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Comparative assessment of nutritional status and body composition of school children in Tororo district, Uganda

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Abstract

Childhood malnutrition remains a critical public health burden in Uganda, with significant rates of stunting, wasting and underweight in rural districts like Tororo. Accurate assessment of nutrition status and body composition is essential for effective intervention. This study aimed to evaluate the accuracy of bioelectrical impedance analysis (BIA) as a non-invasive method for assessing the body composition of children aged 6 (six) to 14 years against the deuterium dilution method (DDM) as a reference method in determining the nutritional status and body composition of school children aged 6 to 14 years in Tororo district Uganda.

This was a cross-sectional study conducted among 152 school children aged 6 (six) to 14 years from Rubongi Primary School, Tororo District, Bukedi sub-region selected through random sampling. BIA measurements of total body water (TBW), fat-free mass (FFM), fat

mass (FM), and fat mass percentage (%FM) were carried out using the TANITA MC-780MA-N body composition analyser, and the results were compared to those obtained using the deuterium dilution method. Statistical analyses, including paired t-tests, correlation coefficients, and Bland-Altman analysis were used to assess the agreement between the two methods.

The results indicated that 8.6%, 10.5% and 4.6% of the children were underweight, stunted and wasted, respectively; none of the children were overweight or obese. However, 2% of the children were severely stunted and wasted. BIA estimates of FFM and TBW were strong and positively correlated with the deuterium dilution method *(r* = 0.85, and r = 8.3) respectively (P<0.0001). However, a slight systematic bias was observed, with the BIA tending to overestimate %FM (20.01 $\pm$ 2.56) in girls than boys (18.90 $\pm$ 3.74). Despite these differences, the limits of agreement were within clinically acceptable ranges for most of the measurement variables. The Bland-Altman analysis showed no systematic bias between BIA and DDM values for FFM and TBW, with narrow limits of agreement between the two methods (TBW: bias of 0.8651 kg [95% CI -4.19-5.92], and FFM: bias of 1.497 kg [95% CI -6.040 to 9.035]. There was no significant difference between BIA and DDM in body composition measurement. Since BIA presents a more feasible method of body composition measurement, and this study has demonstrated its agreement with DDM, it can be used to assess body composition by researchers in the field and in clinics in resource constrained settings.

Key words

Nutrition status, Body composition, Deuterium dilution method, Bioelectrical impedance analysis, Total body water, Fat free mass, Fat mass

Introduction

Worldwide, more than 340 million children and adolescents aged 5-19 years suffer from malnutrition and with more than 149 million from Sub-Saharan Africa. In Uganda, about 3 in every 10 children suffer from undernutrition (Hiba et al., 2020). Childhood malnutrition is a public health concern, and accurate assessment of nutritional status and body composition is important for monitoring and management. Malnutrition can lead to various health problems,

including stunting, wasting, and underweight (Khalil et al., 2014). The prevalence of malnutrition in Uganda remains high with 26% of Ugandan children aged 6-59 months stunted (short for their age), 3% are wasted (thin for their height) and 10% are underweight (thin for their age) while 3.0% are overweight and 1.1 % obese (UBOS, 2023). In Bukedi subregion, the prevalence of stunting, underweight and wasting is 26.0%, 10.0 %, and 4.2%, respectively (UBOS, 2023).

To improve monitoring of body composition, bioelectrical impedance analysis (BIA) which is characterized by its repeatability can be used for body composition analysis. This method allows for a non-invasive, fast and comprehensive assessment of fat mass, fat-free mass, visceral fat rating and total body water (Popkin et al., 2010). Assessment of body composition using BIA allows for a wider range of body composition studies and increases the usefulness of the results obtained in educational and intervention practice (Moon et al., 2008). The deuterium dilution method (DDM) which is considered a reference method by the International Atomic Energy Agency (IAEA) and is widely used in research and clinical settings to measure body composition and nutritional status involves ingesting a known quantity of deuterium oxide (D_2O), and measuring the concentration of deuterium in a saliva sample after it has equilibrated with the body's water. A known amount of D_2O will dilute evenly throughout the total water pool, and by measuring the dilution, one can calculate the volume of that pool. This method provides valuable insights into body composition, hydration status, and body fat percentage, offering a non-invasive way to assess body composition parameters with high accuracy (Kyle et al., 2003).

Childhood malnutrition remains a critical public health issue in Uganda, with significant rates of stunting, wasting and underweight in rural districts like Tororo. Accurate assessment of nutritional and body composition status is essential for effective nutrition intervention. Anthropometric methods are widely used but do not effectively differentiate body composition components, while BIA provides a quicker alternative. However, their comparative reliability against the reference method DDM remains unclear. This study addresses the need to evaluate and compare these techniques to enhance the understanding of their applicability in nutritional assessment of children in low resource settings.

Materials and Methods

Study setting

A cross-sectional study was carried out on 152 primary school children (both boys and girls) aged between six (6) to 14 years , from October 2023 to December 2023 at Rubongi Primary School, Tororo District, Bukedi sub-region, Eastern Uganda located at 0.6871^0N, 34.0641^0E (Figure 1), where three (3) out of 10 homesteads were estimated to have children suffering from malnutrition (UBOS, 2022).

Figure 1: Map of Tororo district Uganda showing location of Rubongi (Image adapted from UBOS 2016).

Sampling

A simple random sampling technique was used to select a representative sample of 152 primary school children aged six (6) to 14 years. A complete list of all eligible children was obtained from Rubongi Primary School enrollment records, which served as the sampling frame. Each child was assigned a unique identification number. Using a computer-generated random number method, 152 children were randomly selected from the list without replacement. This approach ensured that every child in the population had an equal and independent chance of being included in the study

Anthropometric measurement

Nutritional status was assessed by measuring their weight and height. All measurements were performed according to the standard procedures provided by the International Atomic Energy Agency (IAEA Human Health Series, 2010).

Weight was measured to the nearest 0.1 kg using an electronic scale (Seca 869, Hamburg, Germany). The balance was placed on a level surface. This was checked using a spirit level, and the participants wore minimal clothing and no shoes. Each participant stood on the weighing scale pad while facing forward with both arms attached to the body. The measurement was repeated three times and the mean calculated.

Height was measured to the nearest 0.1 cm using a stadiometer (Seca 216) placed on a level surface, height was measured without shoes. Participants stood upright with their heels on the wall or touching the vertical post on the stadiometer and their knees straight. Each participant was asked to look straight ahead and ensure that their eyes were at the same level as their ears. The beam was lowered until it just touched the top of the head and the height was recorded in centimetres on the participant's information sheet. The measurement was repeated three times and the mean calculated.

Bioelectrical Impedance Analysis (BIA)

This was performed using the Bioelectrical Impedance analyzer (TANITA MC-780MA-N), which provides a measure of total body water, fat mass, percent fat mass and fat-free mass using the inbuilt manufacturers' equations. Impedance was measured with each participant standing barefoot on the metal foot-plates of the TANITA machine while holding the TANITA rods in their palms for approximately one minute. The participants' age, gender, and height were entered into the machine, and a standard 0.5 kg was entered as an adjustment for clothing weight for all participants. BIA measurements were performed and a digital display with results was read from the monitor.

Deuterium Dilution Method (DDM)

Baseline saliva samples were collected from participants at least 2 hours after their last meal. The participants were given a dry cotton wool ball which they were asked to move around their mouth for 2 minutes or until it was completely soaked with saliva. The plunger from a new 20 mL plastic syringe was removed and the participants were asked to move the cotton

wool to the front of their mouth, and the cotton wool soaked with saliva was transferred into the syringe barrel. The plunger was replaced into the syringe barrel and used to squeeze the saliva out of the syringe into the appropriately labelled sample tube; 2.0 mL of saliva sample was collected. If an insufficient sample was obtained the first time, the participant was given a second cotton wool ball and the process repeated as above. Precaution was taken never to fill the sample tube fully, 10% of the tube volume was left for sample expansion on freezing. The syringes, cotton wool, and gloves were discarded in the biohazard waste bin.

After collecting the baseline (pre-dose) saliva, a weighed dose of 10% D_2O solution 0.5 g/kg body weight was given to each participant and drunk with a straw. The bottle containing the dose was rinsed twice with 50 mL of drinking water and drunk using the same straw. Participants did not eat food or drink, and did not perform any physical activity for 3 hours that would compromise body composition results. After 3 hours from dose consumption two post-dose saliva samples were collected. Each labelled plastic cryo-vial was tightly capped, placed in labelled separate zip-locked bags, transported inside a cool box and stored in a freezer at $^{-}20$ °C.

The analysis of deuterium enrichment in the saliva samples was performed using the Fourier transform infrared spectrophotometer (FTIR, Agilent 4500 series, Malaysia) in the Department of Biochemistry and Systems Biology, Makerere University, Kampala, Uganda. Background scans were performed using unenriched drinking water. Total body water (TBW), fat-free mass (FFM), fat mass (FM) and percentage fat mass (%FM) were calculated from the saliva sample by plateau method, based on the assumption that the equilibrium between D_2O and body water was attained at 3 hours from dose administration. The deuterium dilution space, the TBW (kg), FFM (kg), the FM (kg) and FM% were calculated. The study used hydration factors for children and adolescents (Lohman & Going, 2006).

Statistical data analysis

Analysis was performed using GraphPad Prism 9.3 and WHO Anthroplus 1.0.4 software. Data were summarized into means and standard deviation. The level of significance was set at $p=0.05$ for all analyses. The difference between measurements obtained by DDM and BIA methods was tested by the paired t-test. Pearson's correlation coefficient was used to study the relationship between the variables measured by BIA and DDM. Bland–Altman analysis was

done to check for bias and limits of agreement between the values of TBW, FFM, FM and % FM measured by BIA and DDM.

Ethical consideration

Ethical approval was obtained from Makerere University School of Public Health Research Ethics Committee (No. SPH-2022-320) and the study research permit was obtained from the Uganda National Council for Science and Technology (No. HS2721ES). The purpose of the study was explained clearly to the parents/guardians of the children, later informed consent and assent were obtained from both the parents/ guardians and children, and they were told that it was voluntary for them to either participate or withdraw from the study.

RESULTS

General characteristics of the study participants

A total of 152 children, 72 boys and 80 girls, aged 6 to 14 years, participated in this study. The means of age, weight, height and BMI were, respectively, 9.9 ± 2.3 years, 28.9 ± 8.1 kg, 135.6 ± 14.6 cm and 15.39 ± 1.319 kg/m^2, the mean height, weight, waist circumference, hip circumference and BMI are higher in boys than seen in girls. As well the mean TBW, FFM, FM and %FM are higher for boys for all the measurement methods compared to the measurement parameters in girls (Table 1).

Table 1: Mean body composition obtained by anthropometrics, BIA, and DDM methods

	Mean±SD		
Variable	**Total subjects (n=152)**	**Males (n=72)**	**Females (n=80)**
Weight(kg)	28.93 ± 8.06	29.51 ± 7.525	28.41 ± 8.531
Height(cm)	135.6 ± 14.61	136.0 ± 14.19	135.2 ± 15.06
BMI (kg/m^2)	15.39 ± 1.39	15.86 ±1.227	15.30 ± 1.569
WC (cm)	59.33 ± 5.28	60.12 ± 5.063	58.62 ± 5.413
HC (cm)	68.55 ± 7.55	69.27 ± 7.271	67.90 ± 7.781
BIA			

TBW (kg)	18.43 ± 4.46	18.23 ± 4.758	16.76 ± 4.872
FFM (kg)	23.46 ± 6.57	23.96 ± 6.462	21.93 ± 6.575
FM (kg)	5.37 ± 1.88	4.894 ± 1.375	5.803 ± 2.159
%FM	18.34 ± 3.04	16.48 ± 2.712	20.01 ± 2.258
DDM			
TBW (kg)	19.29 ± 4.45	21.10 ± 4.323	18.08 ± 5.480
FFM (kg)	24.95 ± 7.27	26.44 ± 7.44	24.06 ± 7.282
FM (kg)	5.41 ± 2.24	5.603 ± 3.276	5.061 ± 3.399
%FM	17.51 ± 4.47	18.138 ± 8.228	17.42 ± 36.64

DDM, deuterium dilution method; BIA, bioelectrical impedance analysis; FFM, fat-free mass; FM, fat mass; %FM, fat mass percentage; TBW, total body water; WC, waist circumference; HC, hip circumference; n, sample number; and SD, standard deviation.

Nutritional status of children aged 6 to 14 years in Tororo district

The Z score classification showed that 5.6 % of boys were underweight compared to 3.7% of girls, while 15.5% of boys and 6.2% of girls were stunted. According to WAZ and HAZ, 2.8% of boys were also underweight compared to 1.2% of girls The BMI for age Z score indicated that 9.9% of girls were underweight more than 7%of the boys. None of the children were obese, Table 2.

Table 2: Percentage of children 6-14 years classified as malnourished based on weight-for-age (underweight), height-for-age (stunting) and BMI-for-age

Weight-for-age					
	N	-2 Z-score		-3 Z-score	Mean (SD) Z score
		n (%)	95% CI	n (%)	
Total	152	7 (4.6)	(0.9%, 8.3%)	3 (2)	-0.28 (0.74)
Boys	71	4 (5.6)	(0%, 11.7%)	2 (2.8)	-0.2 (0.82)

Girls	81	3 (3.7)	(0%, 8.4%)	1 (1.2)	-0.35 (0.65)
Height-for-age					
Total	152	16 (10.5)	(5.3%, 15.7%)	3 (2)	-0.55 (1.23)
Boys	71	11 (15.5)	(6.4%, 24.6%)	2 (2.8)	-0.61 (1.33)
Girls	81	5 (6.2)	(0.3%, 12%)	1 (1.2)	-0.5 (1.14)
BMI-for-age					
Total	152	13 (8.6)	(3.8%, 13.3%)	0	-0.88 (0.76)
Boys	71	5 (7)	(0.4%, 13.7%)	0	-0.76 (0.77)
Girls	81	8 (9.9)	(2.8%, 17%)	0	-0.99 (0.74)

SD; standard deviation, CI; confidence intervals

Comparison between body composition estimates measured by DDM and BIA

BIA measurements showed TBW had a mean difference of 0.45 (95% CI 1.97 to 1.45) and FFM with a mean difference of 1.50 (95% CI 1.11 to 1.88) respectively. Boys showed lower values of TBW measured by BIA 19.58kg ± 4.14 compared to TBW by DDM at 21.10kg ± 4.32 p=0.0731, FFM measured by BIA was 24.81kg ± 6.30 lower compared to FFM by DDM 26.44kg ± 7.44 p=0.0943. Similarly, girls showed no significant difference in the measurements of TBW and FFM while using BIA and DDM. There was a significant difference in %FM 18.3% ± 3.04 measured using BIA than DDM %FM 17.5% ± 4.46 p=0.0039, girls also demonstrated a similar trend with %FM measured by BIA at 20.01% ± 2.56 than the measurements given by DDM 18.90% + 3.74 p=0.0010, Table 3.

Table 3: Comparison between DDM and BIA in measuring body composition

Body Composition	**BIA, mean± SD**	**DDM, mean± SD**	**Mean difference (95% CI)**	**p-value**

Overall (n=152)				
TBW (kg)	18.4 ± 4.46	19.2 ± 4.45	0.45 (1.97 to 1.45)	0.0861
FFM (kg)	23.5 ± 6.57	24.9 ± 7.27	1.50 (1.11 to 1.88)	0.0641
FM (kg)	5.4 ± 1.88	5.4 ± 2.24	0.04 (0.23 to 0.31)	0.7586
%FM	18.3 ± 3.04	17.5 ± 4.46	0.83 (0.27 to 1.39)	0.0039
Boys (n=71)				
TBW (kg)	19.58 ± 4.14	21.10 ± 4.32	-1.52 (-2.05 to -0.98)	0.0731
FFM (kg)	24.81 ± 6.30	26.44 ± 7.44	-1.63 (-2.50 to -0.78)	0.0943
FM (kg)	4.84 ± 1.40	4.84 ± 1.67	0.06 (-0.31 to 0.43)	0.7587
%FM	16.48 ± 2.71	15.96 ± 4.71	0.52 (-0.43 to 1.48)	0.2791
Girls (n=81)				
TBW (kg)	17.39 ± 4.50	17.67 ± 3.93	-0.28 (-0.88 to 0.33)	0.3637
FFM (kg)	22.24 ± 6.62	23.61 ± 6.88	-1.37 (-2.30 to -0.50)	0.0632
FM (kg)	5.80 ± 2.16	5.93 ± 2.55	-0.13 (-0.53 to 0.27)	0.5144
%FM	20.01 ± 2.56	18.90 ± 3.74	1.11 (0.46 to 1.75)	0.0010

DDM, deuterium dilution method; BIA, Bioelectrical impedance analysis; FFM, fat-free mass; FM, fat mass; %FM, fat mass percentage; TBW, total body water; CI, confidence intervals; and n, sample number.

Correlation between TBW, FFM, FM and %FM measured by DDM and BIA

Total body water (TBW), FFM, FM, and %FM demonstrated a strong and positive correlation between the two body composition measurement methods BIA and DDM with correlation coefficients (r) of; 0.83, 0.85, 0.70, and 0.62, respectively. The correlation between the two measurement methods were statistically significant, $p<0.0001$ (Figure 2).

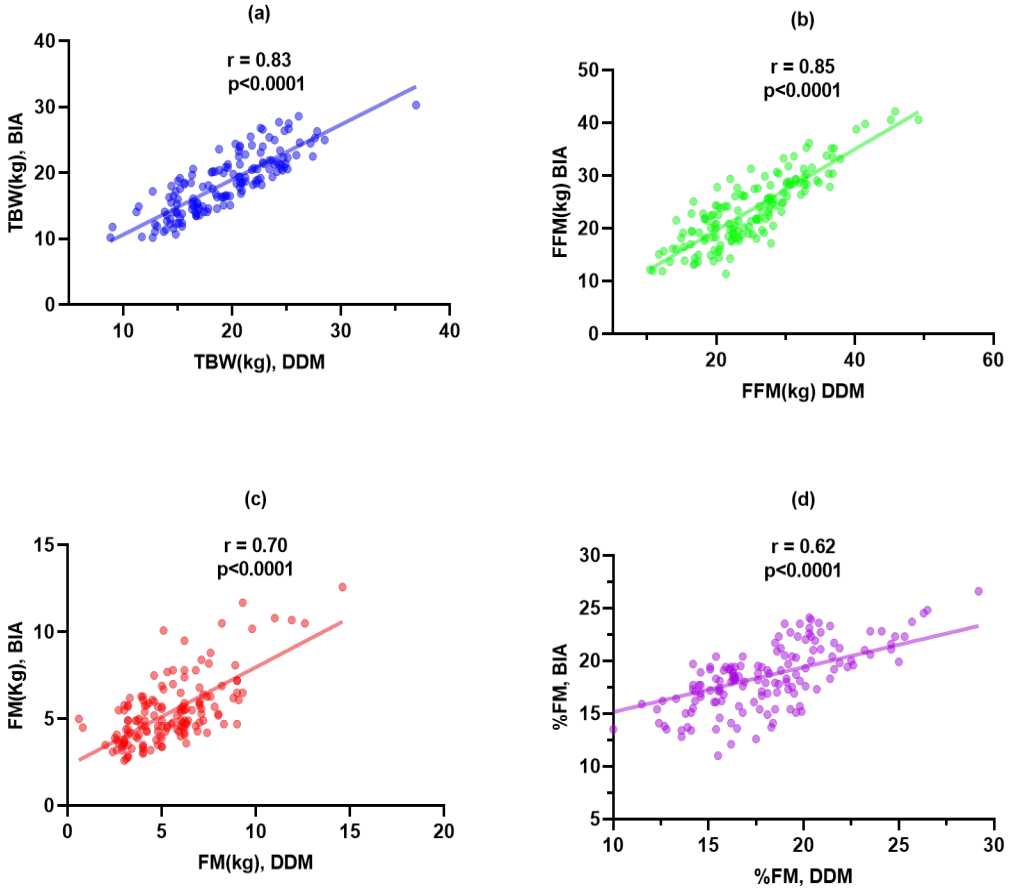

Figure 2: Correlations of (a) Total body water (TBW), (b) Fat-free mass (FFM), (c) Fat mass (FM) and (d) percent fat mass (%FM) measured by DDM and BIA.

Bland-Altman analysis of TBW, FFM, FM and %FM measured by DDM and BIA

The Bland-Altman analysis examined the bias and agreement between BIA and DDM for TBW, FFM, FM, and %FM. The mean bias of the TBW, FFM, FM and %FM were 0.86 kg 95% CI (-4.19 to 5.92), 1.49 kg 95% CI (-6.040 to 9.035), and -0.83 kg 95% CI (-7.68 to 6.02) respectively. The Bland-Altman plots showed a random spread of values with no detectable proportional bias for measured and predicted TBW, FFM, FM and %FM values among the study subjects. It revealed narrow limits of agreement between measured and predicted values of TBW, FFM, FM, and %FM, (Figure 3).

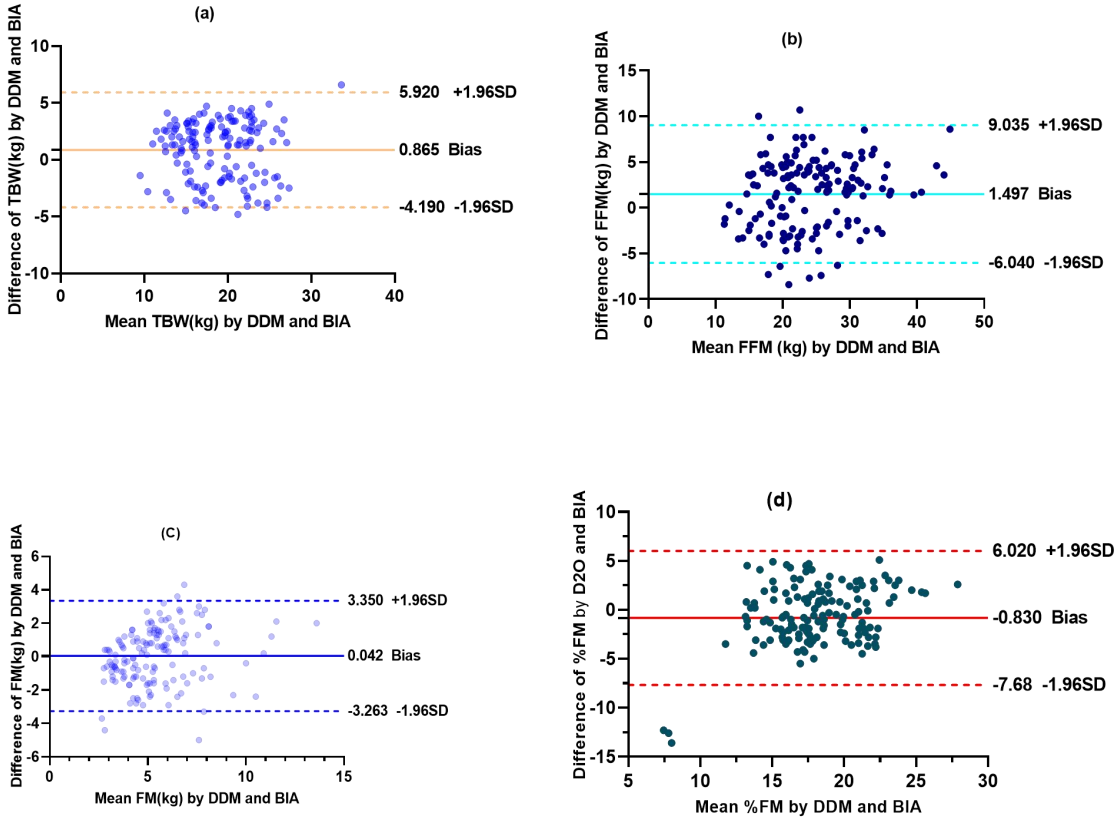

Figure 3: The Bland-Altman plots of (a) Total body water (TBW), (b) Fat-free mass (FFM), (c) Fat mass (FM) and (d) percent fat mass (%FM) measured by DDM and BIA.

Discussion

This study was carried out in Rubongi Primary School Tororo district, Bukedi sub-region. The study aimed at assessing the nutritional status of the children and evaluate the agreement and relationship between BIA and DDM. Nutritional assessment of the children using anthropometry revealed the rate of undernutrition at 8.6%, 10.5% and 4.6% for underweight, stunting and wasting respectively. None of the children were obese. However, 2.8% of the boys were severely stunted and wasted compared to 1.2% of the girls. These findings are below the malnutrition rates from a study done in the Eastern Ugandan district of Mayuge among children and adolescents where 7% of apparently healthy children and adolescents were underweight and 25% were stunted (Namaganda et al., 2023) although the study participants included children 2-5 years, and the data was not disaggregated by age. Poor feeding routines and poverty were among the contributing factors cited as the major causes of

malnutrition. These figures also indicate that the study's findings are relatively consistent with national averages, particularly underweight and wasting. However, the stunting rate in the study is slightly lower than the national average, suggesting either a differences in the study population's characteristics (UBOS, 2023).

The mean BMI in all subjects was 15.39 ± 1.39 kg/m^2, and the mean BMI for boys and girls was 15.86 ± 1.23 kg/m2 and 15.30 ± 1.57 kg/m^2, respectively. This agrees with the findings from Eleni et al (2024) who found that BMI was higher among boys than girls. Widhalm et al (2001) found that BMI explains 73% and 63% of the variance of body fat in boys and girls younger than 10 years, respectively, with a lower predictive value in older children. The correlation between %FM and BMI was stronger in girls than boys, which corresponds to results reported by Schaefer et al (1998).

BIA estimates of TBW, FFM, FM and %FM correlated significantly with the reference method. However, the %FM, showed a weak correlation as observed in both boys and girls. These findings suggest that TBW, FFM, FM as quantified by BIA align closely with the reference method, supporting the reliability and accuracy of BIA. However, %FM was not as strongly correlated, demonstrating the weakness of the technique when separating the body composition. Previous studies (Lohman et al., 2013; Sant'Anna et al., 2009) described BIA validity for body composition investigation through correlation coefficients ranging from 0.59 to 0.88 without presenting the values for each of the components (TBW, FFM, FM, and %FM).

Considering BIA as an instrument capable of measuring changes in body composition, Schoeller et al (2018) studied the body composition using DDM, BIA and skin folds of children who had lost body weight, and detected a significantly high correlation between the data obtained by DDM and BIA (r = 0.971). In a study conducted on Indian children to validate BIA in comparison to DDM, they observed a good correlation between BIA and DDM for the estimate of body fat, although BIA overestimated body fat (Wickramasinghe et al., 2010). In this study, there is a good correlation between the variables in question, and BIA overestimated %FM (18.3) compared to DDM (17.5). However, the reliance on BIA and the DDM within a single population presents important limitations in terms of the generalizability and applicability of findings to broader settings. While both methods are widely used for assessing body composition and total body water, their accuracy is influenced by population-specific factors, and findings derived from one group may not translate directly to others.

The %FM measured by BIA was significantly higher than the values measured by the DDM. Girls also showed a significantly higher mean FM value using BIA method 20.01 ± 2.56 kg than boys 16.48 ± 2.71 kg, p=0.001. These finding suggests that BIA can serve as a reliable and practical alternative to DDM for estimating body composition, mostly in resource-limited or field-based settings as also observed in a study done in Uganda by (Ndagire et al., 2018). BIA offers several practical advantages over DDM, including lower cost, portability, and ease of use (Kyle et al., 2004). These benefits make BIA suitable for large-scale field studies or clinical assessments where rapid and non-invasive methods are preferred. The findings are consistent with prior literature reporting strong correlations between BIA and reference methods like isotope dilution (Andersen et al., 2013).

The Bland-Altman plot showed good agreement with no systematic bias between the BIA and the DDM. This indicates that BIA can produce estimates that are statistically comparable to those derived from DDM. These results align with earlier studies reporting that BIA can provide reliable body composition estimates. The plot revealed no systematic bias, suggesting that BIA neither consistently overestimates nor underestimates values relative to DDM.

The spread of data within the 95% limits of agreement further supports the potential clinical and research utility of BIA. A study undertaken in London on infants and children aged 1-9 years (da Costa et al., 2022) observed the same level of agreement between the two techniques while measuring %FM, while one done in Malawi showed this level of agreement between the two techniques but for different age groups (Divala et al., 2022). The limits of agreement between values from the two methods in this study were narrow comparable to a study done in Ugandan children and adolescents by Ndagire et al (2018), where DDM and BIA exhibited generally narrower limits of agreement for FFM, FM or % BF among children and young adolescents than among older adolescents with mean differences for FFM (− 2.84 kg), FM (2.84 kg), and %BF (5.01)

Recommendations

The findings of this study show that there is malnutrition in children 6-14 years, yet surveys such as the Uganda Demographic Health Survey whose findings guide programming and planning focus on children under 5 years of age, overlooking or neglecting the 6-14 age group. Therefore, it is recommended that surveys include this age group.

While BIA and DDM are valuable body composition measurement methods, the exclusive use of these methods in a single population constrains the broader relevance of the findings. Future research should aim to validate and recalibrate these methods across varied populations, ensuring that body composition assessments remain accurate and meaningful in different demographic, and geographic settings

Population-specific adjustments to BIA should be made to account for variations in body composition across different demographics, including age, sex, and health conditions, to improve measurement precision.

Further research is needed to explore the long-term effectiveness and potential limitations of BIA in diverse settings, including its integration with other assessment methods for comprehensive evaluation of body composition.

Limitations of the study

DDM was used as the reference method which, although widely validated as a reliable estimate, is not a gold standard for body composition. Ideally, a four-component model would have been used as the reference method, but this was not possible in our study setting. While DDM has the advantage that it is relatively easy to perform, it is not without limitations: one assumption is the hydration of FFM, which may vary among persons by age, sex, maturation and ethnicity and to estimate FFM from TBW, age, and sex-specific hydration fractions were used. But the hydration of FFM values used for computation of TBW to estimate FFM, FM, and %BF were not Uganda specific. Higher hydration factors have been observed among African American adults compared to whites using a four-component model (Ndagire et al., 2018). However, there is no information on the hydration factors of FFM for Ugandan populations

Conclusions

Malnutrition is common among school-going children 6-14 years of age in Tororo District, Bukedi sub-region, with 8.6% underweight, 10.5% stunted, and 4.6% wasted, as this study has shown. Measurement of TBW, FFM, FM using BIA and DDM were found to be strongly positively correlated suggesting that BIA could make a suitable field-friendly alternative to DDM as demonstrated strong correlations for TBW, and FFM ($r = 0.83$ to 0.85). Bland-

Altmann analysis revealed an acceptable agreement between the two methods, although BIA slightly overestimated %FM, likely influenced by hydration status of the children. Thus, BIA presents a viable alternative for body composition measurements in resource limited settings. These findings highlight the potential of BIA for field-based nutritional assessments and body composition monitoring in similar populations, offering valuable insights for public health interventions in the region.

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Author contributions

The fieldwork was performed by Jastine Onyilo. The laboratory work was done by Jastine Onyilo and Dan Isabirye. The conception of the study was by Catherine Ndagire and Dorothy Nakimbugwe. All the authors contributed to the writing and editing of the manuscript.

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Data availability statement

All the relevant data is included in this paper

Conflict of interest

The authors declare that there was no conflict of interest in the study.

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