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Anthropometric Characteristics and Dietary Practices among Adolescents in Nnewi, South-eastern Nigeria

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Abstract

Background

Mid-upper arm circumference (MUAC), waist-to-height ratio (WHtR), and neck circumference (NC) are simple measures of body size, but their relationships among Nigerian adolescents are not well described. This study examined associations among MUAC, WHtR, and NC and described selected dietary practices in Nnewi, south-eastern Nigeria.

Methods

In this cross-sectional study, 400 apparently healthy adolescents aged 11–18 years underwent measurement of height, MUAC, waist circumference, and NC; WHtR was calculated from waist circumference and height. Dietary practices were assessed using an adapted adolescent nutrition questionnaire. Pearson's correlation coefficient was used to assess relationships among MUAC, WHtR, and NC.

Results

The mean age was 16.23 ± 2.42 years. Mean MUAC was 26.52 ± 2.81 cm, WHtR was 0.44 ± 0.06, and NC was 31.93 ± 2.68 cm. MUAC correlated weakly but significantly with WHtR ($r = 0.295$, $p < 0.001$) and NC ($r = 0.228$, $p < 0.001$). WHtR and NC showed no significant linear correlation ($r = 0.005$, $p = 0.935$). Most participants reported eating breakfast, lunch, and dinner in the previous 24 hours, although meal skipping at least three times per week was also common.

Conclusion

MUAC, WHtR, and NC showed different patterns of association, suggesting that they may provide partly distinct anthropometric information in these adolescents. Regular meal consumption was common, although meal skipping remained frequent. Further research incorporating BMI-for-age, direct body-composition measures, and age- and sex-specific reference standards is needed to clarify the utility of these measures for assessing nutritional risk.

INTRODUCTION

Adequate nutrition during adolescence is essential for physical growth, cognitive development and long-term health. However, adolescence is also a period during which both under-nutrition and excess adiposity may emerge, particularly in settings undergoing dietary and lifestyle transitions [1–4]. Anthropometric assessment provides a simple, inexpensive and non-invasive approach for

characterising body size and identifying adolescents who may require further nutritional or health assessment [5, 6].

Mid-upper arm circumference (MUAC), waist-to-height ratio (WHtR) and neck circumference (NC) are simple anthropometric measures that capture different aspects of body size. MUAC reflects upper-arm size and has traditionally been used in nutritional assessment, while evidence suggests that it may also relate to overall body size and adiposity [7–12]. WHtR relates waist circumference to height and provides an indicator of relative central body size, with studies demonstrating its usefulness in assessing abdominal adiposity and cardio-metabolic risk in children and adolescents [13–17]. NC provides an additional measure of upper-body size and has been associated with BMI, waist circumference and other indicators of adiposity in paediatric populations [18–23]. Nigerian studies have likewise reported associations between NC and conventional anthropometric measures, although these relationships may vary across populations [24, 25].

Although each measure has been investigated individually, less is known about how MUAC, WHtR and NC relate to one another within the same adolescent population. Because they represent different anatomical dimensions, their relationships may not necessarily be strong or interchangeable. Determining whether these measures demonstrate overlapping or complementary patterns may provide useful information for selecting simple anthropometric approaches in settings where more sophisticated body-composition methods are unavailable. This is particularly relevant in resource-constrained settings, where practical field-based measures may have value for adolescent health surveillance.

Dietary practices provide additional context for understanding adolescent nutritional characteristics. Meal skipping and irregular meal patterns are common among adolescents and may reflect broader dietary and lifestyle behaviours [26–29]. Nigerian studies have similarly reported variable meal patterns and dietary practices among adolescents [30, 31]. However, in the present study, dietary information was intended primarily to describe selected eating practices within the study population rather than to establish dietary determinants of the anthropometric measures.

Despite growing evidence on individual anthropometric indicators, information on the relationships among MUAC, WHtR and NC among adolescents in Nigeria remains limited, particularly in south-eastern Nigeria. Therefore, this study investigated the relationships among MUAC, WHtR and NC in adolescents aged 11–18 years in Nnewi, south-eastern Nigeria. The study also described selected dietary practices of the participants to provide additional context for their nutritional characteristics.

MATERIALS AND METHODS

2.1 Study design and setting

This study employed a cross-sectional analytical design to investigate the relationships among mid-upper arm circumference (MUAC), waist-to-height ratio (WHtR), and neck circumference (NC), and to describe selected dietary practices among adolescents in Nnewi, Anambra State, south-eastern Nigeria.

The study was conducted in Okofia, Nnewi, the community in which the College of Health Sciences, Nnamdi Azikiwe University, Nnewi Campus is located. Participants were recruited through both school-based and community-based approaches, including house-to-house recruitment. All participants were residents of Nnewi.

2.2 Study population and sample size

The study population comprised apparently healthy adolescents aged 11–18 years residing in Nnewi. Participants were recruited from schools and households within the study area. A total of 410 adolescents were approached for participation, of whom 400 completed the study and had complete anthropometric measurements, giving a completion rate of 97.6%. The final sample therefore consisted of 400 adolescents.

No a priori sample-size calculation was performed; the sample comprised eligible adolescents who were recruited and completed the study during the data-collection period.

2.3 Eligibility criteria

Adolescents aged 11–18 years who were residents of Nnewi and were apparently healthy were eligible for participation. Participants were excluded if they were outside the specified age range, were not residents of Nnewi, or had physical abnormalities that could interfere with accurate anthropometric measurements, including obvious limb-length discrepancy or deformity of the upper or lower limbs.

2.4 Ethical considerations

Ethical approval

for the study was obtained from the Nnamdi Azikiwe University Research Ethics Committee, Faculty of Basic Medical Sciences, College of Health Sciences, Nnamdi Azikiwe University, Nnewi Campus (*NAU/CHS/NC/FBMS/1081*). The study was conducted in accordance with the ethical principles of the Declaration of Helsinki [32]. The purpose and procedures of the study were explained to participants and their parents or guardians before data collection. Written parental or guardian consent was obtained in advance of the anthropometric assessment. Participation was voluntary, and participants were informed of their right to decline participation or withdraw from the study.

2.5 Data collection instruments

Data were collected using a structured questionnaire and standard anthropometric equipment. The questionnaire was adapted from the Bright Futures Nutrition Questionnaire for Adolescents Ages 11 to 21, 3rd edition [33]. Selected items assessing meals and snacks consumed during the preceding 24 hours, meal-skipping patterns, and family meal practices were adapted for use in the present study. Basic demographic information, including age and sex, was also recorded. The adapted questionnaire was pre-tested before the commencement of the study to assess its clarity and suitability for the study population. The questionnaire used for data collection is provided as *Supplementary File 1*.

Anthropometric measurements were obtained using a calibrated stadiometer and a non-stretchable measuring tape. Standing height was measured using the stadiometer, while MUAC, waist circumference, and NC were measured using the measuring tape.

2.6 Assessment of dietary practices

Dietary practices were assessed using selected items from the adapted adolescent nutrition questionnaire. Participants were asked about their consumption of breakfast, lunch, dinner/supper, morning snacks, afternoon snacks, and evening/late snacks during the 24-hour period preceding the survey. They were also asked whether they skipped breakfast, lunch, or dinner/supper three or more times per week and whether they consumed dinner or supper with their family at least four times per week. These variables were treated as indicators of dietary practices rather than measures of dietary adequacy or nutrient intake.

2.7 Anthropometric measurements

2.7.1 Height

Standing height was measured to the nearest 0.1 cm using a calibrated stadiometer. Participants were measured without wearing footwear, standing upright with their feet appropriately positioned, arms relaxed at their sides, and head maintained in the horizontal plane. The measurement was taken from the vertex of the head to the standing surface.

2.7.2 Mid-upper arm circumference

MUAC was measured to the nearest 0.1 cm using a non-stretchable measuring tape. The measurement was taken at the midpoint between the acromion process of the scapula and the olecranon process of the ulna. Participants stood upright with the arm relaxed and hanging freely at the side of the body, with the palm facing the thigh. The tape was placed around the arm at the identified midpoint without compressing the underlying tissue (Fig. 1A).

2.7.3 Waist Circumference

Waist circumference (WC) was measured with a non-stretchable measuring tape while the participant was standing upright with the abdomen relaxed and feet slightly apart. The tape was positioned horizontally around the waist at the mid-point between the lower margin of the last rib and the top of the iliac crest, without compressing the skin (Fig. 1B). Measurements were recorded in centimetres.

2.7.4 Waist-to-Height Ratio

Waist-to-height ratio (WHtR) was calculated as the ratio of waist circumference to standing height, both measured in centimetres:

WHtR = waist circumference (cm) / height (cm).

Because both measurements were expressed in the same units, the resulting ratio was dimensionless.

2.7.5 Neck circumference

Neck circumference was measured using a non-stretchable measuring tape while participants stood upright with the head positioned in a neutral horizontal position and the eyes facing forward. The tape was placed at the level just below the laryngeal prominence, ensuring that it remained horizontal and did not compress the soft tissues (Fig. 1C).

2.8 Statistical analysis

Data were entered into Microsoft Excel and subsequently analysed using the Statistical Package for the Social Sciences (SPSS), version 23.0 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized using means and standard deviations, while categorical variables were presented as frequencies and percentages. Pearson's product–moment correlation coefficient (r) was used to assess the linear relationships among MUAC, WHtR, and NC. All correlation tests were two-tailed, and a p-value < 0.05 was considered statistically significant.

RESULTS

3.1 Participant characteristics

A total of 410 adolescents were approached for participation, of whom 400 completed the study and had complete anthropometric data, giving a completion rate of 97.6%. The participants were aged 11–18 years, with a mean age of 16.23 ± 2.42 years. There were 241 males (60.25%) and 159 females (39.75%). Participants aged 17–18 years constituted the largest age group (31.25%), whereas those aged 11–12 years constituted the smallest (16.25%) (Table 1).

Table 1
Demographic characteristics of the study participants

Characteristic	Frequency (*n = 400*)	Percentage (%)
Age group (years)		
11–12	65	16.25
13–14	104	26.00
15–16	106	26.50
17–18	125	31.25
Sex		
Male	241	60.25
Female	159	39.75
Total	400	100.00

3.2 Anthropometric characteristics

The anthropometric characteristics of the participants are presented in Table 2. The mean standing height was 164.17 ± 6.49 cm. The mean MUAC was 26.52 ± 2.81 cm, while the mean WHtR was 0.44 ± 0.06. The mean NC was 31.93 ± 2.68 cm.

Table 2
Descriptive characteristics of anthropometric variables

Variable (*n = 400*)	Mean ± SD
Age (years)	16.23 ± 2.42
Height (cm)	164.17 ± 6.49
MUAC (cm)	26.52 ± 2.81
WHtR	0.44 ± 0.06
NC (cm)	31.93 ± 2.68

SD, standard deviation; MUAC, mid-upper arm circumference; WHtR, waist-to-height ratio; NC, neck circumference.

3.3 Correlations among MUAC, WHtR and NC

Pearson's correlation analysis demonstrated weak positive correlations between MUAC and WHtR and between MUAC and NC, whereas WHtR and NC showed virtually no linear correlation (Table 3). MUAC showed a weak positive correlation with WHtR ($r = 0.295$, $p < 0.001$). Similarly, MUAC demonstrated a

weak positive correlation with NC (r = 0.228, p < 0.001). In contrast, WHtR and NC showed virtually no linear correlation (r = 0.005, p = 0.935).

Table 3
Pearson's correlations among MUAC, WHtR and NC (n = 400)

Variables (*n = 400*)	**Pearson's (*r*)**	***p*-value**
MUAC vs. WHtR	0.295	< 0.001
MUAC vs. NC	0.228	< 0.001
WHtR vs. NC	0.005	0.935

MUAC, mid-upper arm circumference; WHtR, waist-to-height ratio; NC, neck circumference.

3.4 Dietary practices of the participants

The dietary-practice characteristics of the participants are presented in Table 4. Most participants reported consuming the three main meals during the 24-hour period preceding the survey. Breakfast was consumed by 376 participants (94.0%), lunch by 353 (88.25%), and dinner or supper by 388 (97.0%). Snack consumption was less frequent, with 118 participants (29.50%) reporting consumption of a morning snack, 165 (41.25%) reporting an afternoon snack, and 94 (23.50%) reporting an evening or late snack.

Regarding meal-skipping practices, 126 participants (31.50%) reported skipping breakfast three or more times per week, while 274 (68.50%) did not. Similarly, 147 participants (36.75%) reported skipping lunch three or more times per week, whereas 253 (63.25%) did not. Dinner or supper was skipped three or more times per week by 116 participants (29.00%), while 284 (71.00%) reported that they did not regularly skip dinner or supper.

Most participants (381, 95.25%) reported eating dinner or supper with their family at least four times per week, whereas 19 (4.75%) did not.

Table 4
Dietary practices of the study participants

Dietary practice	Frequency	Percentage (%)
Meals consumed during the preceding 24 hours		
Breakfast	376	94.00
Lunch	353	88.25
Dinner/supper	388	97.00
Morning snack	118	29.50
Afternoon snack	165	41.25
Evening/late snack	94	23.50
Skipped breakfast ≥ 3 times/week		
Yes	126	31.50
No	274	68.50
Skipped lunch ≥ 3 times/week		
Yes	147	36.75
No	253	63.25
Skipped dinner/supper ≥ 3 times/week		
Yes	116	29.00
No	284	71.00
Family dinner/supper ≥ 4 times/week		
Yes	381	95.25
No	19	4.75

DISCUSSION

The present study examined the relationships among mid-upper arm circumference (MUAC), waist-to-height ratio (WHtR), and neck circumference (NC), while also describing selected dietary practices among adolescents aged 11–18 years in Nnewi, southeastern Nigeria. The findings showed weak but statistically significant positive correlations of MUAC with both WHtR and NC, whereas WHtR and NC were not significantly correlated. The dietary findings further showed that consumption of the principal daily meals was common, although meal skipping remained frequent, while shared family meals were also widely reported.

Characteristics of the Study Population

The participants had a mean age of 16.23 ± 2.42 years, with adolescents aged 17–18 years constituting the largest age group. Males accounted for 60.25% of the sample and females for 39.75%. These characteristics are relevant because adolescence is a period of rapid growth and changes in body composition, with anthropometric dimensions influenced by age, sex and pubertal development. Previous studies among Nigerian adolescents have similarly demonstrated age- and sex-related differences in anthropometric characteristics. Oyewale et al. [34] reported progressive increases in anthropometric measurements with advancing age among school children in Zaria, while Omigbodun et al. [35] observed differences in height and BMI according to sex, pubertal development and place of residence. Mbagwu et al. [36] also reported differences in stature and other anthropometric dimensions among Nigerian school children according to school type. These findings underscore the importance of considering the developmental characteristics of the study population when interpreting anthropometric measurements in adolescents.

MUAC, WHtR and NC as Complementary Anthropometric Measures

The mean MUAC, WHtR and NC were 26.52 ± 2.81 cm, 0.44 ± 0.06 and 31.93 ± 2.68 cm, respectively. These measures represent different anthropometric dimensions and may therefore provide complementary information about body size. MUAC reflects the size of the upper arm, including muscle and subcutaneous tissue, and has been investigated as a simple anthropometric measure for identifying excess weight in children and adolescents [37, 38]. WHtR represents waist circumference relative to height and provides an indicator of relative central body size that can be obtained without calculating BMI [13]. NC provides a measure of upper-body size and has also been investigated as an anthropometric indicator in paediatric and adolescent populations [39, 40]. Its relative simplicity and ease of measurement have contributed to increasing interest in its use in population-based anthropometric assessment [41, 42].

The use of these three measures together is potentially informative because they represent different anatomical regions rather than measuring exactly the same dimension. However, the present study did not include body composition assessment or BMI-for-age classification and therefore cannot determine which measure provides the most accurate estimate of adiposity or nutritional status. The observed values should consequently be interpreted as descriptive anthropometric characteristics of the study population rather than as evidence of normal or abnormal nutritional status.

Correlation among MUAC, WHtR, and NC

MUAC showed a weak but statistically significant positive correlation with WHtR ($r = 0.295$, $p < 0.001$), indicating that adolescents with larger MUAC values tended to have higher WHtR values. MUAC also demonstrated a weak positive correlation with NC ($r = 0.228$, $p < 0.001$). Although both relationships were statistically significant, their relatively small correlation coefficients indicate that the measures shared only limited linear variation.

The positive association between MUAC and WHtR may partly reflect their common relationship with overall body size. Similarly, the association between MUAC and NC may reflect the tendency for different body dimensions to increase concurrently during adolescent growth. Previous studies have reported associations between NC and other anthropometric measures among children and adolescents, including BMI and waist circumference [39, 40]. In Nigerian adults, Ugwueze et al. [24] also reported significant correlations between NC and BMI, waist circumference, hip circumference and waist-to-hip ratio. In a young-adult population, R K et al. [43] reported that MUAC and NC were useful in identifying overweight and abdominal obesity. Although these populations differ from the present adolescent sample, their findings provide supporting evidence that MUAC and NC may vary with broader measures of body size.

In contrast, WHtR and NC showed essentially no linear correlation in the present study ($r = 0.005$, $p = 0.935$). Thus, variation in WHtR was not accompanied by corresponding variation in NC among these adolescents. This finding differs from studies reporting significant associations between NC and measures such as BMI and waist circumference [39, 40], but such differences may arise from variations in age, sex distribution, body composition, population characteristics and the specific anthropometric measures examined.

Taken together, the correlation pattern suggests that MUAC had some shared variation with both WHtR and NC, whereas WHtR and NC behaved independently in this population. This finding is relevant to the interpretation of these measures because it suggests that they should not automatically be regarded as interchangeable anthropometric indicators. Their respective usefulness for identifying excess adiposity or nutritional risk in Nigerian adolescents would require further evaluation against appropriate reference measures, such as BMI-for-age, body-fat estimates or other validated indicators.

Dietary practices among the adolescents

Beyond the anthropometric relationships, the study also examined selected dietary practices to provide additional context for the nutritional characteristics of the adolescent population. Consumption of the three principal meals during the preceding 24 hours was common, with breakfast reported by 94.0% of participants, lunch by 88.25% and dinner or supper by 97.0%. However, meal skipping remained notable: approximately one-third reported skipping breakfast at least three times per week, while 36.75% skipped lunch and 29.0% skipped dinner at least three times per week.

The frequency of meal skipping is consistent with evidence that irregular meal patterns are common among adolescents, although prevalence varies between populations and meals. In Lagos, Nigeria, 57.4% of secondary-school adolescents reported consuming breakfast daily, with breakfast skipping more common among older adolescents and girls [44]. Similarly, 33.46% of Spanish adolescents reported skipping breakfast on at least one day [45]. A systematic review of Nigerian adolescent studies also identified meal skipping as a recurring feature of dietary patterns [46]. These findings suggest that regular consumption of principal meals and intermittent meal skipping can coexist, as observed in the present study.

The reasons for meal skipping were not assessed in this study. However, previous research has linked meal skipping to particular snacking contexts and behavioural routines. Savige et al. [47] found that adolescents who frequently snacked on the run, on the way to or from school, throughout the day or at night were more likely to skip meals. A systematic review also identified lack of time as an important correlate of meal skipping, with breakfast being the most frequently skipped meal [48]. These findings provide possible contextual explanations, although they cannot be assumed to apply directly to the present population. Furthermore, meal frequency alone does not establish dietary adequacy because the present study did not assess total energy intake, nutrient composition or dietary diversity. This is important in the Nigerian context, where inadequate micronutrient intake and suboptimal dietary patterns have been reported among adolescents [46, 49].

Family meals were also common, with 95.25% of participants reporting that they ate dinner or supper with their family at least four times per week. This suggests that shared eating occasions remain a common feature of the participants' dietary environment.

Overall, the dietary findings indicate that although consumption of the principal meals and family meals was common, meal skipping remained a notable behaviour. These findings highlight the importance of considering meal regularity alongside dietary quality when assessing adolescent nutritional practices, rather than using meal frequency alone as an indicator of dietary adequacy.

Study limitations

This study has several limitations that should be kept in mind. The cross-sectional design allows identification of associations but cannot establish causality or the sequence of events. Weight measurements were not available, so BMI-for-age and some standard nutritional indices could not be calculated. Dietary data captured selected meal patterns only and did not quantify total energy, macro- or micronutrient intake, dietary diversity, or overall diet quality. Biochemical tests and direct body-composition measures were not performed, so we could not compare MUAC, WHtR, and NC with objective adiposity measures. We did not include pubertal stage, socioeconomic status, or physical activity in the analysis; these factors may partly explain variation in anthropometry and dietary behaviour. The sample had unequal sex representation, which may affect comparisons because growth differs by sex. Finally, the study was conducted in a single population in Nnewi, south-eastern Nigeria, and age- and sex-specific reference standards were not applied; therefore the results describe relationships within this sample and may not be directly generalisable to other populations.

Conclusion

The present study demonstrates that although MUAC, WHtR and NC share some variation in body size, they should not be assumed to provide interchangeable anthropometric information. The dietary findings further showed that consumption of the principal daily meals and family meals was common, but meal skipping remained frequent. Collectively, the findings highlight the value of considering multiple anthropometric measures and broader dietary practices when characterising adolescent nutritional

profiles. Further studies incorporating BMI-for-age, body-composition measures, pubertal stage and detailed dietary assessment are warranted to determine the clinical and nutritional significance of these anthropometric relationships in Nigerian adolescents.

Abbreviations

BMI
Body mass index
NC
Neck circumference
MUAC
Mid—upper arm circumference
SPSS
Statistical Package for the Social Sciences
WC
Waist circumference
WHtR
Waist—to—height ratio

Declarations

Conflict of Interest

The authors declare that they have no conflicts of interest.

Ethics Approval

Ethical approval was obtained from the Nnamdi Azikiwe University Research Ethics Committee, Faculty of Basic Medical Sciences, College of Health Sciences, Nnamdi Azikiwe University, Nnewi Campus (*NAU/CHS/NC/FBMS/1081*).

Consent to Participate

Written informed consent was obtained from the participants or their parents before enrolment. Participants were also informed about the study procedures and their right to decline participation or withdraw from the study.

Consent for Publication

Written informed consent for publication of the photographs used in *Fig. 1* was obtained from the participants and/or their parents, as applicable. No full facial images or other direct personal identifiers

are shown.

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Author Contribution

UU conceived and designed the study, coordinated data collection, contributed to data interpretation, and drafted the manuscript. ERO contributed to study design, data collection, interpretation of findings, and critical revision of the manuscript. KI contributed to statistical analysis, interpretation of results, and manuscript preparation. CU contributed to critical review and revision of the manuscript. All authors reviewed and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

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Not Applicable

Data Availability

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

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Figures

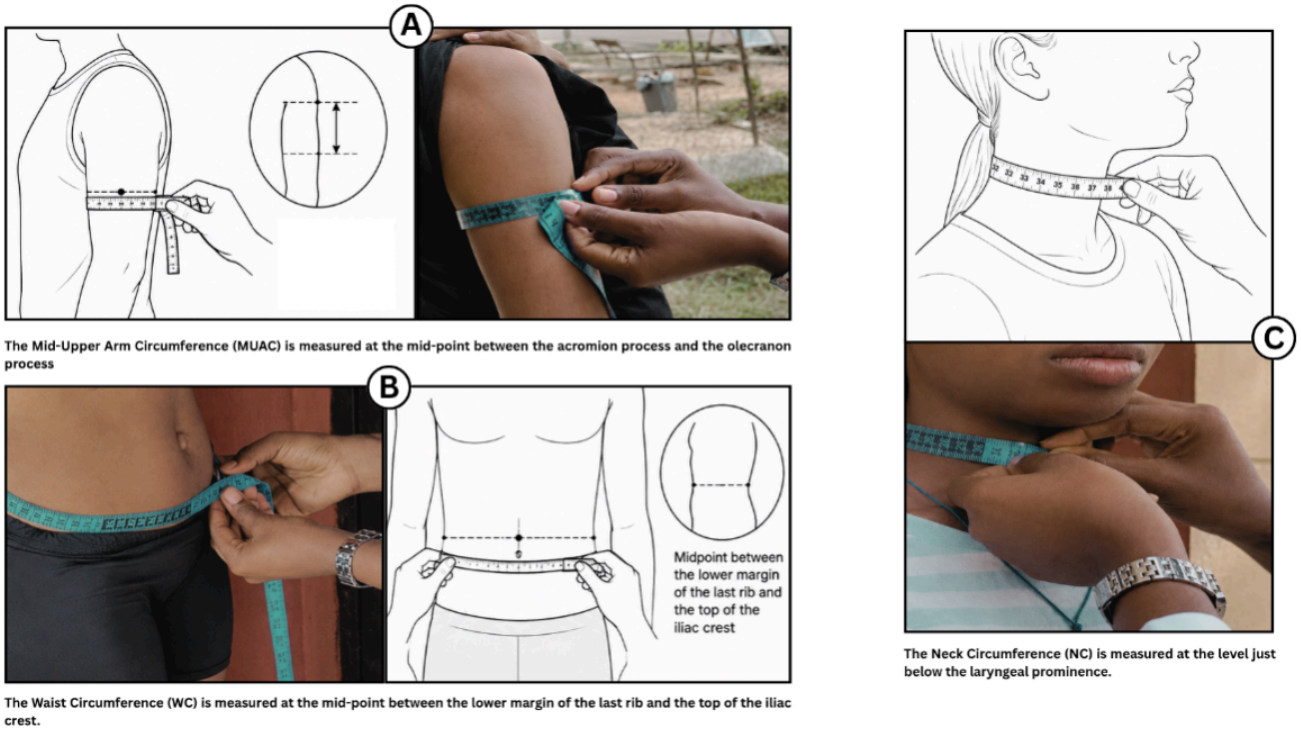


Figure 1

Schematic illustration of anthropometric measurement procedures. (A) Mid-upper arm circumference measured at the midpoint between the acromion process and the olecranon process with the arm relaxed alongside the body. (B) Waist circumference measured horizontally at the midpoint between the lower margin of the last rib and the upper border of the iliac crest. (C) Neck circumference measured horizontally at the level just below the laryngeal prominence.

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