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Evaluating the STRONGkids Tool for Assessing Malnutrition Risk in Hospitalized Iranian Children – A Cross-Sectional Study

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ABSTRACT

Introduction: Malnutrition in hospitalized children can impair health outcomes. The STRONGkids screening tool requires further reliability testing across diverse healthcare providers to identify pediatric patients requiring nutritional support**.** This study evaluated the effectiveness of STRONGkids compared to standard anthropometric criteria in determining malnutrition risk among hospitalized Iranian children.

Methods: This cross-sectional analysis evaluated 287 patients (mean age nine months) admitted for ≥4 days across all non-critical wards in a pediatric hospital in Mashhad, Iran, from November 2020 to October 2021. STRONGkids categories were compared to weight-for-age (WAZ), height-for-age (HAZ), BMI-for-age (BMIZ), and weight-for-length/height (WLZ/H) z-scores using agreement statistics.

Results: The malnutrition rate exceeded previous estimates for Iranian pediatric patients. STRONGkids demonstrated statistically significant agreement with WLZ/H ($p<0.001$) and WAZ ($p=0.014$) in ruling out malnutrition risk. However, sensitivity for identifying high-risk cases was suboptimal.

Conclusions: STRONGkids can reliably exclude malnutrition when agreement exists with anthropometric criteria. Standardizing training and administration of the tool could optimize sensitivity and utility for detecting hospitalized children requiring nutritional intervention.

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List of Abbreviations

WAZ: weight-for-age z-score
HAZ height-for-age z-score
BMIZ: BMI-for-age z-score
WLZ/H: weight-for-length/height z-score

Introduction

Malnutrition refers to the inadequate or imbalanced consumption of nutrients, encompassing both undernutrition and overnutrition (1, 2). Undernutrition manifests in children as stunting, wasting, or being underweight (3, 4). Malnutrition poses a significant public health threat to pediatric populations by impairing physical growth and immune function, elevating infection risk, and increasing the likelihood of mortality (4-6). Approximately 149 million children globally under age five are estimated to have stunted growth, 45 million are wasted, and 38.9 million are overweight or obese (4, 7, 8). In Iran specifically, research suggests malnutrition rates among children aged 6-14 years old parallel global averages (9). Imanzadeh et al. found that 37% of hospitalized Iranian children were malnourished based on BMI z-scores (10).

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Detecting malnutrition is critical in hospitalized children, as it can prolong hospital stays and contribute to higher mortality (11). Reported prevalence varies substantially based on geographic location and patient age (11-14). However, statistics likely underestimate severe malnutrition cases. When overlooked in pediatric inpatients, severe malnutrition may directly translate to inflated admissions and mortality stemming from common childhood infections (15, 16). The hospitalization process can also worsen nutritional status (15, 16).

The STRONGkids assessment tool is extensively used internationally for its feasibility and reproducibility in rapidly detecting patients needing nutritional support on admission (17-20). However, data elucidating pediatric hospital malnutrition and relevant factors is currently limited. This is the first study to evaluate the utility of the STRONGkids screening tool for detecting malnutrition among hospitalized Iranian children by comparing it to several standard anthropometric criteria. The study provides new evidence regarding the prevalence of malnutrition in this population using multiple assessment techniques.

Materials & Methods

This cross-sectional study evaluated patient files over one year at Akbar Children's Hospital. Patients aged one month to 18 years across all wards except ICU and Emergency Department were included based on global sampling method. Exclusion criteria were emergency/ICU admission, inability to measure accurate weight/height, and incomplete data. Initially, 650 files were reviewed; 287 met the inclusion criteria.

Length (≤2 years old) or height (>24 months old) was measured with 0.1 cm accuracy. Length was taken supine using a Seca infantometer with fixed head/foot pieces for ages 1-24 months. For >24 months, standing height was measured with a stadiometer with a setback piece and movable headpiece. Weight was measured to 0.1 kg using a Seca digital baby scale (≤2 years old) or a Seca 730 scale (>24 months old). BMI was calculated for >2 years old per WHO and CDC growth charts. Weight-for-age (WAZ), height-for-age (HAZ), BMI-for-age (BMIZ), and weight-for-length/height (WLZ/H) z-scores were determined.

The validated STRONGkids nutritional screening tool was applied, which stratifies hospitalized pediatric patients aged 1 month-18 years as low, medium, or high malnutrition risk based on a 5-point scoring system with yes/no questions. Scores of 0, 1-3, and 4-5 indicate low, medium, and high risk, respectively (17, 18, 21).

Statistical Analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 22 (IBM Corp., Armonk, NY, USA). The Kolmogorov-Smirnov test was used to assess the normality of continuous variables. Mean and standard deviation (SD) and median and interquartile range (IQR) were used to present normally and non-normally distributed variables, respectively. Frequency and percentage were used to describe categorical variables. Cohen's Kappa was used to evaluate the agreement between STRONGkids categories and categories of anthropometric measurements. Based on Cohen's suggestion, the agreement is considered none if the Kappa value equals zero, while slight, fair, moderate, substantial, and almost perfect agreements are defined as Kappa values between 0.01 and 0.20; 0.21 and 0.40; 0.41 and 0.60; 0.61 and 0.80; and 0.81 to 100, respectively (22). Statistical analyses were performed considering α=0.05.

Results

Of the 287 patients evaluated in this study, 151 (52.6%) were boys and 136 (47.4%) were girls. The median (IQR) for the age of the patients was 26 (9.00-76.00) months. Most patients (222, 77.4%) were older than six months. Characteristics of the patients are presented in Table 1.

Anthropometric indices for the study patients are presented in Table 2. Weight for age, height for age, BMI for age, and weight for length/height above -1 Z score were observed in 252 (56.0%), 242 (47.3%), 317 (61.8%), and 217 (65.8%), respectively. Height for age Z score below -3 Z score was observed in 122 (23.6%) patients.

Based on the STRONGKids score, low, moderate, and severe malnutrition were observed in 105 (36.6%), 154 (53.7%), and 28 (9.8%) patients, respectively. Agreement between the STRONGkids categories and malnutrition based on anthropometric measurements among patients are presented in Figure 1. Agreement between STRONGkids categories and weight for length/height (p=0.009, Kappa=-0.038), and

height for age (p=0.029, Kappa=-0.035) were statistically significant. These findings indicated that STRONGkids agreed fairly with weight for length/height and weight for age in the study patients.

Table 1. Characteristics of the patients included in the study

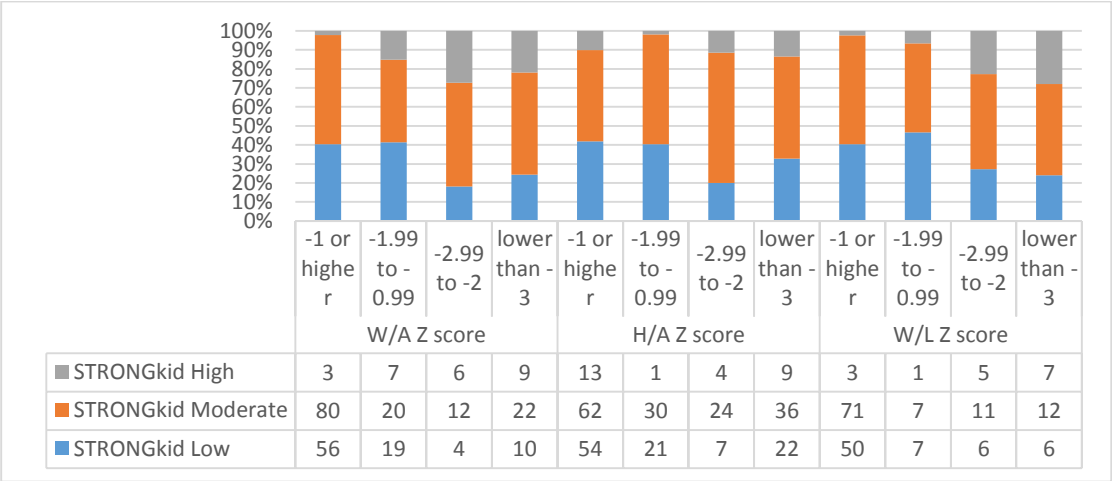
Variable		Mean/Median	SD/IQR
Birth weight (kg)		2.90	0.52
Age (months)†		26.00	9.00-76.00
Admission duration (days)†		4.00	2.00-7.00
Variable		**Frequency**	**Percentage**
Sex	Boy	151	52.6
	Girl	136	47.4
Ward	Immunology and Allergy	104	36.2
	Infectious diseases and Gastroenterology	50	17.4
	Endocrine diseases	18	6.3
	Surgery	57	19.9
	General	58	20.2

Quantitative data were presented as mean and SD or Median and IQR
SD: Standard Deviation**, IQR:** Interquartile Range
† Median and IQR were presented

Table 2. Anthropometric measurements of the patients included in the study

Variable		Frequency	Percentage
Waight for age Z score	-1 or higher	139	56.0
	-0.99 to -1.99	46	18.5
	-2 to -2.99	22	8.9
	-3 or lower	41	16.5
Height for age Z score	-1 or higher	129	45.6
	-0.99 to -1.99	52	18.4
	-2 to -2.99	35	12.4
	-3 or lower	67	23.7
BMI for age Z score	-1 or higher	178	62.9
	-0.99 to -1.99	39	13.8
	-2 to -2.99	29	10.2
	-3 or lower	37	13.1
Weight for length/height Z score	-1 or higher	124	66.7
	-0.99 to -1.99	15	8.1
	-2 to -2.99	22	11.8
	-3 or lower	25	13.4

Qualitative variables were presented as frequency and percentage.



	W/A Z score				H/A Z score				W/L Z score			
	-1 or higher	-1.99 to -0.99	-2.99 to -2	lower than -3	-1 or higher	-1.99 to -0.99	-2.99 to -2	lower than -3	-1 or higher	-1.99 to -0.99	-2.99 to -2	lower than -3
STRONGkid High	3	7	6	9	13	1	4	9	3	1	5	7
STRONGkid Moderate	80	20	12	22	62	30	24	36	71	7	11	12
STRONGkid Low	56	19	4	10	54	21	7	22	50	7	6	6

W/A: weight for age, **H/A:** height for age, **W/L:** weight for length
Figure 1. Agreement between STRONGkids and malnutrition based on anthropometric measurements

The percentage of moderate to high STRINGkids among malnourished patients based on each anthropometric measurement cut-off among patients younger than six months and those older than six months are presented in Figure 2. Among patients younger than six months, there was no significant agreement between the dichotomized STRONGkids category (low and moderate to high groups) and malnutrition based on the evaluated anthropometric measurements (p>0.05). Among patients older than six months, there was a significant agreement between the dichotomized STRONGkids category (low and moderate to high groups) and malnutrition based on weight for length/height (p<0.001, Kappa=-0.403) and weight for age (p=0.014, Kappa=-0.046). These findings indicated that STRONGkids had a slight agreement with weight for age and fair agreement with weight for length/height among patients older than six months.

The sensitivity and specificity of STRONGkids for detecting malnutrition based on BMI, weight for length/height, weight for age, and height for age are presented in Table 3.

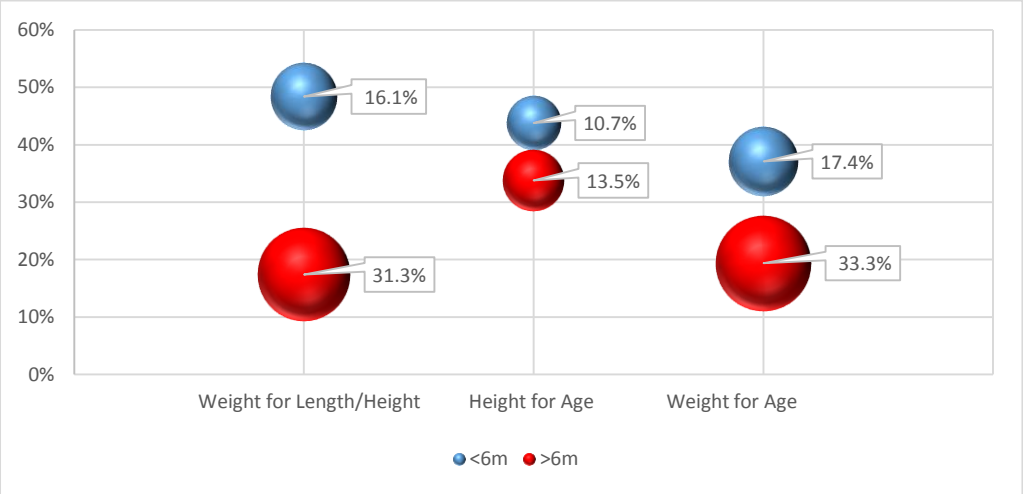


Figure 2. Percentage of moderate to severe STRONGkids category among malnourished patients based on each anthropometric measurement cut-off among patients who were younger than six months and those older than six months. The bubble size represents the percentage of malnourished patients categorized as moderate to severe based on STRONGkids (values presented in callouts), and the vertical axis represents the percentage of patients with malnutrition based on each anthropometric measurement.

Table 3. Sensitivity and specificity of STRONGkids based on study parameters

Variable	Sensitivity	Specificity
Waight for age	30.3%	83.5%
Height for age	38.6%	72.3%
BMI for age	25.6%	85.4%
Weight for length/height	25.6%	85.4%

Sensitivity and specificity were presented as percentages.

Discussion

The study evaluated malnutrition in hospitalized children in a tertiary children's hospital in Mashhad, Iran, using the STRONGkids score to categorize patients into low, medium, and severe malnutrition groups. We also used anthropometric measurements as the gold standard for assessing malnutrition and evaluated the agreement between STRONGkids and anthropometric indices.

We observed higher malnutrition prevalence rates than previous studies in Iran, highlighting the need for routine nutritional screening to prevent crises and enable timely interventions among hospitalized children (23, 24). An observational study in Africa reported that sixty percent of newborn children were at risk of malnutrition (25). Alternatively, another study in Indonesia found this valuable method in 1899 children with cleft lip or palate (26). A cross-

sectional study conducted in Pakistan found that stunting, wasting, and underweight were measured using weight-for-length/height and height-for-age indicators.

Furthermore, we utilized z-scores of weight-for-age, height-for-age, BMI-for-age, and weight-for-length/height to evaluate nutritional status by comparing children's measurements against a reference population(27, 28). In our study, z-scores of -1 or lower, signifying below-average status, were most prevalent—a significant sign of malnutrition.

Additionally, according to our study, the agreement between these Z-score and STRONGkids categories was statistically significant. Children from low-income households may face an elevated susceptibility to developing obesity as they advance in age. Poverty emerges as a pivotal factor influencing the occurrence of malnutrition (29-31). Kapci et al. conducted a study to assess chronicity categories in different diseases and compare them among various groups. Interestingly, the prevalence of malnutrition was notably higher in the acute illness group. However, this study did not examine the relationship between age and malnutrition, despite previous studies emphasizing its significance as a critical variable (32).

Overall, this study found that the STRONGkids tool had slight to fair agreement with anthropometric indices, but its sensitivity in detecting malnutrition was poor. These findings indicate that STRONGkids could be ~~a~~ reliable in ruling out malnutrition. Similarly, a previous study showed an inverse association with anthropometric indexes such as weight-to-height ratio and BMI adjusted for age (33). In contrast to the current study's findings, previous studies have shown that STRONGkids had a high sensitivity in detecting malnutrition in chronic and acute pediatric patients (19, 34-38). This finding might be due to the difference in sample size, patient selection (chronic and acute patients), and inter-rater reliability of the translated versions of the tool. Another reason for the observed low sensitivity of STRONGkids in the current study might be related to the utilization of the tool by various raters from different educational backgrounds (dieticians, nurses, physicians, medical and dietetic students) that might affect their judgment regarding the questionnaire items. Furthermore, the workload in some wards might have affected the accuracy of filling the STRONGkids items.

Strengths and Limitations of Study

Our study has certain limitations that need to be acknowledged. Our sample was limited to hospital patients, which may affect the generalizability of our results. Secondly, due to our study's cross-sectional design, we could not establish any causal relationships. To better understand this issue, we recommend that future studies clearly define their methodological aspects, including sample size considerations.

Conclusion

Our study emphasizes the importance of addressing malnutrition's impact on pediatric mortality and morbidity, particularly among hospitalized children. It provides valuable insights for future researchers regarding methodology and target population selection in investigating child malnutrition. It highlights the need for standardized assessment techniques and diverse study designs to ensure reliable results. However, STRONGkids demonstrated the potential to rule out malnutrition when agreeing with standard criteria reliably but had suboptimal sensitivity to positively identify high-risk cases compared to some international studies. Still, evidence-based nutritional screening protocols are essential for hospitals to combat the severe health threats of pediatric malnutrition, enabling early intervention through routine assessment.

Availability of Data and Materials

Once the study is concluded and the results are published, access to the anonymized datasets will be granted upon reasonable request. However, approval to access the data will be granted only if all investigators approve the request.

Declarations

Acknowledgments

Not applicable.

Ethics Declarations

Ethics approval and consent to participate

The research received approval from the Research Committee of the Mashhad University of Medical Sciences, Iran. The study adheres to the principles outlined in the Declaration of Helsinki. All participants provided written informed consent before participating in this

study. Moreover, it was approved by the Ethics Committee of the Research Vice-Chancellor at Mashhad University of Medical Sciences (IR.MUMS.REC.1397.257), and all personal information about participants will be kept secure in a database.

Consent for Publication

It is not applicable, as there are no identifying images of participants presented or to be presented in reports of trial results.

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Conflicts of Interest

The authors declare that they have no competing interests.

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