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ARTICLE

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StrongKids for pediatric nutritional risk screening in Brazil: a validation study

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Abstract

Objectives To evaluate the validity and reproducibility of StrongKids as a pediatric nutritional screening tool in Brazil, which has no validated method for this purpose.

Methods A cross-sectional study was conducted with 641 patients admitted to the pediatric care unit of a public hospital from 2014 to 2018. The concurrent validity was assessed by evaluating the sensitivity, specificity, and the positive and negative predictive values of StrongKids in detecting acute, chronic, and overall malnutrition. Predictive validity was determined by calculating the same indices to identify longer than median hospital stay, need of enteral nutrition, 30-day hospital readmission, transfer to hospitals with more complex procedures, and death. StrongKids was reapplied to a subsample to evaluate the inter-rater reproducibility.

Results Prevalence of low risk was 15.6%, moderate risk was 63.7%, and high nutritional risk was 20.7%. A positive test, corresponding to the moderate or high risk category, identified all those with acute malnutrition and showed sensitivity of 89.4% (95% CI: 76.9–96.4) and 94.0% (95% CI: 86.6–98.0) for the detection of chronic and overall malnutrition, respectively. Regarding its predictive capacity, 100% of the patients who needed enteral nutrition, who were transferred, died, or were readmitted to hospital within 30 days after discharge were considered in risk by StrongKids, and the sensitivity to identify those with prolonged hospital stays was 89.2 (95% CI: 84.6–92.7). The inter-rater agreement was excellent (PABAK: 0.87).

Conclusions StrongKids had satisfactory validity and reproducibility and successfully identified nutritional deficits and predict unfavorable health outcomes. Our results support the use of StrongKids as a pediatric nutritional risk screening method in Brazil.

Introduction

Malnutrition in pediatric patients is a frequent and underdiagnosed condition worldwide. The prevalence is dependent on the regional differences and diagnostic methods, ranging from 6.1 to 50% [1, 2]. The consequences are serious and include increased infection complications, prolonged length of hospital stay, increased hospital costs, and higher morbidity and mortality [3, 4].

Nutritional screening is a simple, fast, noninvasive method that identifies patients at risk of malnutrition, who would benefit from an early evaluation and intervention. Its use has been recommended by international guidelines [5], and health services must establish standardized protocols for the implementation of a validated tool [6]. This practice is well established for adults and older people, but there is still no consensus on the most appropriate method for hospitalized children [7, 8].

StrongKids was developed by Hulst et al. [9] in the Netherlands and considered a good nutritional screening method by comparative studies among the existing proposals [10, 11]. It assesses important factors that generate nutritional impact: underlying illness with risk for malnutrition or expected major surgery; poor nutritional status;

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diarrhea and/or vomiting; reduced food intake; preexisting nutritional intervention and weight loss or poor weight gain. According to the final score, the patient is classified as low risk (LR), moderate risk (MR), or high risk (HR) of malnutrition. It is the only method that has been translated and transculturally adapted into Portuguese [12], but it still needs to be validated for Brazilian pediatrics [13].

A recent systematic review of the scientific evidence related to the StrongKids [14] confirmed the lack of studies of validity and reproducibility in Brazil, which limits the recommendation and implementation of pediatric screening in the country. The aim of this study was to evaluate the criterion validity (concurrent and predictive) and the inter-rater reproducibility of StrongKids in a large sample of pediatric patients in Brazil.

Materials and methods

Study population

This is a cross-sectional study with patients admitted to the pediatric care unit of a public hospital in Minas Gerais, Brazil, from 2014 to 2018. The inclusion criteria were patients aged between 1 month to 17 years old and at least 1 day of hospital stay [9].

The sample size was defined according to Jones et al.'s recommendations for the validation of nutritional screening and assessment tool [15]. The calculation of sample size considered a malnutrition prevalence of 50% [2], sensitivity of 71.9% [16], and tolerated error of 5%, totaling 621 patients. The reproducibility analysis used the minimum sample size recommended by Bujang and Baharum [17]. Considering the study to have 90% power, $\alpha = 0.05$, $\kappa_1 = 0.00$, and $\kappa_2 = 0.60$ [16], at least 25 individuals should be reevaluated.

Anthropometry

Weight and height were measured according standard procedures [18] by a trained investigator on the same day of the interview. Weight-for-age (WFA), weight-for-height (WFH), height-for-age (HFA), and Body Mass Index (BMI)-for-age z-scores were calculated with the softwares WHO Anthro and WHO AnthroPlus, according to World Health Organization child growth standards (0–5 years) [19] and growth references (5–19 years) [20].

A z-score of <-2 for WFH (<5 years) or <-2 for BMI-for-age (≥5 years) was used to indicate acute malnutrition, and a z-score of <-2 for HFA was used to indicate chronic malnutrition (all ages) [21]. Overall malnutrition was defined as the presence of acute and/or chronic malnutrition [9, 16]. Preterm-born children (gestational age <37 completed weeks) had their age corrected up to 24 months [22]. Children with cerebral palsy were excluded from the anthropometric analysis, since the growth curves used do not apply to this group.

Nutritional risk

StrongKids was applied by a nutritionist within 48 h after hospital admission, in its translated version transculturally adapted to Brazil [12]. According to the final score, the patients were classified into: 0 points: LR; 1–3 points: MR; and 4–5 points: high nutritional risk (HR). To perform the reproducibility analysis, StrongKids was reapplied by a second nutritionist 1 day after the first screening, with the same parents/caregivers and without information about the result of the previous evaluation. In this step, the time spent to apply the questionnaire was recorded by a stopwatch.

Data analysis

Data analysis was carried out in STATA version 13.0. The significance level was set at 5%. Data were checked for normality by the Shapiro–Wilk test, graphical analysis, and coefficients of asymmetry and kurtosis. The association between variables of interest and the nutritional risk was verified by the Pearson's chi-square test or Fisher's exact test. The medians of variables were compared among the nutritional risk categories by the Mann–Whitney test. Kruskal–Wallis test with Dunn's post hoc was performed to verify differences in length of hospital stay and anthropometric indices among the three risk categories (LR, MR, HR). The correlation of the final StrongKids score with the length of hospital stay and the anthropometric indices was determined by the Spearman correlation coefficient.

The concurrent criterion validity was evaluated by the sensitivity, specificity, and predictive values of StrongKids for the detection of acute, chronic, and overall malnutrition. The predictive criterion validity was evaluated by the same indices used to identify a prolonged hospital stay (according to the sample median), need of enteral nutrition, 30-day hospital readmission, transfer to hospitals with more complex procedures, and death. The association between the nutritional risk and the occurrence of malnutrition and other outcomes was assessed by odds ratio (OR), with 95% confidence intervals.

The reproducibility of the classification of patients at nutritional risk (yes/no) was assessed by simple percentage agreement (% of concordant classifications) and by prevalence-adjusted and bias-adjusted kappa (PABAK). Considering the ordinal classification in the categories (LR, MR, HR), the weighted Kappa (κw) was calculated. The agreement with the final score was assessed by the Intra-class Correlation Coefficient (ICC). The magnitude of the

Table 1 Characteristics of the total sample and according to the nutritional risk.

Characteristics	*n* (%) or median (IQR)[d]	LR	MR/HR	*p* value
Sex				
Male	352 (54.9)	55 (55.0)	297 (54.9)	0.985[a]
Female	289 (45.1)	45 (45.0)	244 (45.1)	
Age (years)	2.8 (0.9–6.4)[d]	2.5 (0.6–6.8)[d]	2.8 (0.9–6.3)[d]	0.389[b]
Length of hospital stay (days)	5.0 (3.0–7.0)[d]	4.0 (3.0–6.0)[d]	5.0 (3.0–7.0)[d]	**0.003**[b]
HFA < −2 *z*-score (0–18 years; $n = 513$)				
Yes	47 (9.2)	5 (5.6)	42 (9.9)	0.232[c]
No	466 (90.8)	84 (94.4)	382 (90.1)	
WFH < −2 *z*-score (0–5 years; $n = 359$)				
Yes	32 (8.9)	0 (0.0)	32 (10.8)	**0.003**[c]
No	327 (91.1)	62 (100.0)	265 (89.2)	
WFA < 2 *z*-score (0–10 years; $n = 527$)				
Yes	44 (8.4)	0 (0.0)	44 (10.0)	**<0.001**[c]
No	483 (91.6)	88 (100.0)	395 (90.0)	
BMI-for-age < −2 *z*-score (0–18 years; $n = 513$)				
Yes	52 (10.1)	0 (0.0)	52 (12.3)	**<0.001**[c]
No	461 (89.9)	89 (100.0)	372 (87.7)	

LR low risk, *MR* moderate risk, *HR* high risk, *IQR* interquartile range, *HFA* height-for-age, *WFH* weight-for-height, *WFA* weight-for-age, *BMI* Body Mass Index.

[a]Pearson's chi-square test.

[b]Mann–Whitney test.

[c]Fisher's exact test.

[d]Median and interquartile range.

Bold values indicate significant *p*-values ($p < 0.05$).

reproducibility was interpreted according to Landis and Koch [23]: kappa from 0 to 0.19 = poor agreement; 0.20 to 0.39 = weak; from 0.40 to 0.59 = moderate; 0.60 to 0.79 = substantial; and 0.81 to 1.00 = excellent. The same criterion was used for the interpretation of the ICC.

Ethical aspects

This study has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) and was approved by the Ethics Committee for Research on Humans of the Federal University of Viçosa (No. 841.492/2014). Informed consent was obtained from the parents/caregivers of all the patients involved in the study.

Results

The study included 641 patients, most male (54.9%), less than 10 years of age (91.1%) and living in the urban area (74.1%). The most frequent admission diagnoses according to the 10th revision of the International Classification of Diseases were respiratory diseases (35.7%), infectious and parasitic diseases (19.7%), injuries, poisoning or external causes (8.1%), digestive diseases (6.6%) and genitourinary diseases (5.6%).

StrongKids identified 15.6% of patients as LR ($n = 100$), 63.7% as MR ($n = 408$), and 20.7% as HR ($n = 133$). Those classified as "at risk" (MR or HR) had prolonged hospital stay and higher frequency of inadequacy of the indices WFH, WFA, and BMI-for-age (Table 1).

An increase in the mean hospital stay was observed for the three categories of nutritional risk, (LR: 4.8 days; MR: 5.5 days; HR: 8.2 days, $p < 0.001$). The anthropometric indices WFH, WFA, and BMI-for-age were significantly lower at each change of category to a higher risk ($p < 0.001$). For the HFA indice, lower values were found in HR category compared to MR and LR ($p < 0.001$).

The StrongKids score correlated directly with a longer hospital stay (ρ: 0.30; $p < 0.001$) and inversely with all anthropometric indices: WFA (ρ: −0.34; $p < 0.001$), WFH (ρ: −0.28; $p < 0.001$), HFA (−0.17 $p < 0.001$), and BMI-for-age (ρ: −0.30; $p < 0.001$).

Validation

In the concurrent validity analysis, StrongKids identified all those patients with acute malnutrition. Patients identified as at nutritional risk were about four times (95% CI: 1.5–9.7)

Table 2 Concurrent and predictive validity of StrongKids.

	OR (95% CI)	SENS (95% CI)	SPEC (95% CI)	PPV (95% CI)	NPV (95% CI)
Concurrent validity					
Acute malnutrition[a] ($n = 46/503$)	–	100.0 (92.3–100.0)	19.0 (15.5–22.9)	11.1 (8.2–14.5)	100.0 (95.9–100.0)
Chronic malnutrition[b] ($n = 47/513$)	1.9 (0.7–4.8)	89.4 (76.9–96.4)	18.0 (14.6–21.8)	9.9 (7.2–13.1)	94.4 (87.4–98.1)
Overall malnutrition[c] ($n = 84/505$)	3.8 (1.5–9.7)*	94.1 (86.6–98.0)	19.5 (15.8–23.6)	18.9 (15.3–23.0)	94.3 (87.1–98.1)
Predictive validity					
Need of enteral nutrition ($n = 15/641$)	–	100.0 (78.2–100.0)	16.0 (13.2–19.1)	2.8 (1.6–4.5)	100.0 (96.4–100.0)
Prolonged hospital stay[d] ($n = 249/641$)	1.9 (1.2–3.0)*	89.2 (84.6–92.7)	18.6 (14.9–22.8)	41.0 (36.9–45.3)	73.0 (63.2–81.4)
Death ($n = 3/641$)	–	100.0 (29.2–100.0)	15.7 (12.9–18.7)	0.6 (0.1–1.61)	100.0 (96.4–100.0)
Transfer ($n = 18/641$)	–	100.0 (81.5–100.0)	16.1 (13.3–19.2)	3.3 (2.0–5.2)	100.0 (96.4–100.0)
30-day hospital readmission ($n = 15/641$)	–	100.0 (78.2–100.0)	16.0 (13.2–19.1)	2.8 (1.6–4.5)	100.0 (96.4–100.0)

OR Odds ratio, *CI* confidence interval, *SENS* sensitivity, *SPEC* specificity, *PPV* positive predictive value, *NPV* negative predictive value.

[a]Weight-for-height < −2 *z*-score (<5 years) or Body Mass Index-for-age < −2 *z*-score (≥5 years).

[b]Height-for-age < −2 *z*-score (all ages).

[c]Acute and/or chronic malnutrition.

[d]Categorization according to median: ≤5 days; >5 days.

*p value < 0.001.

more likely to present overall malnutrition (acute and/or chronic). For this classification, StrongKids showed sensitivity of 94.1% (95% CI: 86.6–98.0), specificity of 19.5% (95% CI: 15.8–23.6), positive predictive value (PPV) of 18.9% (95% CI: 15.3–23.0), and negative predictive value (NPV) of 94.3% (95% CI: 87.1–98.1). The rates were lower for chronic malnutrition, but still 89.4% (95% CI: 76.9–96.4) of the children with low HFA were classified as at risk by StrongKids (Table 2). It is of note that we could not obtain complete anthropometric measurements (weight and height) of 121 patients (18.9%); however, no differences were found for age, sex, StrongKids score, or categorical risk classification in the comparison of children with and without anthropometric data ($p > 0.05$).

In the predictive validity assessment, all children who needed enteral nutrition, who were transferred, who had hospital readmission within 30 days after discharge, or died were classified as at risk by StrongKids. In addition, StrongKids showed sensitivity of 89.2% (95% CI: 84.6–92.7) to identify patients with a longer hospital stay. Patients at nutritional risk had almost twice the chance of having prolonged hospital stays.

Reproducibility

The reproducibility analysis included 31 patients (58.6% male, median age: 1.1 years, IQR: 0.5–2.0 years). The agreement between the raters for nutritional risk was excellent (PABAK: 0.87; 95% CI: 0.69–1.00), as well as the κw for the three nutritional risk categories (κw: 0.84; 95% CI: 0.62–1.00). The ICC for the final score was also excellent (ICC: 0.86; 95% CI: 0.73–0.93).

The item analysis showed perfect agreement for the questions "preexisting nutritional intervention" and "inability to consume adequate intake because of pain." The lowest coefficients were found for "reduced food intake during the last few days before admission" and "poor nutritional status," with magnitude scored as substantial and excellent, respectively (Table 3). The frequency of risk categories was the same in the two evaluations (LR: 12.9%; MR: 77.4%, HR: 9.7%). Only one child that was considered at LR by the rater 1 was classified as MR by the rater 2; and one child at MR according to the rater 1 was considered at LR by the rater 2.

The mean time spent in the application of StrongKids was 2 min (ranging from 1.5 to 4 min).

Discussion

This study evaluated the validity and reproducibility of the Portuguese version of the StrongKids as a nutritional screening method in pediatrics in Brazil. As far as we know, this is the first study with this focus, involving a large sample of hospitalized Brazilian patients.

StrongKids was able to identify all patients with acute malnutrition in the concurrent validation, which indicates that the method is effective in tracking those who are possibly undergoing a recent and rapid process of weight loss in the hospital environment. Sensitivity was lower for the chronic and overall malnutrition, but still high (89.4% and 94.0%, respectively). Huysentruyt et al. [16] also identified a greater ability to detect acute malnutrition (sensitivity of 71.9%) compared with chronic malnutrition (sensitivity of 69%), when validating the tool in Belgium.

Table 3 StrongKids reproducibility.

	Overall agreement (%)	PABAK (95% CI)
StrongKids items		
Is there an underlying illness with risk for malnutrition or expected major surgery?	93.55	0.87 (0.69–1.00)
Is the patient in a poor nutritional status judged by subjective clinical assessment?	90.32	0.81 (0.50–1.00)
Excessive diarrhea (≥5 per day) and/or vomiting (>3 times/day) in the last few days?	96.77	0.94 (0.80–1.00)
Reduced food intake during the last few days before admission?	83.87	0.68 (0.40–0.95)
Preexisting dietetically advised nutritional intervention?	100.00	1.00
Inability to consume adequate intake because of pain?	100.00	1.00
Weight loss or poor weight gain?	96.77	0.93 (0.80–1.00)
StrongKids classification		
Nutritional risk[a]	93.55	0.87 (0.69–1.00)

PABAK prevalence-adjusted and bias-adjusted kappa, *CI* confidence interval.

[a]Moderate risk or high risk.

In the predictive validation, the sensitivity of StrongKids to identify the patients with the longest hospital stays (>5 days) was 89.2%. Huysentruyt et al. [16] reported sensitivity of 62.2% to identify patients with similar outcome (≥4 days). The OR of longer hospital stays (OR: 1.96; 95% CI: 1.25–3.07) were similar to our finding (OR: 1.88; 95% CI: 1.17–3.02), as well as the direct correlation between the score and the days of hospital stay (ρ: 0.25 vs. ρ: 0.30, $p < 0.001$). Our results corroborate the association between the nutritional risk by StrongKids and a longer hospital stay [9, 22, 24–27], which may be twice or more in patients at HR [28, 29]. A longer hospital stay, besides increasing the risk of complications associated with prolonged hospitalization (such as infections and weight loss), also increases hospital costs, which has also been shown to be associated with the risk identified by StrongKids [22, 25, 26].

StrongKids was also able to identify all children who needed nutritional intervention (83% HR and 9% MR) in a validation study conducted in the UK [10]. Huysentruyt et al. [16] reported sensitivity of 94.6% to identify who needed supplemental nutrition (enteral nutrition, oral supplementation, or unspecified intervention), and those at risk (MR or HR) had almost 20 times the chance of needing nutritional support when compared with children without risk (LR). The association between nutritional risk by StrongKids and the need for nutritional support has also been identified in children with liver disease in China [22] and in European countries [30].

The 30-day hospital readmission is considered a marker of health services performance and quality of patient care [31–33]. Although this frequency was low in our study (2.3%), StrongKids identified all patients with this outcome, as well as all children who were transferred to hospitals with more complex procedures (indirect indicator of severity) and who died. These associations reinforce the predictive capacity of the method for unfavorable health outcomes.

The high sensitivity of StrongKids for all the analyses meets one of the desirable attributes of the screening methods: they are more likely to correctly identify patients who have nutrition problems, resulting in a low number of the false-negative results [34, 35]. Although specificity and PPV have been low for all analyses, indicating a high number of false positives, the priority in this context is not to leave individuals potentially at risk without identification. The confirmation of nutritional diagnosis should be made at the next stage of the nutritional care, the nutritional assessment [36]. In this sense, it is also important to highlight that there are no laboratory or radiological tests, not even a clinical parameter that alone can incorporate all aspects that define the nutritional risk. Since it is a subjective concept, both the development and validation of a tool are challenging, especially due to the lack of a "gold standard" for comparison [11]. Besides, it is necessary to consider that the incorporation of more accurate tests, such as biochemical markers, may be more time consuming and require resources that are not available for all the patients, especially in developing countries, such as Brazil.

It is necessary to point out that the negative results (LR) are more accurate, mainly due to the high NPV. Although the positive results (MR/HR) are less precise and more frequent (about 85% of the sample), it is relevant to mention that they already allow an initial concentration of efforts. StrongKids also permits the prioritization of assistance according to the magnitude of the three risk categories (first HR, then MR, and last LR), especially in settings where it is not possible to evaluate all patients in the two highest risk classifications grouped together (MR/HR).

The excellent inter-rater agreement ($\kappa = 0.87$) was slightly higher than other studies that have reported substantial agreement in Korea ($\kappa = 0.61$) [26], Belgium ($\kappa = 0.61$) [16], Mexico ($\kappa = 0.67$) [37], and Spain ($\kappa = 0.72$) [38]. These studies included both the comparison between the diagnosis performed by different raters with the same training [16, 26], and the diagnosis performed by professionals with different training and different previous knowledge [37–39]. These results confirm the satisfactory reproducibility of the method in different circumstances. In our study, evidence was provided for the reliability of the Portuguese version of StrongKids when applied by different nutritionists, reinforcing an important advantage of the method: allowing its application by a larger number of health professionals makes it possible to reach a greater coverage [11].

A screening method, by definition, should be practical, simple and rapid [5]. One important feature is the speed of administration [40], because the less time used to apply the questionnaire will allow resources to be allocated to higher-priority actions of nutritional care [41]. The time of application in our study was low (2 min) and close to the time reported by Huysentruyt et al. [16] (3 min).

Since StrongKids requires no anthropometric data, it provides an additional advantage in terms of feasibility, easiness of data collection, and speed of administration. In a comparative study, the application of the Screening Tool for the Assessment of Malnutrition in Pediatrics (which requires weight and height measurements) was about 10 min longer than the application of StrongKids (15 min 326 vs. 5 min).

The mainly potential clinical impact of the implementation of StrongKids in hospital care protocols is the possibility of identifying children with a high probability of nutritional impairment. This step represents an opportunity of early detection of patients requiring dietary intervention, improving their prognosis, and promoting a better nutritional status at hospital discharge. Our results support the implementation of this tool in hospital routines in Brazil, which is an effective action for the prevention of child hospital malnutrition in the country.

Our study has some limitations. First, this is a single-center experience, so the results should be extrapolated cautiously to other populations. Second, it was not possible to obtain anthropometric data to all the screened patients. However, we believe that this fact has no significant impact on the results, since the characteristics of the groups with and without anthropometry were not significantly different. Third, due to the low frequency of adolescents in the sample ($n = 57$; 8.9%), it was not possible to perform the validity analysis stratified by age group; in this respect, it should be mentioned that the frequency of nutritional risk (LR compared with MR/HR) and the StrongKids' score did not differ in the comparison between children and adolescentes (data not shown).

The strengths of our study are the large number of participants included, the specific sample calculation for validity and reproducibility analysis, and the combination of different variables for the validity evaluation. To the best of our knowledge, this is the first study to comprehensively demonstrate the validity (concurrent and predictive) and the reproducibility of StrongKids in a Brazilian population, corroborating the tool's usefulness in this country.

The StrongKids tool shows substantial reproducibility, rapid application, and satisfactory validity to identify nutritional deficits and predict unfavorable health outcomes. Our results support the use of StrongKids as a nutritional risk screening method in hospitalized children and adolescents in Brazil.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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