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ISSN Online 2704-4890 | ISSN Print 2720-7609

Online first publication

Original Research Article

HSI Journal (2023) Volume 4 (Issue 1):428-434. https://doi.org/10.46829/hsijournal.2022.6.4.1.428-434

Open Access

Validity of STRONGkids and MUAC as nutritional screening tools for predicting acute malnutrition among hospitalized children in Accra, Ghana

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Received September 2022; Revised January 2023; Accepted January 2023

Abstract

Background: Malnutrition is commonly reported among hospitalized paediatric patients. However, it is often not diagnosed leading to prolonged hospital stays and other medical complications.

Objective: This study aimed at evaluating the validity of the Screening Tool for Risk of Nutritional Status and Growth (STRONGkids) and mid-upper arm circumference (MUAC) for assessing malnutrition in paediatric inpatients between the ages of 6 months and 5 years. The weight-for-height (WFH) z-score was used as a reference standard for the evaluation.

Methods: A cross-sectional study design was used in this study. A total of 96 individuals were enrolled in the study from both the Princess Marie Louise Children's Hospital and Korle Bu Teaching Hospital, located in Accra, Ghana. Data were collected on demographics, admission details, weight, height, MUAC, and length of hospital stay. The STRONGkids screening tool was used for nutrition risk screening. Data analysis was performed using R version 4.1.0. Descriptive statistics were used to report frequencies, averages, percentages, standard deviations, and interquartile ranges. Diagnostic values were computed for STRONGkids and MUAC using WFH z-scores. Cohen's kappa was utilized to measure inter-rater agreement, with statistical significance set at $p < 0.05$.

Results: Males accounted for 59.3% (n = 57/96) of the study sample. The prevalence of malnutrition in this study was 30% [n = 27/96; 95% confidence interval (CI): 21-39%]. The sensitivity and specificity of STRONGkids were 70% (95% CI: 52-86%) and 43% (95% CI: 31-55%), respectively. The sensitivity and specificity of MUAC were 45% (95% CI: 27-63%) and 93% (95% CI: 86-99%), respectively. The inter-rater agreement, based on two blinded assessments, for STRONGkids, was 0.57 ($p = 0.006$).

Conclusion: The study revealed that STRONGkids had a low overall degree of validity, while MUAC had a high validity for specificity but lower validity for other diagnostic values. As a result, it is not recommended to use STRONGkids or MUAC individually for screening pediatric malnutrition in this setting, but rather in conjunction.

Keywords: STRONGkids, MUAC, acute malnutrition, nutrition risk

Cite the publication as Anku EK, Adu-Amoah GH, Ainuson-Quampah J (2023) Validity of STRONGkids and MUAC as nutritional screening tools for predicting acute malnutrition among hospitalized children in Accra, Ghana. HSI Journal 4(1):428-434. https://doi.org/10.46829/hsijournal.2023.6.4.1.428-434

INTRODUCTION

Malnutrition is commonly reported in hospitalised children. The prevalence is between 6.1 to 50% worldwide [1]. Despite malnutrition being widespread, it largely remains underdiagnosed in hospitalised children [2,3] leading to prolonged hospital stays and other medical complications [4,5]. In Ghana, the routine assessment of children's height and weight is not conducted, which often results in a significant number of missed diagnoses [3,6]. The time-consuming nature of a comprehensive anthropometric assessment may explain why it is not routinely performed [7]. A study conducted in a Ghanaian hospital setting [3] revealed that only 15 out of 251 identified malnourished patients were accurately diagnosed by doctors. This finding emphasizes the significant number of children who were not diagnosed with malnutrition. Similar situations were also reported in studies from Belgium and Canada [8,9]. Nutrition screening offers an

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opportunity to identify children at risk of malnutrition sufficiently and provide prompt interventions. Several pediatric nutrition screening tools have been published in the literature [1,10]. However, there is no consensus on which is best for use in the pediatric population [7,10]. A review by Klanjsek et al. [1] concluded that the Pediatric Yorkhill Malnutrition Score is a more valid tool for nutrition screening in pediatric patients. A major limitation of this tool is that its risk score assessment utilises body mass index (BMI), which is a time-consuming process [11]. The use of BMI also provides limited information for children as there are no valid cut-offs. Various studies have established the practical utility and validity of the Screening Tool for Risk of Nutritional Status and Growth (STRONGkids) in comparison to other published pediatric nutrition screening tools [10,12-14].

The STRONGkids is deemed easy to complete in a short time [10,15,16]. The STRONGkids is a pediatric nutrition screening tool developed in a Dutch population of pediatric patients [17,18]. It was designed with 4 key questions based on subjective clinical assessment, presence of high-risk disease, nutritional intake and losses, and weight loss or poor weight gain [18]. The tool stratifies nutrition risk into low risk, medium risk, and high risk [18]. The sensitivity of the tool has been reported to range from 22 to 100%, while the specificity ranges between 0 and 97% [1,13,17]. Variability in reported sensitivity and specificity can largely be attributed to the use of different reference standards across studies, as well as the inclusion of varying age ranges. A previous study recommended that a specific reference standard be established to evaluate pediatric screening tools for comparability of results [1]. The STRONGkids correlates well with weight-for-height (WFH), BMI, and height-for-age z-scores [19].

Mid-upper arm circumference (MUAC) is a tool used to screen and identify malnutrition in infants and children aged between 6 months and 5 years [5]. The MUAC is relatively easy and less cumbersome to perform [20,21]. In settings where height and weight measurement may be a challenge, MUAC provides a quick evaluation of the nutritional status of children ≤ 5 years [1,21]. However, the correlation between MUAC and WFH z-scores is poor [20]. The MUAC is reported to miss children who are malnourished based on WFH z-scores [20]. A recent systematic review recommended the use of MUAC as a screening tool as opposed to a nutrition assessment tool to allow for the quick identification of malnutrition [17]. This study aimed to evaluate the validity of STRONGkids and MUAC with reference to WFH z-scores for paediatric inpatients aged between 6 months and 5 years.

MATERIALS AND METHODS

Study design

This study employed a cross-sectional design, with 96 patients selected through purposive sampling at Princess Marie Louise (PML) Children's Hospital and Korle Bu Teaching Hospital (KBTH), both located in Accra, Ghana.

Study sites

The study was conducted at the Child Health Department of the KBTH and the PML Children's Hospital in Accra, Ghana. The Child Health Department at Korle Bu Teaching Hospital serves as a tertiary reference centre for children up to 13 years old who have medical and surgical issues. The PML Children's Hospital is a Ghana Health Service healthcare facility that provides medical care, child health, and nutrition services for all children.

Sampling population and sampling procedure

Participants included in this study were patients aged 6 months to 5 years. Nutrition screening was applied to selected patients within 24 hours of admission. Admissions and discharge books were used to identify patients admitted within 24 hours. Patients for whom anthropometric measurements (weight, height, MUAC) could not be obtained were excluded from the study. Additionally, patients admitted to intensive care were excluded. Patients with an expected length of stay of ≤ 1 day were also excluded from the study.

Data collection

Data on age, sex, diagnosis on admission, and length of stay were collected using a structured questionnaire after informed consent was obtained from caregivers of patients. Anthropometric measurements were measured following a standardised protocol [22].

Weight. If the patient was aged ≤ 2 years, tared weighing was used to obtain the weight to the nearest 0.1 kg using the Omron BF508 weighing scale (Omron, Osaka, Japan) according to the manufacturer's instructions. Briefly, the mother of the patient removed her footwear and stepped on the scale to be weighed alone first. After the mother's weight appeared on the display, she remained standing on the scale. The scale was reset to zero. The patient was given to the mother to hold with minimal or no clothing, and the weight was recorded. Before this, the mother was informed about the necessity of removing outer clothing for accurate weight measurement. Patients who were ≥ 2 years old and capable of standing still were weighed individually.

Height and length. Recumbent length was measured for all patients aged ≤ 2 years to the nearest 0.1 cm using a Seca 210 infantometer measuring mat (SECA Corp, Hamburg, Germany). The standing height for all children aged ≥ 2 years who could stand upright was measured with a Seca 213 stadiometer (SECA Corp, Hamburg, Germany). If a patient aged ≥ 2 years was unable to stand upright, their recumbent length was measured, and 0.7 cm was deducted from the observed value to convert it to height [22].

MUAC. The MUAC was measured using a MUAC colour tape. The mother or caregiver was asked to remove any clothing that covered the left arm so that it could be measured. The midpoint of the left bent upper arm was identified and marked between the acromion and olecranon process. The patient's hand was straightened, and the MUAC tape was wrapped around the arm at the marked midpoint. When the tape was in the correct position, the

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measurement was read to the nearest 0.1 cm. A MUAC of < 11.5 cm is indicative of severe malnutrition. A MUAC between 11.5 cm and 12.5 cm is indicative of moderate malnutrition. A MUAC > 12.5 cm is indicative of normal nutritional status.

Nutrition risk screening. The STRONGkids screening tool was used to screen for the risk of malnutrition. The tool is divided into four questions that result in three categories (low risk, medium risk, and high risk) with a maximum score point of 5. A score of 0 indicated low risk, while a score of 1-3 indicated medium risk and a score of 4-5 denoted high risk. A yes/no response was used to assign scores. The underlying diseases for admission were obtained from the medical folder and used to score the presence of high-risk diseases. The first question assessed the subjective clinical assessment of patients and scored 1 point. The second question scored 2 points for high-risk diseases (Table 1). The third question scored 1 point for nutritional intake or losses evidenced by diarrhoea, vomiting, reduced food intake, and pre-existing nutrition intervention. The fourth question scored 1 point for weight loss or poor weight gain.

Table 1: High risk disease items from STRONGkids screening tool

Disease items
Anorexia Nervosa
Burns
Bronchopulmonary dysplasia (for patients ≤ 2 years old)
Celiac disease
Cystic fibrosis
Dysmaturity/Prematurity (corrected age 6 months)
Cardiac disease, chronic
Infectious disease (AIDS)
Inflammatory bowel disease
Cancer
Liver disease, chronic
Kidney disease, chronic
Pancreatitis
Short Bowel Syndrome
Muscle disease
Metabolic disease
Trauma
Handicap/retardation
Expected major surgery
Not specified (classified by doctor)

Table 2: Demographic characteristics

Characteristics	Frequency (n = 96)	Percentage
Age		
<24 months	53	55
≥ 24 months	43	45
Sex		
Male	57	59
Female	39	41
Disease categories		
Respiratory	19	20
Multiple diagnoses	19	20
Infectious	15	16
Haematological	13	14
Gastrointestinal	12	12
Neurologic	6	6
Tumor	3	3
Renal	1	1
Cardiac	1	1
Others	7	7

Inter-rater agreement. A separate cohort of 19 children was assessed independently by a clinical dietitian at PML Children's Hospital and an independent researcher after both had undergone training on the STRONGkids tool. The first assessor rated the children as either at risk or not at risk. The other assessor, blinded to the results of the other assessor, rated the patients within 24 hours of the first assessment.

Outcome measures

The outcome measures for the study were sensitivity, specificity, positive predictive value, and negative predictive value. Sensitivity (Sn) represents the likelihood that a patient with malnutrition defined by the WFH z-score will have an at-risk score. Sensitivity was calculated as true positive (TP) divided by the sum of TP and false negative (FN) [23]. The TP represents patients with an at-risk score who are malnourished whereas FN represents patients with a low-risk score but malnourished. Specificity (Sp) represents the likelihood that a patient with normal nutritional status defined by the WFH z-score will have a low-risk score on the screening test. Specificity was calculated as true negative (TN) divided by the sum of TN and false positive (FP) [23]. The TN represents patients with normal nutritional status and a low-risk score whereas FP represents patients with an at-risk score but are not malnourished. A positive predictive value (PPV) represents the proportion of patients with an at-risk score in the malnourished category calculated as TP divided by the sum of TP and FP [23]. A negative predictive value (NPV) represents the proportion of patients with a low-risk score in the normal nutritional status group. A negative predictive value was calculated as TN divided by (TN + FN) [23].

Statistical analysis

Data analyses were performed using R version 4.1.0. Descriptive statistics were used to report frequencies, averages, percentages, standard deviations, and interquartile ranges. Inferences for means, medians, and proportions for both sexes were reported. The Chi-square test or Fisher's exact test (where appropriate) was used to evaluate the independence of categorical variables. The WHO Anthro software (version 3.2.2) was used to calculate WFH z-scores. The WFH z-score < -2 standard deviations was used to define acute malnutrition. To compare the Sn, Sp, NPV, and PPV of both tools (STRONGkids and MUAC), the WFH z-scores were divided into normal and malnourished categories. For STRONGkids, the scores were divided into two categories: at-risk (medium and high-risk) and no risk (low-risk). The interpretation for MUAC was divided into normal and malnourished (moderate and severe malnutrition). The WFH z-score was used as a reference standard for this study. Cohen's kappa was used to describe the inter-rater agreement of STRONGkids**.** Statistical significance was set at $p < 0.05$.

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Table 3: Descriptive information

Variables	Number of males	Number of females	All	*p* value
Median age in months (IQR)	24 (13, 36)	25 (16, 48)	24 (14, 39)	0.64
Median weight in kg (IQR)	10.8 (8.7, 14.1)	10.3 (9.0, 15.0)	10.6 (8.9, 14.5)	0.91
Mean height in cm (± SD)	87.6 ± 12.7	88.9 ± 14.7	88.1 ± 13.4	0.65
Median length of stay in days (IQR)	3 (1, 6)	3 (1, 7)	3 (1, 6)	1.00
Mean MUAC in cm (± SD)	14.3 ± 1.6	14.1 ± 1.8	14.2 ± 1.7	0.66
STRONGkids (%)				0.05
Low risk	27 (47)	11 (28.2)	38 (40)	
Medium risk	28 (49)	22 (56.4)	50 (52)	
High risk	2 (4)	6 (15.4)	8 (8)	
MUAC categories (%)				0.66
Normal	48 (84)	30 (77)	78 (81)	
Moderate malnutrition	6 (11)	6 (15)	12 (13)	
Severe malnutrition	3 (5)	3 (8)	6 (6)	
Total	57	39	96	

IQR, Interquartile range; SD, standard deviation; MUAC, mid-upper arm circumference; STRONGkids, screening Tool for Risk of Nutritional Status and Growth; %, percentage

Table 4: Diagnostic values of STRONGkids and MUAC compared to WFH < -2 SD computed from WHO Growth charts

Tool	Reference standard	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	Inter-observer agreement Kappa (*p* value)
STRONGkids	WHO WFH < - 2 SD	70.0% (0.52-0.86)	43.3% (0.31-0.55)	34.5% (0.22-0.47)	76.3% (0.63-0.90)	0.57 (p = 0.006)
MUAC	WHO WFH < - 2 SD	44.8% (0.27-0.63)	92.5% (0.86-0.99)	72.2% (0.52-0.93)	79.5% (0.71-0.88)	

PPV, positive predictive value; NPV, negative predictive value; WFH, weight-for-height; SD, standard deviations; CI, confidence interval.

RESULTS

Patient characteristics

The study included 96 participants between the ages of 6 and 60 months, with a median age of 24 months. Most participants were male (59%), and the majority were admitted to the hospital with respiratory diseases (n=19) or multiple diagnoses (n=19) (Table 2). The average weight and height/length were 10.6 kg and 88.1 cm, respectively. The median length of stay was 3 days, which was not significantly different between males and females (p = 1.00). More females were classified as high-risk for malnutrition compared to males (6 versus 2). Based on MUAC values, there were an equal number of malnourished males and females.

Prevalence of malnutrition

The prevalence of malnutrition in this study was 30% (95% CI: 21-39%). The MUAC z-scores < -2 standard deviations identified 22% of individuals as malnourished compared to 19% using the raw MUAC values. There was no significant association between sex and acute malnutrition defined by MUAC and WFH z-scores as shown in Figure 1a and 1b respectively.

Validity of STRONGkids and MUAC

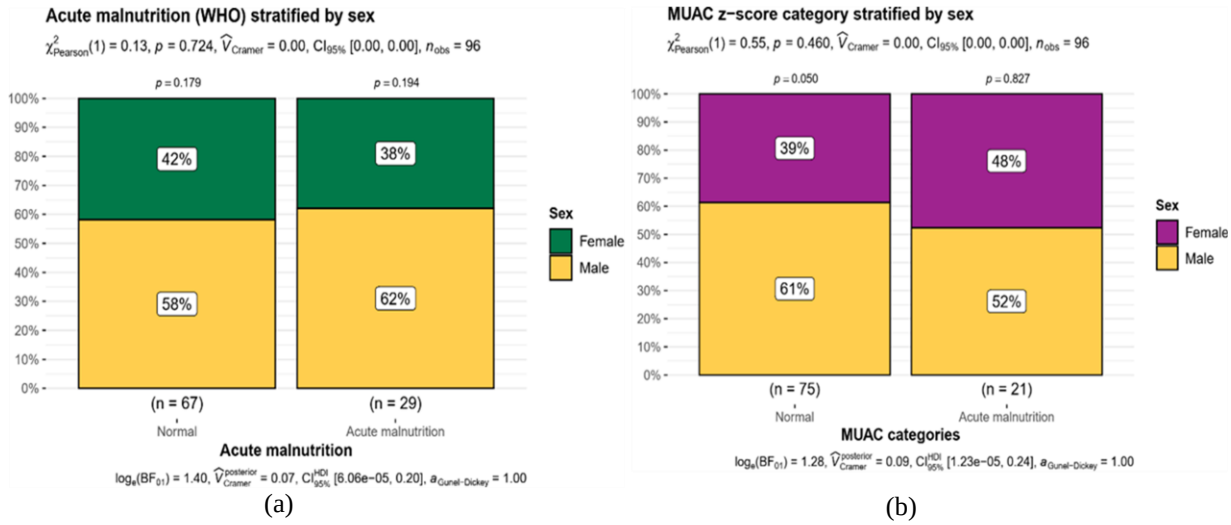
The sensitivity of STRONGkids was 70% based on WFH z-score values whereas MUAC's sensitivity was lower at 45%. The specificity of STRONGkids was 44% using the WFH z-score whereas MUAC's specificity was higher at 93%. The STRONGkids had an overall low degree of validity (Sn, Sp, NPV, and PPV) as shown in Table 4 using an established grading system [17]. The overall degree of validity of MUAC was low (Sn, PPV, and NPV). However, the MUAC demonstrated high validity for specificity.

Inter-observer agreement

Moderate inter-observer agreement (0.57) was found between two users of the STRONGkids tool as shown in Table 4 using the established grading system [24]. However, another established grading system indicated a weak level of agreement with the tool [17].

DISCUSSION

This study highlighted the concurrent validity of STRONGkids and MUAC in predicting acute malnutrition in children aged 6 months and 60 months. The degree of validity of STRONGkids was fair for Sn, poor for Sp, poor for PPV, and fair for NPV, based on proposed cut-off points [17]. The overall degree of validity was low. The degree of validity of MUAC was poor for Sn, excellent for Sp, and fair for PPV and NPV, based on proposed cut-off points [17]. The overall degree of validity of MUAC was low for Sn, PPV, and NPV; and high for Sp. As with previous studies, more males were present than females [15,25,26].



(a) (b)

Figure 1: (a) Descriptive information and association between malnutrition status defined by MUAC z-score < - 2SD and sex (b) Descriptive information and association between acute malnutrition defined using WFH z-score < -2SD and sex.

The median length of stay in this study was similar to previous studies with a median length of stay of 2 days [18], 3 days [9,27] and 4 days [2,28]. Respiratory and multiple diagnoses accounted for common disease categories for admission in our study in contrast with the findings of other studies that mainly found cancers as the major causes of admission [25,29].

In this study, cancer presented as one of the least causes of admission in participants recruited in this study. Respiratory diseases as a major reason for admission among children less than 5 years has been reported in a previous study in our setting [6]. The prevalence of malnutrition in this study was 30%. This was consistent with the findings from previous studies [20,29,30]. Males were relatively acutely malnourished compared to females based on WFH z-scores. However, this did not reach statistical significance. The MUAC z-score identified more children as malnourished compared to using raw MUAC values (21 versus 18). Previous studies typically used the WHO chart as a reference standard similar to our study [16,18,19,26,28,31–34]. The sensitivity of STRONGkids from these studies ranged between 37.5 to 84%. Specificity reported from these studies ranged between 41.5 to 94.4%. The validity of STRONGkids from this study was similar. Using an established grading system, the sensitivity of STRONGkids in this study was fair [17].

Generally, STRONGkids was more sensitive compared to MUAC. The MUAC's low sensitivity and high specificity in identifying malnutrition in this study are reported by Laillou et al., 2014 [35]. This implies that using MUAC values to predict malnutrition may lead to several missed diagnoses compared to WFH z-scores. This has been reported in another pediatric study from Ghana [20]. However, due to its high specificity, MUAC may be essential in a low resource where health resources may already be strained. This notwithstanding, sensitivity has been suggested as a more important indicator than specificity in predicting malnutrition [16]. This is because a false-positive result due to low specificity will only lead to exposing a patient to a full dietetic assessment which is not a harmful exposure. On the other hand, a false-negative result due to low sensitivity will lead to unrecognized malnutrition which is undesirable compared to the former. An increase in false positives due to low specificity will increase the burden on dietitians or nutrition professionals because of unnecessary referrals for full dietetic assessment. Thus, both tools (STRONGkids and MUAC) have their limitations in predicting acute malnutrition. The STRONGkids is more sensitive whereas MUAC is more specific. Moderate inter-rater reliability was found between two users of the STRONGkids tool similar to previous studies [17].

Conclusion

STRONGkids is a more sensitive tool for predicting acute malnutrition compared to MUAC. Regardless, its overall degree of validity in our study was low. MUAC is a more specific tool than the STRONGkids tool with high validity for its specificity. This study highlights the potential limitations in utilizing MUAC and STRONGkids in screening for malnutrition in pediatric in-patients. Therefore, in our setting, it is recommended to use STRONGkids and MUAC concurrently rather than separately for screening pediatric malnutrition. Further studies to evaluate other published pediatric screening tools may be necessary to identify a highly valid tool in our setting. Nutrition screening tools or cut-off adjustments designed and validated specifically for our setting may be necessary.

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DECLARATIONS

Ethical considerations

This study was submitted to the Ethics and Protocol review committee of the University of Ghana School of Biomedical Health and Allied Sciences (SBAHS-ND./10465360/AA/5A/2016-2017) and the Institutional Review Board of Korle Bu Teaching Hospital for approval. Permission was also sought from the Child Health Department of the Korle Bu Teaching Hospital to use their premises for the study. Also, approval was sought from the Regional Directorate of the Ghana Health Service to conduct the study at PML Children's Hospital. The protocol and nature of the study were explained to parents and caregivers and written informed consent was obtained before recruiting their children into the study. Caregivers were at liberty to refuse to participate in the study without any consequences on healthcare provision for their children.

Consent to publish

All authors agreed to the content of the final paper.

Funding

This research was conducted with personal funds, with no external sponsorship or financial support.

Competing Interests

The authors report no potential conflict of interest.

Author contributions

EKA, HGA-A, and JA-Q contributed to the conception of the study; EKA contributed to data collection and analysis; EKA, HGA-A, and JA-Q contributed to drafting the manuscript. All authors read through and approved the final manuscript for submission.

Acknowledgements

None.

Availability of data

Datasets and code used for the analysis of this study are available at: https://github.com/KomlaRD/strongkids_muac_analysis.git.

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