AMP ACTA MÉDICA PORTUGUESA
A Revista Científica da Ordem dos Médicos

Nutritional Risk and Malnutrition in Paediatrics: From Anthropometric Assessment to STRONGkids® Screening Tool

Risco Nutricional e Desnutrição em Pediatria: Da Avaliação Antropométrica à Ferramenta de Rastreio STRONGkids®

Luís VIEIRA GONÇALVES✉[1], Ana Gisela OLIVEIRA[2], Mariana BARRACOSA[3], Joaquina ANTUNES[2], Joana PIMENTA[2]
Acta Med Port 2023 May;36(5):309-316 ▪ https://doi.org/10.20344/amp.16768

ABSTRACT

Introduction: The prevalence of malnutrition in hospitalized children is high and is associated with negative health impact. The aim of this study was to characterize the nutritional status of hospitalized children as well as comparing nutritional risk stratification using the STRONGkids® tool and anthropometric assessment.

Material and Methods: A prospective study was conducted between March and June 2019 in a paediatric unit of a district hospital. Children with ages between one month and 17 years were included. Nutritional screening (STRONGkids®) was performed, and demographic and anthropometric variables were assessed by trained doctors and nurses (z-scores for height-for-age, weight-for-age, weight-for-height and body mass index were compared to the World Health Organization reference values) and related to the underlying condition (cause of hospitalization; hospital stay; the presence of chronic disease).

Results: A total of 209 children were evaluated, 188 of whom were included. Median age was 4.6 years and median hospital length of stay was four days. Fifty-four per cent were classified with “moderate risk” and 2% with “high risk” of developing malnutrition; 25% were effectively malnourished. Of the 105 children for which it was possible to calculate the z-scores, 6% presented acute malnutrition and nearly 14% presented chronic malnutrition. The STRONGkids® score correlated positively with nutritional status on admission, disease type on admission, and presence of previous underlying disease ($p < 0.05$).

Conclusion: STRONGkids® is a simple, quick nutritional screening tool for hospitalized children that is related to nutritional status on admission. Given that a considerably high percentage of children were identified as being at risk for malnutrition, it is essential to identify this early and provide nutritional intervention during hospitalization.

Keywords: Anthropometry; Child, Hospitalized; Malnutrition/diagnosis; Nutritional Status

RESUMO

Introdução: A prevalência de desnutrição em crianças hospitalizadas é alta e associada a impactos negativos na saúde. O objetivo deste estudo foi caraterizar o estado nutricional de crianças hospitalizadas, bem como comparar a estratificação de risco nutricional através da ferramenta STRONGkids® e da avaliação antropométrica.

Material e Métodos: Estudo prospetivo realizado no período de março a junho de 2019 numa unidade de internamento pediátrica de um hospital de nível 2. Foram incluídas crianças com idades entre um mês e 17 anos. O rastreio nutricional (STRONGkids®) foi realizado e as variáveis demográficas e antropométricas (z-*scores* para altura-por-idade, peso-por-idade, peso-por-altura e índice de massa corporal foram comparados com os valores de referência da Organização Mundial de Saúde) e relacionadas com doença de base (motivo do internamento; permanência hospitalar; presença de doença crónica) foram determinadas por médicos e enfermeiros com formação prática e teórica adequada.

Resultados: Foram avaliadas 209 crianças, das quais 188 foram incluídas. A idade média foi de 4,6 anos e o tempo médio de internamento hospitalar foi de quatro dias. Dos 188 indivíduos, 54% foram classificados com ‘risco moderado’ e 2% com ‘alto risco’ de desenvolver desnutrição; 25% estavam efetivamente desnutridos. Das 105 crianças para as quais foi calculado o z-*score*, 6% apresentaram desnutrição aguda e cerca de 14% desnutrição crónica. O *score* STRONGkids® correlacionou-se positivamente com o estado nutricional à admissão, tipo de patologia à admissão e presença de doença de base prévia ($p < 0,05$).

Conclusão: O STRONGkids® é uma ferramenta de rastreio nutricional simples e rápida para crianças hospitalizadas que avalia o estado nutricional na admissão hospitalar. Devido à prevalência consideravelmente alta de crianças identificadas em risco de desnutrição, é essencial identificar e intervir precocemente durante a hospitalização.

Palavras-chave: Antropométria; Criança Hospitalizada; Desnutrição/diagnóstico; Estado Nutricional

INTRODUCTION

Adequate psychomotor growth and development are crucial for the health and well-being of children and adolescents, with nutrition playing a key role in these processes.[1,2]

The European Society for Clinical Nutrition and Metabolism (ESPEN) defines malnutrition as a state resulting from lack of uptake or intake of nutrition, leading to measurable adverse effects on tissue/body composition, reduced physical and mental function, and poor clinical outcomes.[3] Undernutrition results from deficient energy and/or protein intake or absorption.[4-6]

The prevalence of paediatric malnutrition in healthcare settings is high and often underestimated.[7-9] It is associated with longer hospitalization stays, multiple interventions, readmissions, and higher susceptibility to infections and,

1. Serviço de Anestesiologia. Centro Hospitalar de Leiria. Leiria. Portugal.
2. Serviço de Pediatria. Centro Hospitalar Tondela-Viseu. Viseu. Portugal.
3. Faculdade de Ciências da Nutrição e Alimentação. Universidade do Porto. Porto. Portugal.
✉ **Autor correspondente:** Luís Vieira Gonçalves. luismiguelvieiragoncalves@gmail.com
Recebido/*Received*: 23/06/2021 - **Aceite/*Accepted***: 20/09/2022 - **Publicado *Online*/*Published Online***: 18/01/2023 - **Publicado/*Published***: 02/05/2023

therefore, with significant morbimortality.[7-11] The resulting impact on quality of life carries great costs on a personal level, to society, and to the healthcare system.[12]

According to the literature, the prevalence of undernutrition in hospitalized patients ranges from 20% to 50%.[12] In children, studies point to a similar prevalence of 15% to 50%.[7,8,10,13-16] A study carried out in 2015 in the paediatric population of a level-three hospital unit in the Azores with a sample of 299 children showed 11.4% of the children were severely wasted and 18.1% severely stunted.[17]

Since 2005, the European Society of Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) has recommended the implementation of nutritional screening strategies to establish individualized nutritional plans in order to improve paediatric care, thus reducing the incidence of nutritional deficiencies and undernutrition during hospital stays.[18,19] Since 2018, the Portuguese government has been implementing strategies in National Health Service hospitals to optimize inpatient nutritional care and directly promote the recovery of quality of life.[17] Therefore, early identification of individuals at nutritional risk upon admission, followed by appropriate nutritional management, is essential.[7-9,13,19-21]

Nutritional risk is defined by the current nutritional status and the risk of deterioration of the current status, due to an increase in nutritional requirements caused by metabolic stress associated with the clinical condition.[22]

Since 2018, the Portuguese government has been implementing strategies in National Health Service hospitals to optimize inpatient nutritional care and directly promote the recovery of quality of life, and recommended a systematic evaluation of nutritional risk to all patients hospitalized for a period longer than 24 hours.[12]

In paediatric patients, the nutritional risk assessment tool adopted is STRONGkids® (Screening Tool for Risk of Impaired Status and Growth), a simple, safe, sensitive, specific, low-cost questionnaire which is widely used to identify nutritional risk in different populations worldwide.[12,13,23] It consists of four items: subjective assessment of nutritional status, recent weight changes, assessment of food intake and nutritional losses and presence of medical condition with risk for malnutrition.[12] Each item is assigned a score. The sum of these points identifies the risk of malnutrition and guides the necessary intervention and follow-up.[2,13] Even though there are translations of STRONGkids® into the Portuguese language, there is, to our knowledge, only one study that used this tool for the hospitalized paediatric population in the Azores.[17]

The authors aimed to characterize the nutritional status of hospitalized children admitted to the Paediatric Department of Centro Hospitalar Tondela-Viseu, as well as comparing nutritional risk stratification using the STRONGkids® screening tool and anthropometric assessment.[24,25]

MATERIAL AND METHODS

A longitudinal study was conducted on hospitalized children in a Portuguese second-level public hospital between the 15th March and the 15th July 2019, after the Ethics Committee of the hospital reviewed and approved the protocol of the present study.

Patients aged between one month and 18 years and admitted for an expected length of stay (LOS) of more than 24 hours were invited to participate in the study at the time of admission. Written informed consent was obtained. Data was collected from a questionnaire designed for the study (Appendix 1: https://www.actamedicaportuguesa.com/revista/index.php/amp/article/view/16768/15025) by trained professionals (nurses and doctors). The questionnaire consisted of three groups of questions: the first was about demographic questions, the second to record anthropometric measures and the third to score the risk for malnutrition using a nutritional risk screening tool (STRONGkids®).

Data were collected from the patients' medical records, and from interviews with the patients and family members. The children's age was categorized into four different clusters: one month - one year, two - five years, six -10 years, and 11 - 17 years. The length of hospital stay (LOS) was divided into two groups: less than four days (inclusive) and more than four days; the cut-off was calculated as the median. The medical condition that led to the admission was classified according to different groups as respiratory, infectious, gastroenterological, neurological, psychiatric, cardiovascular, trauma/surgical, or other. For the purpose of comparison, the relative and absolute weight loss of body weight was also calculated such as the verification of infectious complications that were diagnosed if any one of three occurred with the clinical syndrome: (1) fever (body temperature above 38.5º C without the presence of other fever-causing factors such as surgery, blood transfusion, infusion reactions or drug fever), along with incision pain, swelling, cough, sore throat, abdominal pain, diarrhoea, frequent or urgent urination, dysuria, and other clinical manifestations, (2) presence of pathogens in incision secretions, throat swabs, sputum, urine, faeces, blood and bone marrow specimens being positive in culture; or (3) chest X-ray or another diagnostic test showing infection.

The anthropometric measurements were taken following a protocol (Appendix 2: https://www.actamedicaportuguesa.com/revista/index.php/amp/article/view/16768/15026) and included weight, length/height, and mid-upper arm circumference (MUAC). Children were weighed on a calibrated electronic scale [weight < 20 kg using Oriola® data baby-scale 930 (precision 0.001 kg) and > 20 kg using SECA® 703 column scale (precision 0.1 kg)] naked and without diaper or wearing minimal clothing (light underwear and without socks or shoes). Height was measured using an infantometer in children aged below two years (Jofre®, precision 0.5 cm), and a stadiometer included in the SECA® 703 column scale (precision 0.1 cm) in those aged over two years, with the child barefoot. The mid-upper arm circumference was measured in all children using a measuring tape.

Anthropometric data were compared with reference values for height-for-age (HFA), weight-for-height (WFH) and body mass index (BMI) defined by the World Health Organization (WHO).[26-29]

For preterm infants, Fenton curves were used up to 50 weeks of chronological age, after which the WHO curves were the reference.[4,30,31]

Malnutrition was defined according to the WHO guidelines as acute if < −2 SD of WFH or BMI for ages under five years and from five to 18 years, respectively; and chronic if < −2 SD of HFA. With regards to severity, acute malnutrition was defined as; moderate if WFH or BMI-for-age ≤ -2 SD and ≥ -3 SD of the median; and severe if WFH or BMI-for-age < -3 SD; chronic malnutrition was: moderate if HFA ≤ -2 SD and ≥ -3 SD; and severe if HFA < -3 SD. For the purpose of this article, malnutrition refers to the presence of acute and/or chronic malnutrition.[9,13,29]

The z-scores for anthropometric indices were calculated using the software WHO Anthro® and WHO AnthroPlus®, for the age group zero to five and five to 19 years, respectively.[30-32]

The nutritional risk screening tool included was STRONGkids® to score the risk for malnutrition, conducted using the Portuguese version of the questionnaire.[24] The STRONGkids® tool consists of four scored questions addressing the underlying disease, subjective clinical assessment, weight changes, food intake, and losses. At the end, the total sum of the points is calculated, with a minimum of zero and a maximum of five points, and the nutritional risk is classified as 'low' (zero points), 'moderate risk' (one to three points), or 'high' (four or five points).[13,23]

Depending on the STRONGkids® score, children were re-evaluated and when necessary, referred to a nutritionist according to the protocol. In 'low risk', reassessment was scheduled every five days; 'moderate risk', after 72 hours and if the score was maintained or changed to high, the patient was referred for nutritional support; patients diagnosed as 'high risk' were immediately referred to the nutritionist and re-evaluated after 72 hours. Patients at nutritional risk referred to a nutritionist underwent a complete assessment of their nutritional status (anthropometric measures, clinical history data, recent analytical results, and dietary history) and individual nutritional plans were established.

Statistical analysis

IBM Statistical Package for Social Sciences (SPSS®) version 26 was used for data analysis. The clinical outcomes for the different groups were compared with the Mann-Whitney U test; the chi-square and Fisher exact tests were performed to compare proportions between groups. Logistic regression analysis was used to compare 'nutritionally at risk' or low-risk STRONGkids® scores and 'nutritionally not at risk' or moderate to high-risk children in STRONGkids®. Sensitivity, specificity, negative and positive predictive values (NPV and PPV, respectively) were also calculated for the following outcome variables: acute, chronic and malnutrition (WFH/BMI < -2 SD, HFA < -2 SD or both, respectively), MUAC < -2 SD, hospital LOS over four days and weight loss over 2%. Correlation studies were demonstrated in r values provided (Spearman correlation; $p < 0.05$ was considered significant).

RESULTS

Characteristics of the study participants

During the three months, there were 283 children hospitalized of whom 210 met the inclusion criteria and were enrolled in the study. However, 22 children were excluded because the STRONGkids® score was absent or incomplete, leaving a total of 188 patients. The median age was 4.78 years, 68 (36.2%) were girls and 120 (63.8%) were boys. The median for the LOS was four days (1 to 54 days).

Risk classification and anthropometric measures

Anthropometric characteristics of patients are shown in Table 1.

There was no significant association found between STRONGkids® risk stratification and the age and sex neither comparing with LOS ($p = 0.076$ and $p = 0.747$, respectively).

Regarding the risk classification, 82 (43.6%) presented a low-risk score, 102 (56.4%) moderate risk and only four (2.1%) high risk. The moderate and high-risk patients were analysed together as a group.

Using nutritional assessment at admission through anthropometric measures: 29 (15%) were classified as malnourished (acute and/or chronic) and 129 (69%) as not being malnourished. Of these, 151 (80.3%) were classified as not acute malnourished (WFH > -2 SD), six (3%) had moderate acute undernutrition (WFH ≤ -2 SD and ≥ -3 SD) and four (2%) severe acute undernutrition (WFH< -3 SD); 143 (76%) were classified as not chronic malnourished (HFA > -2 SD), 13 (7%) as moderate chronic malnourished (HFA ≤ -2 SD and ≥ -3 SD) and 10 (5%) as severe chronic malnourished (HFA < -3 SD).

A statistically significant association was found comparing the STRONGkids® stratification and the state of

Table 1 – Patients' anthropometric characteristics

		Age cluster											
		Infant			Pre-school			School			Adolescent		
		n	Median	IQ (25^{th}; 75^{th})	n	Median	IQ (25^{th}; 75^{th})	n	Median	IQ (25^{th}; 75^{th})	n	Median	IQ (25^{th}; 75^{th})
Anthropometry	Weight (kg)	37	7.49	(5.22; 8.14)	60	12.6	(10.55; 15.34)	19	29.4	(23.1; 31.4)	51	55.7	(45.60; 62.53)
	Stature/lenght (cm)	36	61.75	(57.25; 69.00)	58	86.75	(80.00; 104.00)	19	131	(126.90; 136.25)	53	160.5	(153.88; 171.00)
	BMI (kg/m^2)	39	16.29	(14.73; 17.29)	61	15.839	(14.56; 17.12)	21	15.72	(15.09; 17.42)	61	19.63	(16.85; 22.62)
	MUAC (cm)	36	13.25	(11.88; 14.00)	56	15.5	(14.56; 16.58)	18	19.7	(17.50; 20.55)	55	24	(22.23; 27.13)
Z-scores	Weight-for-age	33	-0.69	(-1.75; 0.19)	59	-0.11	(-0.84; 0.60)	14	0.29	(-0.88; 0.92)	*	*	*
	Height-for-age	34	-1.29	(-2.09; 0.04)	59	-0.36	(-1.28; 0.60)	19	0.1	(-0.81; 0.73)	52	-0.6	(-0.56; 0.54)
	WFH and BMI/age[a]	33	-0.26	(-0.93; 0.37)	59	-0.07	(-0.46; 1.01)	19	0.12	(-1.05; 0.76)	50	0.25	(-0.35; 0.87)
	MUAC[b]	22	-0.43	(-1.50; 0.36)	49	0.167	(-0.38; 0.84)	*	*	*	*	*	*

IQ: interquartile range
[a]: Weight-for-height and body mass index/age for ages under 5 years and from 5 to 18 years, respectively
[b]: Mid-upper arm circumference
*: Data excluded because of low number of cases included

malnutrition at admission (whether acute or chronic) as well as being acutely malnourished at admission ($p = 0.018$ and $p = 0.011$, respectively) (Table 2).

Clinical outcomes of patients by risk classification

Sixty-five (34.5%) children were identified at the time of admission as having an underlying disease before admission. Of those, 23 had acute conditions and 42 had chronic conditions (12.2% *vs* 22.3%). According to the existing medical conditions upon admission, 65 (34.6%) patients were classified as having an infectious disease, 45 (23.9%) respiratory, 34 (18.1%) trauma/surgical, 17 (9.0%) psychiatric and 27 (14.4%) other conditions. According to the definition of cases as medical or surgical, 154 (81.9%) were classified as medical and 34 (18.1%) as surgical.

Having underlying disease at admission, type of diagnostic categories and medical versus surgical condition on admission were all significantly different among the different risk groups ($p = 0.019$, $p = 0.001$ and $p = 0.006$, respectively).

For comparing terms with data from previous studies,[11,33] the children who had records of body weight at admission and at discharge, only eight (9.76%) had lost more than 2% of the total weight in the group that scored as low risk, 23 (22.55%) in the group that scored moderate risk and none in the group that scored as high risk. A statistically significant association between STRONGkids® risk stratification and weight loss was not found ($p = 0.185$).

Regarding infectious complications, there were 112 (59.6%) children who presented infectious complications *versus* 76 (40.4%) that did not. A significant association between STRONGkids® risk stratification and the presence of infectious complications was found ($p < 0.001$) (Table 2).

Concurrent and prospective validity of STRONGkids®

In our study, STRONGkids® had a sensitivity of 90%, a specificity of 44%, a PPV of 10% and a NPV of 99% for detecting acutely malnourished children, while STRONGkids® had a sensitivity of 74%, a specificity of 45%, an PPV of 18% and a NPV of 91% for detecting chronic malnourished children (Table 3).

Logistic regression

After producing a multivariate analysis and eliminating the variables sex, presence of disease upon admission and diagnostic group of disease, the logistic regression analysis showed the children that scored as moderate or high risk versus low risk had 2.23 (95% CI 0.862 – 5.779) times greater odds of being malnourished and 2.01 (95% CI, 0.38 – 10.70) times greater odds of losing more than 2% of weight upon admission. The odds of children that were scored as moderate or high risk versus low risk for children with

Table 2 – Characteristics at admission and clinical outcomes of children with risk groups of each nutritional risk screening tools analysed by the chi-squared test, fisher exact test and Mann–Whitney U-test

			STRONGKids®				
			Low risk		Moderate and high risk (only high risk)		*p* value
	n	%	n	%	n	%	
Total	188	100.0%	82	43.6%	106 (4)	56.4% (2.1%)	
Age							
Infant [1m - 1y]	42	22.3%	19	23.2%	23 (1)	21.7% (0.9%)	
Pre-school [2y - 5y]	65	34.6%	21	25.6%	44 (2)	41.5% (1.9%)	0.076
School [6y - 10y]	21	11.2%	10	12.2%	11 (0)	10.4% (0.0%)	
Adolescent [11y - 17y]	60	31.9%	32	39.0%	28 (1)	26.4% (0.9%)	
Sex							
Female	68	36.2%	24	29.3%	44 (1)	41.5% (0.9%)	0.083
Male	120	63.8%	58	70.7%	62 (3)	58.5% (2.8%)	
Weight-for-height (acute malnutrition)[a]							
Not acute malnourished (WFH > -2 SD)	151	80.3%	67	81.7%	84 (1)	79.2% (0.9%)	
Moderate acute malnourished (WFH < -2 SD and > -3 SD)	6	3.2%	1	1.2%	5 (1)	4.7% (0.9%)	< 0.05*
Severe acute malnourished (WFH < -3SD)	4	2.1%	0	0.0%	4 (1)	3.8% (0.9%)	
Height-for-age (chronic malnutrition)[a]							
Not chronic malnourished (HFA > -2 DP)	143	76.1%	64	78.0%	79 (3)	74.5% (2.8%)	
Moderate chronic malnutrition (HFA < -2 DP and > -3 DP)	13	6.9%	3	3.7%	10 (0)	9.4% (0.0%)	0.98
Severe chronic malnutrition (HFA < -3 SD)	10	5.3%	3	3.7%	7 (0)	6.6% (0.0%)	
Malnourished at admission (acute or chronic)[a]							
No	129	68.6%	58	70.7%	71 (1)	66.9% (0.9%)	< 0.05*
Yes	29	15.4%	7	8.5%	22 (2)	20.8% (1.9%)	
Previous disease upon admission[a]							
No	120	63.8%	60	73.2%	60 (0)	56.6% (0.0%)	
Yes, acute	23	12.2%	6	7.3%	17 (0)	16.0% (0.0%)	< 0.05*
Yes, chronic	42	22.3%	15	18.3%	27 (4)	25.5% (3.8%)	
Diagnostic group							
Respiratory	45	23.9%	19	23.2%	46 (1)	43.4% (0.9%)	
Infectious	65	34.6%	15	18.3%	30 (1)	28.3% (0.9%)	
Psychiatric	17	9.0%	9	11.0%	8 (1)	7.5% (0.9%)	< 0.05*
Trauma/surgical	34	18.1%	22	26.8%	12 (0)	11.3% (0.0%)	
Other	27	14.4%	17	20.7%	10 (1)	9.4% (0.9%)	
Division medical/surgical							
Medical	154	81.9%	60	73.2%	94 (4)	88.7% (3.8%)	< 0.05*
Surgical	34	18.1%	22	26.8%	12 (0)	11.3% (0.0%)	
Lenght of stay							
< 4 days	90	47.9%	37	45.1%	53 (3)	50.0% (2.8%)	
> 4 days	92	48.9%	40	48.8%	52 (1)	49.1% (0.9%)	0.747
Excluded	6	3.2%	5	6.1%	1 (0)	0.9% (0.0%)	
Weight loss							
No	157	83.5%	74	90.2%	83 (4)	78.3% (3.8%)	0.185
Yes (> 2%)	31	16.5%	8	9.8%	23 (0)	21.7% (0.0%)	
Infectious intercurrence							
No	76	40.4%	48	58.5%	28 (2)	26.4% (1.9%)	< 0.05*
Yes	112	59.6%	34	41.5%	78 (2)	73.6% (1.9%)	

[a]: Some results were not possible to display in the table because they were excluded or not measured
*: Significant for $p < 0.05$

Table 3 – Performance of the STRONGkids® tool accuracy tests in relation to the anthropometric indexes of malnourished children and those at nutritional risk

	Sensitivity	Specificity	PPV	NPV	Accuracy
Z-score WFH/BMI (acute malnutrition)	90.0%	44.4%	9.7%	98.5%	47.2%
Z-score HFA (Chronic malnutrition)	73.9%	44.8%	17.7%	91.4%	48.8%
Malnourished (either acute or chronic)	77.4%	45.8%	25.3%	89.6%	52.0%
Z-score MUAC	64.8%	53.8%	88.5%	21.9%	63.1%
Weight loss	77.8%	44.7%	6.6%	97.6%	46.3%
Infectious intercurrence	69.4%	62.3%	72.6%	58.5%	66.5%
Lengh of stay	58.9%	43.0%	50.0%	51.9%	50.8%

MUAC: mid-upper arm circumference; NPV: negative predictive value; PPV: positive predictive value

infectious complications was 3.09 (95% CI, 1.41 – 6.79) times greater odds compared with children without infectious complications and it showed a strong association ($p = 0.005$). Spearman's r was used to determine correlations between continuous variables) (Table 4).

DISCUSSION

Although the consequences of malnutrition in hospitalized patients are consensually recognized, nutritional screening tools – in addition to being validated – are not yet employed in Portugal on the desired scale. This study is one of the few assessing nutritional status through the use of the STRONGkids® tool Portuguese paediatric hospitalization and anthropometric measures and our data is consistent with that published by Sousa *et al*[17] and by Huysentruyt *et al*[11] and reinforced by Carter *et al*[34], in that half of paediatric patients lose weight while hospitalized and those who were malnourished on admission are being discharged without improvement of nutrition status. There is a growing need to screen nutritional status to identify malnourished children early.[11,17,34]

According to WHO cut-off values, our findings concur with those of studies from other European countries.[11,35,36] Compared with countries from Latin America and Africa, the prevalence of acute malnutrition in our study was lower.[38,39] The sensitivity of the STRONGkids® calculated in this study to detect acutely malnourished children was 90.0% and 73.9% to detect chronically malnourished children. Sensitivity is argued as being important when it comes to screening tests which leads us to consider STRONGkids® as a good screening tool when it comes to detecting acutely malnourished children but not as good for chronically malnourished children. The NPV and PPV calculated for acute malnutrition was 98.5% and 9.7% respectively, and the NPV and PPV calculated for chronic malnutrition was 91.4% and 17.7% respectively, being approximate to what is found in other developed countries. This means that in a population with this prevalence rate, 2.5% will have a probability of being acutely malnourished and 8.6% will have a probability of being chronically malnourished.[11]

There were only four children that were scored as high risk in STRONGkids®, of whom two had a history of congenital heart condition (six months and two years of age), one had a history of serious dysmorphic syndrome and the other was an adolescent with a history of autism and a severe eating behaviour disorder. We believe that the lower number of patients classified with high risk compared to the number of patients with moderate risk can be justified with two reasons 1) Only twelve cases had one of the conditions specified in the table attached to the STRONGkids® questionnaire which refers to previous conditions before the admission or 2) the observer underestimated the nutritional deficiency when carrying out the questionnaire.

Moreover, one interesting finding was that two infants that were diagnosed as having failure to thrive and scored as low nutritional risk, which suggests that the application of this questionnaire might underestimate this kind of cases probably because of its user-dependent, subjective nature. The evaluation using STRONGkids® along with the objective anthropometric evaluation seems to prevent cases like

Table 4 – Multivariate logistic analysis for predictors of higher STRONGkids® score

	Significance	OR	95% CI
Age	0.681	1.013	0.951 - 1.079
Long length of Stay (> 4 days)	0.780	0.909	0.464 - 1.780
Weight loss > 2%	0.415	2.006	0.376 - 10.703
Malnourished (general)	0.098	2.233	0.862 - 5.779
Infectious complication	0.005	3.096	1.412 - 6.789

OR: odds ratio; CI: confidence interval

these from being underestimated.

Our study found a strong correlation between the STRONGkids® screening and the state of malnutrition at admission (acute and/or chronic) and being acutely malnourished at admission but not with having chronic malnutrition at admission, which may indicate a weaker prediction of this type of patients.

Thirty-four-point six percent of the total number of children had a previous condition at admission, contrasting with 63.8% that did not. The STRONGkids® screening showed a strong correlation between the presence of a previous condition at admission, which strengthens the evidence that having a previous history of health problems predicts higher nutritional risk.

In terms of the type of condition upon admission, of the children that were scored as being at nutritional risk, 43.4% had an infectious disease on admission and 28.3% had a respiratory disease on admission – which comprises a total of 71.7% of all disease types at admission – showing a high prevalence of malnutrition in this type of diseases.

Nutritional deterioration was found in 10% of the children with low malnutrition risk and 21.7% of the children with moderate and high risk. Even though there was no statistically significant correlation found between the STRONGkids® score and nutritional deterioration, our data shows that higher-risk children might have a higher probability of developing acute malnutrition.

Our study found a strong correlation between the children scored as being at risk of malnutrition and the presence of infectious complications at admission. Compared with Cao *et al*,[39] the prevalence of infectious complications distributed in the STRONGkids® stratification is similar, as 73.6% of the children that were at risk had infectious complications.[39] Our findings show that the presence of infectious complications will affect the probability of malnutrition on admission and may validate items that are related to the presence of infection. This opens the possibility of further adaptations of this tool.

We believe that a weakness of this study was the fact that the hospital where it was performed is a second-level hospital, which made it impossible to add and assess some serious cases; it was not possible to assess anthropometric measures in a considerable percentage of surgical patients because of logistic reasons. The fact that the assessment of the STRONGkids® questionnaire and anthropometric measurements were made by different professionals may be a limitation as it can present different assessments for the same individual. In terms of opportunities, there should be studies on how the STRONGkids® Portuguese translation assessed nutritional screening and if there are changes that need to be made. It would be important to carefully evaluate the children that had nutritional intervention, how they were followed up during the intervention, and assess morbidity and mortality and possible readmission rates. It would be also interesting to assess the intrarater and interrater reliability of the process of this screening assessment.

CONCLUSION

STRONGkids® is a simple, quick nutritional screening tool for hospitalized children which demonstrates sustained evidence of being a reliable tool for assessing nutritional status on admission and all the valuable additional information related to it. Given that a considerably high percentage of children were identified as being at risk for malnutrition, it is essential to identify this early and provide nutritional intervention during and after hospitalization in order to improve individual and systematic health outcomes.

AWARDS AND PREVIOUS PRESENTATIONS:

Presented in poster format with presentation on December 6th, 2019, at the 11th Excellence in Pediatrics Conference.

AUTHOR CONTRIBUTIONS

All authors contributed equally to this manuscript.

PROTECTION OF HUMANS AND ANIMALS

The authors declare that the procedures were followed according to the regulations established by the Clinical Research and Ethics Committee and to the Helsinki Declaration of the World Medical Association updated in 2013.

DATA CONFIDENTIALITY

The authors declare having followed the protocols in use at their working center regarding patients' data publication.

COMPETING INTERESTS

The authors have declared that no competing interests exist.

FUNDING SOURCES

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

REFERENCES

1. Rito A, Breda J, Carmo I. Guia de avaliação do estado nutricional infantil e juvenil. Instituto Nacional de Saúde Dr. Ricardo Jorge. 2010. [cited 2021 Mar 10]. Available from: https://www.insa.min-saude.pt/wp-content/uploads/2017/11/GuiaAvaliacaoEstadoNutricional.pdf.
2. Moutinho JC. Estudo de rastreio de risco nutricional: strongkids das crianças internadas no Hospital Pediátrico de Coimbra. 2014. [cited 2021

Mar 10]. Available from: https://estudogeral.uc.pt/handle/10316/31556.
3. Guerra AJ, Teixeira Santos N, Almeida Santos L, Carreiro E, Morais MR, Prata A. Avaliação nutricional infantil. Rev Port Pediatr. 1990;21:5-46.
4. Lochs H, Allison SP, Meier R, Pirlich M, Kondrup J, Van den Berghe G, et al. Introductory to the ESPEN guidelines on enteral nutrition: terminology, definitions and general topics. Clin Nutr. 2006;25:180-6.
5. Campanozzi A, Russo M, Catucci A, Rutigliano I, Canestrino G, Giardino I, et al. Hospital-acquired malnutrition in children with mild clinical conditions. Nutrition. 2009;25:540-7.
6. Moreno Villares JM, Varea Calderón V, Bousoño García C, Lama Moré R, Redecillas Ferreiro S, Peña Quintana L. Evaluación del estado nutricional de niños ingresados en el hospital en España: estudio DHOSPE (Desnutrición Hospitalaria en el Paciente Pediátrico en España). Nutr Hosp. 2013;28:709-18.
7. Costa C, Matos C, Cândido C, Gaspar E. Avaliação do risco nutricional e caracterização do estado nutricional de crianças internadas. Acta Port Nutr. 2017;10:18-22.
8. Pawellek I, Dokoupil K, Koletzko B. Prevalence of malnutrition in paediatric hospital patients. Clin Nutr. 2008;27:72-6.
9. Joosten KF, Hulst JM. Prevalence of malnutrition in pediatric hospital patients. Curr Opin Pediatr. 2008;20:590-6.
10. Sermet-Gaudelus I, Poisson-Salomon AS, Colomb V, Brusset MC, Mosser F, Berrier F, et al. Simple pediatric nutritional risk score to identify children at risk of malnutrition. Am J Clin Nutr. 2000;72:64-70.
11. Huysentruyt K, Alliet P, Muyshont L, Rossignol R, Devreker T, Bontems P, et al. The STRONGkids nutritional screening tool in hospitalized children: a validation study. Nutrition. 2013;29:1356-61.
12. Portugal. Despacho n.º 6634/2018 do Gabinete do Secretário de Estado Adjunto e da Saúde. Diário da República, II Série, n.º 129 (2018/07/06). p.1-2.
13. Hulst JM, Zwart H, Hop WC, Joosten KF. Dutch national survey to test the STRONGkids nutritional risk screening tool in hospitalized children. Clin Nutr. 2010;29:106-11.
14. Rocha GA, Rocha EJ, Martins CV. Hospitalização: efeito sobre o estado nutricional em crianças. J Pediatr. 2006;82:70-4.
15. Mehta NM, Corkins MR, Lyman B, Malone A, Goday PS, Carney L, et al. Defining pediatric malnutrition: a paradigm shift toward etiology-related definitions. J Parenter Enteral Nutr. 2013;37:460-81.
16. Joosten KF, Hulst JM. Nutritional screening tools for hospitalized children: methodological considerations. Clin Nutr. 2014;33:1-5.
17. Sousa I, Mendes I, Lopes J, Mendes A, Franchini B, Carvalho R. Nutritional risk screening in azorean hospitalized children: a portuguese validation study. Port J Pediatr. 2022;53:383-92.
18. Guarino A, Albano F, Ashkenazi S, Gendrel D, Hoekstra JH, Shamir R, et al. European Society for Paediatric Gastroenterology, Hepatology, and Nutrition/European Society for Paediatric Infectious Diseases evidence-based guidelines for the management of acute gastroenteritis in children in Europe: executive summary. J Pediatr Gastroenterol Nutr. 2008;46:619-21.
19. Hartman C, Shamir R, Hecht C, Koletzko B. Malnutrition screening tools for hospitalized children. Curr Opin Clin Nutr Metab Care. 2012;15:303-9.
20. Moeeni V, Walls T, Day AS. Assessment of nutritional status and nutritional risk in hospitalized Iranian children. Acta Paediatr. 2012;101:e446-51.
21. Moeeni V, Walls T, Day AS. Nutritional status and nutrition risk screening in hospitalized children in New Zealand. Acta Paediatr. 2013;102:e419-23.
22. Direção-Geral da Saúde. Programa Nacional para a Promoção da Alimentação Saudável. Lisboa: DGS; 2020.
23. Matos C, Faria A, Vasconcelos C, Asseiceira I, Tomada I, Dias MP, et al. NOP 001/2018. Versão 01 - Identificação do Risco Nutricional em Idade Pediátrica. 2018. [cited 2021 Mar 22]. Available from: https://www.ordemdosnutricionistas.pt/documentos/NOP/NOP/NOP0012018-RNIdadePediatrica01062018.pdf.
24. Maciel JR, Nakano EY, Carvalho KM, Dutra ES. STRONGkids validation: tool accuracy. J Pediatr. 2020;96:371-8.
25. Barros TA, da Silva Cruvel JM, de Melo Silva B, Pires BR, Barroso MP, Coutinho MA, et al. Agreement between nutritional risk screening tools and anthropometry in hospitalized pediatric patients. Clin Nutr. 2022;47:227-32.
26. World Health Organization. Length/height-for-age. 2015. [cited 2021 Apr 02]. Available from: http://www.who.int/childgrowth/standards/height_for_age/en/.
27. World Health Organization. Weight-for-length/height. 2015. [cited 2021 Jun 16]. Available from: http://www.who.int/childgrowth/standards/weight_for_height/en/.
28. World Health Organization. BMI-for-age (5-19 years). 2015. [cited 2021 May 18]. Available from: http://www.who.int/growthref/who2007_bmi_for_age/en/.
29. World Health Organization. Management of severe malnutrition: a manual for physicians and other senior health workers. Geneva: World Health Organization; 1999.
30. Chou JH, Roumiantsev S, Singh R. PediTools electronic growth chart calculators: applications in clinical care, research, and quality improvement. J Med Internet Res. 2020;22:e16204.
31. Fenton TR, Kim JH. A systematic review and meta-analysis to revise the Fenton growth chart for preterm infants. BMC Pediatr. 2013;13:1-13.
32. World Health Organization. Growth reference data for 5-19 years. 2009. [cited 2021 Mar 12]. Available from: https://www.who.int/tools/growth-reference-data-for-5to19-years/application-tools.
33. Sermet-Gaudelus I, Poisson-Salomon AS, Colomb V, Brusset MC, Mosser F, Berrier F, et al. Simple pediatric nutritional risk score to identify children at risk of malnutrition. AmJ Clin Nutr. 2000;72:64-70.
34. Carter LE, Shoyele G, Southon S, Farmer A, Persad R, Mazurak VC, et al. Screening for pediatric malnutrition at hospital admission: which screening tool is best? Nutr Clin Pract. 2020;35:951-8.
35. Widhalm K, Rashidian F, Emminger W, Huber WD, Bariss-Riedl M, Fritsch M, et al. Malnutrition in hospitalized children aged 3-18 years. Results by using a new score in comparison with previous described scores. J Ernährungsmedizin. 2007;9:13-7.
36. Hendrikse WH, Reilly JJ, Weaver LT. Malnutrition in a children's hospital. Clin Nutr. 1997;16:13-8.
37. Shaaban S, Nassar M, El-Gendy Y, El-Shaer B. Nutritional risk screening of hospitalized children aged < 3 years. Eastern Mediterr Health J. 2019;25:18-23.
38. Rocha GA, Rocha EJ, Martins CV. Hospitalização: efeito sobre o estado nutricional em crianças. J Pediatr. 2006;82:70-4.
39. Cao J, Peng L, Li R, Chen Y, Li X, Mo B, et al. Nutritional risk screening and its clinical significance in hospitalized children. Clin Nutr. 2014;33:432-6.