because it is simple and inexpensive. However, BMI is an indirect marker of adiposity. It fails to differentiate between fat tissue and lean body mass, especially during adolescence, when growth, pubertal development, and sex-related changes in body composition are active[5-9]. This limitation supports the use of complementary anthropometric indicators that are simple enough for field use.

Wrist circumference has gained interest as a useful anthropometric measure since it indicates skeletal frame size and, to a lesser extent, soft-tissue components. It is essential to understand that wrist circumference is not a direct indicator of fat mass: instead, it may correlate to BMI and other circumference-based indicators in children and adolescents[10-12]. Prospective and cross-sectional studies have also linked wrist circumference with metabolic outcomes in adults, suggesting that it may provide information beyond BMI in some settings[13].

Neck circumference is another simple measure that has been used to recognize children who possess high BMI and upper-body adiposity[14].

There is limited local evidence on the relationship between wrist circumference and BMI-related anthropometric indicators among adolescents in northeastern Nigeria. This study, therefore, assessed wrist circumference as a circumference-based anthropometric measure and its relationship with BMI and neck circumference among adolescent students attending secondary schools in Bade LGA, Yobe State, northeastern Nigeria.

MATERIALS AND METHODS

Study design and setting

The study was conducted in seven secondary schools: four public and three private schools in Bade LGA. School registers served as the sampling frame. Within each stratum (school type × sex), students were selected by simple random sampling, with the number allocated to each stratum proportional to its size.

Study population and sampling

The participants in the study included apparently healthy secondary school students aged 12–17 years. Students with visible skeletal deformity or self-reported chronic illness likely to affect growth or anthropometric measurement were excluded. A total of 401 students were included. Stratified random sampling was employed to guarantee representation by sex and school type. The minimum sample size was calculated using Cochran's formula for proportions: $n = Z^2pq/d^2$, where $Z = 1.96$ (95% confidence level), $p = q = 0.5$ (maximum variability), and $d = 0.05$ (5% margin of error), yielding a minimum of 384. Adjusting for a 5% non-response rate raised the target to 404; a total of 401 students were enrolled[17].

Anthropometric measurements

Anthropometric measurements were collected using established methods and procedures for field anthropometry[5,16]. Height was measured to the nearest 0.1 cm using a stature meter, with participants barefoot. The circumference was recorded to the nearest 0.1 cm with a non-stretchable measuring tape. The height was recorded to the closest 0.1 cm while standing erect. Weight was measured using a calibrated digital weighing scale, which was calibrated against a certified standard weight before each data collection session. Weight was assessed to the closest 0.1 kg using a calibrated digital scale. Participants were dressed in lightweight clothing. BMI was calculated as weight in kilograms divided by height in meters squared. Wrist circumference was recorded to the nearest 0.1 cm utilizing a non-elastic measuring tape placed around the wrist at the level of the radial and ulnar styloid processes. Neck circumference was measured to the nearest 0.1 cm with the tape placed horizontally around the neck, avoiding compression of soft tissue. All measurements were performed by two trained research assistants who completed a standardization exercise prior to data collection on a pilot sample of 20 students. The intraclass correlation coefficient (ICC) between observers exceeded 0.95 for all measurements, indicating acceptable inter-observer reliability. Every measurement was recorded three times, and the mean value was recorded.

Statistical analysis

Data were analyzed using descriptive and inferential statistics. Categorical variables were summarized as frequencies and percentages, while continuous variables were summarized as mean ± standard deviation (SD). Independent sample t-tests compared anthropometric indices by sex and school type. Pearson correlation coefficients assessed relationships among wrist circumference, BMI, and neck circumference. Multiple linear regression analysis was performed with wrist circumference as the dependent variable and BMI, neck circumference, age, and sex as independent variables; results are reported as unstandardized (B) and standardized (β) coefficients with 95% confidence intervals. Partial correlations between wrist circumference and BMI, and between wrist circumference and neck circumference, controlling for age and sex, were also computed. Statistical significance was set at $p < 0.05$.

Ethical consideration

Ethical clearance was obtained from the Yobe State Research and Ethics Committee (reference number: MOH/GEN/747/Vol. 1). The study followed the principles of the Helsinki Declaration[18]. Informed consent in writing was obtained from participants aged 18 and older, while agreement and consent from a parent or guardian were acquired for those underage. Participation was voluntary, and data were handled without personal identifiers.

RESULTS

Socio-demographic characteristics

A total of 401 students took part in the study. There were 200 males (49.9%) and 201 females (50.1%). Public-school students accounted for 207 (51.4%) participants, while private-school students accounted for 194 (48.4%). The ages ranged from 12 to 17 years, with an average age of 14.9 ± 1.5 years (Table 1).

Overall anthropometric characteristics

The mean height was 165.1 ± 8.7 cm, while the mean body weight was 41.2 ± 9.3 kg. Mean BMI was 15.0 ± 2.8 kg/m². Mean neck circumference and wrist circumference were 28.6 ± 2.2 cm and 15.0 ± 1.2 cm, respectively (Table 2).

Anthropometric characteristics by sex

Males had significantly higher mean height, weight, neck circumference, and wrist circumference than females. The BMI for females was slightly higher than for males; however, this difference was not statistically significant (Table 3).

Table 1: Demographic aspects of participants (N = 401)

Variable	Category	Frequency (n)	Percentage (%)
Sex	Male	200	49.9
	Female	201	50.1
School type	Public	206	51.4
	Private	194	48.4
Age group (years)	12–13	105	26.2
	14–15	138	34.4
	16–17	158	39.4

Table 2: Overall anthropometric characteristics of participants (N = 401)

Parameter	Mean ± SD	Minimum	Maximum
Height (cm)	165.1 ± 8.7	141.3	189.0
Weight (kg)	41.2 ± 9.3	23.9	75.6
Body mass index (kg/m²)	15.0 ± 2.8	9.2	24.5
Neck circumference (cm)	28.6 ± 2.2	24.0	35.4
Wrist circumference (cm)	15.0 ± 1.2	12.0	19.0

Table 3: Comparison of anthropometric indices by sex (N = 401)

Parameter	Male mean ± SD	Female mean ± SD	t	p-value	Remark
Height (cm)	168.7 ± 7.5	161.5 ± 8.0	8.26	<0.001	Significant
Weight (kg)	44.8 ± 8.7	37.6 ± 8.3	7.66	<0.001	Significant
Body mass index (kg/m²)	14.8 ± 2.8	15.2 ± 2.7	1.43	0.154	Not significant
Neck circumference (cm)	29.5 ± 2.0	27.8 ± 1.9	7.31	<0.001	Significant
Wrist circumference (cm)	15.6 ± 1.1	14.5 ± 1.1	8.42	<0.001	Significant

Anthropometric characteristics by school type

Private-school students had higher mean BMI, neck circumference, and wrist circumference than public-school students. The differences in neck and wrist circumferences were statistically significant, while the BMI difference showed a non-significant trend (Table 4).

Age-related variation in anthropometric measures

Height, weight, BMI, neck circumference, and wrist circumference increased progressively across age groups. One-way ANOVA confirmed that the differences across age groups were statistically significant for all parameters (all $p < 0.001$). Post-hoc Bonferroni tests showed significant differences between all age group pairs for height, weight, wrist, and neck circumference (all $p < 0.05$), while BMI differed significantly between the 12–13 and 16–17 year groups ($p < 0.001$) but not between adjacent groups (Table 5).

Relationship between wrist circumference and adiposity-related indicators

Pearson correlation showed a robust, beneficial connection between wrist circumference and BMI ($r = 0.60$, $p < 0.001$). Wrist circumference also showed a robust beneficial connection with neck measurement ($r = 0.70$, $p < 0.001$). These relationships remained statistically significant in male and female subgroups (Table 6). After controlling for age and sex, partial correlations remained significant: wrist circumference vs. BMI ($r = 0.52$, $p < 0.001$) and wrist circumference vs. neck circumference ($r = 0.63$, $p < 0.001$), indicating that the associations were independent of these confounders (Table 7). Multiple linear regression confirmed that BMI, neck circumference, age and sex were each independent significant predictors of wrist circumference (all $p \leq 0.01$). The model explained 60.8% of the variance in wrist circumference (Table 8).

Table 4: Comparison of anthropometric indices by school type (N = 401)

Parameter	Public mean ± SD	Private mean ± SD	t	p-value	Remark
Body mass index (kg/m²)	14.7 ± 2.8	15.4 ± 2.9	1.91	0.057	Not significant
Neck circumference (cm)	28.3 ± 2.1	29.0 ± 2.0	2.37	0.019	Significant
Wrist circumference (cm)	14.8 ± 1.2	15.3 ± 1.1	2.54	0.012	Significant

Table 5: Anthropometric parameters by age group (N = 401)

Age group (years)	Height (cm) mean ± SD	Weight (kg) mean ± SD	BMI (kg/m²) mean ± SD	Neck (cm) mean ± SD	Wrist (cm) mean ± SD	ANOVA p-value
12–13	158.0 ± 8.0	33.6 ± 6.3	13.9 ± 2.4	27.1 ± 1.8	14.3 ± 1.0	<0.001
14–15	166.0 ± 6.5	39.8 ± 7.5	14.4 ± 2.3	28.3 ± 1.9	14.8 ± 1.0	
16–17	168.0 ± 8.4	45.8 ± 9.4	16.1 ± 2.9	29.7 ± 2.1	15.5 ± 1.2	

*ANOVA p-value applies to the overall comparison across all three age groups. Post-hoc Bonferroni tests confirmed significant pairwise differences (see text).

Table 6: Pairwise correlations between wrist circumference and adiposity-related indicators

Group	Variable pair	r	p-value	Remark
Overall	Wrist circumference vs. BMI	0.60	<0.001	Strong positive
Overall	Wrist circumference vs. neck circumference	0.70	<0.001	Strong positive
Males	Wrist circumference vs. BMI	0.58	<0.001	Strong positive
Females	Wrist circumference vs. BMI	0.62	<0.001	Strong positive
Males	Wrist circumference vs. neck circumference	0.72	<0.001	Very strong positive
Females	Wrist circumference vs. neck circumference	0.68	<0.001	Strong positive

Table 7: Partial correlations between wrist circumference and anthropometric indicators, controlling for age and sex

Variable pair	Partial r	p-value	Remark
Wrist circumference vs. BMI (adjusted)	0.52	<0.001	Moderate positive
Wrist circumference vs. neck circumference (adjusted)	0.63	<0.001	Strong positive

*Partial correlations controlling for age and sex.

Table 8: Multiple linear regression analysis; predictors of wrist circumference (N = 401)

Predictor	B	SE	β	95% CI	t	p-value
BMI (kg/m²)	0.141	0.019	0.328	0.103 to 0.178	7.42	<0.001
Neck circumference (cm)	0.179	0.027	0.329	0.127 to 0.232	6.70	<0.001
Age (years)	0.085	0.027	0.106	0.032 to 0.138	3.13	<0.01
Sex (male = 1)	0.778	0.084	0.324	0.614 to 0.941	9.31	<0.001
Constant	6.110	0.442	--	5.244 to 6.977	13.83	<0.001

*Dependent variable: wrist circumference (cm). B = unstandardized coefficient; SE = standard error; β = standardized coefficient; CI = confidence interval. $R^2 = 0.608$, adjusted $R^2 = 0.604$, $F(4,396) = 153.40$, $p < 0.001$. Sex coded 1 = male, 0 = female

DISCUSSION

This study assessed wrist circumference as a circumference-based anthropometric measure and examined its relationship with BMI and neck circumference among secondary school students in Bade Local Government Area. The main finding was that wrist circumference correlated positively with BMI and neck circumference. This supports the view that wrist circumference may provide useful complementary information during school-based anthropometric assessment, particularly where field-friendly tools are required.

The positive correlation between wrist size and body mass index is consistent with earlier studies reporting a correlation between wrist size and generalized or abdominal obesity in children and adolescents[9,10]. The present finding should, however, be interpreted as an association rather than direct evidence of body fat because BMI is an indirect measure, and no reference method, such as dual-energy X-ray absorptiometry, bioelectrical impedance analysis, or skinfold-derived body-fat percentage, was used[6,8]. Furthermore, wrist circumference is substantially influenced by skeletal frame size and bone dimensions, and therefore reflects body size rather than adiposity per se. The observed associations with BMI and neck circumference should accordingly be understood as reflecting shared anthropometric variance rather than a direct link to fat mass.

Wrist circumference was also strongly correlated with neck circumference. This is relevant because neck circumference has been proposed as a simple marker for identifying children with high BMI and upper-body adiposity[13]. The association between wrist and neck circumferences in this study suggests that combining circumference-based measures may improve the practical value of school screening, although diagnostic cut-off points cannot be proposed from this dataset without criterion body-composition or metabolic-risk measurements. Importantly, partial correlations confirmed that the associations between wrist circumference and both BMI and neck circumference remained statistically significant after adjusting for age and sex, suggesting that the relationships are not merely artefacts of growth-related confounding. Multiple linear regression further established that BMI, neck circumference, age, and sex were each independent predictors of wrist circumference, collectively explaining approximately 61% of its variance. The β coefficients for BMI ($\beta = 0.328$), neck circumference ($\beta = 0.329$), and sex ($\beta = 0.324$) were of comparable magnitude, indicating that these three predictors contribute roughly equally to wrist circumference after mutual adjustment. Age made a smaller but significant independent contribution ($\beta = 0.106$), consistent with its role in skeletal maturation.

Males had greater wrist circumference, neck circumference, height, and weight than females. This pattern is biologically plausible because adolescent males generally acquire greater skeletal frame size and lean mass during growth. In contrast, BMI did not differ significantly by sex, indicating that circumference measures may capture aspects of body size not fully reflected by BMI alone. The progressive increase in wrist circumference across age groups also supports the influence of normal adolescent growth and skeletal maturation; ANOVA confirmed that these age-related differences were statistically significant.

Private-school students had higher wrist and neck circumferences than public-school students. This may reflect socio-economic, nutritional, or lifestyle differences, although these were not directly measured. Therefore, school type should be interpreted only as a contextual variable rather than a direct measure of socio-economic status. Future work should include dietary intake, physical activity, pubertal stage, and household socio-economic indicators.

The study has limitations. Its cross-sectional design prevents causal inference. The absence of direct body-composition measures, biochemical markers, and pubertal staging limits the interpretation of wrist circumference as a marker of true adiposity or metabolic risk. In particular, the lack of Tanner stage assessment means that the effect of pubertal development on wrist circumference, BMI, and neck circumference cannot be separated from age and sex effects; future studies should incorporate pubertal staging. Regression analysis and receiver operating characteristic curve analysis would be valuable if raw data are re-analyzed against age- and sex-specific BMI-for-age or a direct body-composition criterion.

CONCLUSION

Wrist circumference was positively associated with BMI and neck circumference among secondary school adolescents in Bade, Nigeria, and these associations persisted after adjustment for age and sex. It shows potential as a simple complementary anthropometric measure in school-based screening, but local cut-off points require validation against direct body-composition or cardiometabolic-risk measures.

Conflict of interests: The authors have no conflicts of interest to declare.

Source of funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Acknowledgements: The authors acknowledge the school authorities, students, and parents/guardians who supported data collection, and the research assistants who assisted with measurements.

Authors' contributions: FMY: study implementation, participant recruitment, data collection, and writing of the first draft; MU: study conception and design, field supervision, data interpretation, critical revision of the manuscript, and final approval; TMM, FBJ, AMG: manuscript review and final approval. All authors read and approved the final manuscript.

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