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Comparison of four different nutritional risk screening tools in hospitalized children

Comparação de quatro ferramentas diferentes de triagem de risco nutricional em crianças hospitalizadas

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ABSTRACT

Objective

Early detection of malnutrition risk in hospitalized children can improve health outcomes and quality of life; however, the number of studies where the pediatric screening tool is appropriate for Turkish children is limited. Therefore, this article aims to determine the prevalence of malnutrition risk in pediatric patients evaluated with Screening Tool for Risk on Nutritional Status and Growth, Screening Tool for the Assessment of Malnutrition in Pediatrics, Pediatric Yorkhill Malnutrition Score, and Simple Pediatric Nutrition Screening Tool with original and adjusted cutoffs and to evaluate which pediatric screening tool is appropriate for Turkish children.

Methods

In this cross-sectional study, four published nutritional risk screening tools (Screening Tool for Risk on Nutritional Status and Growth, Screening Tool for the Assessment of Malnutrition in Pediatrics, Pediatric Yorkhill Malnutrition Score, Pediatric Nutrition Screening Tool) were applied to pediatric inpatients (n=604) aged 1 month to 17 years, admitted to a pediatric ward for at least 24 hours.

Results

Pediatric Nutrition Screening Tool with adjusted cutoffs had the greatest recognition rate (94.2%) of acute malnutrition. Having a high nutritional risk by Pediatric Yorkhill Malnutrition Score was associated with an increased risk of acute (OR: 6.57 for Screening Tool for Risk on Nutritional Status and Growth, 5.84 for Screening Tool for the Assessment of Malnutrition in Pediatrics, and 20.35 for Pediatric Yorkhill Malnutrition Score) and chronic malnutrition (OR: 1.27 for Screening Tool for Risk on Nutritional Status and Growth, 3.28 for Screening Tool for the Assessment of Malnutrition in Pediatrics, and 1.72 for Pediatric Yorkhill Malnutrition Score). Classifying the at-risk category by the Pediatric Nutrition Screening Tool was related to raised odds of malnutrition (OR: 2.64 for original and 5.24 for adjusted cutoffs). This positive association was also observed for acute (OR: 4.07 for original cutoffs, and 28.01 for adjusted cutoffs) and chronic malnutrition (OR: 1.14 for original cutoffs, and 1.67 for adjusted cutoffs).

Conclusion

Pediatric Nutrition Screening Tool with adjusted cutoffs and Pediatric Yorkhill Malnutrition Score have higher diagnostic accuracy than other screening tools in assessing the nutritional status of hospitalized Turkish children and detecting children, particularly with acute malnutrition.

Keywords: Child, hospitalized. Malnutrition. Nutrition assessment.

RESUMO

Objetivo

A detecção precoce do risco de desnutrição em crianças hospitalizadas pode melhorar a saúde e a qualidade de vida, porém o número de estudos em que a ferramenta de triagem pediátrica é apropriada para crianças turcas é limitado. O objetivo deste estudo foi determinar a prevalência do risco de desnutrição em pacientes pediátricos avaliados com Ferramenta de Triagem para Risco no Estado Nutricional e Crescimento, Ferramenta de Triagem para Avaliação de Desnutrição em Pediatria, Escore de Malnutrição Pediátrica de Yorkhill e Ferramenta de Triagem de Nutrição Pediátrica Simples com pontos de corte originais e ajustados para avaliar qual ferramenta de triagem pediátrica é apropriada para crianças turcas.

Métodos

Neste estudo transversal, quatro ferramentas de triagem de risco nutricional publicadas (Ferramenta de Triagem para Risco no Estado Nutricional e Crescimento, Ferramenta de Triagem para Avaliação de Desnutrição em Pediatria, Escore de Malnutrição Pediátrica de Yorkhill, Ferramenta de Triagem de Nutrição Pediátrica) foram aplicadas a pacientes pediátricos (n=604) com idades entre 1 mês e 17 anos, internados em uma enfermaria pediátrica por pelo menos 24 horas.

Resultados

A Ferramenta de Triagem de Nutrição Pediátrica com pontos de corte ajustados obteve a maior taxa de reconhecimento de desnutrição aguda (94,2%), enquanto a Ferramenta de Triagem para Avaliação de Desnutrição em Pediatria teve a maior taxa na identificação da desnutrição crônica (67,4%). Essas associações positivas foram mais notáveis para desnutrição aguda (OR: 6,57 para Ferramenta de Triagem para Risco no Estado Nutricional e Crescimento, 5,84 para Ferramenta de Triagem para Avaliação de Desnutrição em Pediatria e 20,35 para Escore de Malnutrição Pediátrica de Yorkhill) do que para desnutrição crônica (OR: 1,27 para Ferramenta de Triagem para Risco no Estado Nutricional e Crescimento, 3,28 para Ferramenta de Triagem para Avaliação de Desnutrição em Pediatria e 1,72 para Escore de Malnutrição Pediátrica de Yorkhill). A classificação da categoria de risco pela Ferramenta de Triagem de Nutrição Pediátrica foi relacionada a maiores chances de desnutrição (OR: 2,64 para pontos de corte originais e 5,24 para pontos de corte ajustados). Essa associação positiva também foi observada para desnutrição aguda (OR: 4,07 para pontos de corte originais e 28,01 para pontos de corte ajustados) e crônica (OR: 1,14 para pontos de corte originais e 1,67 para pontos de corte ajustados).

Conclusão

A Ferramenta de Triagem de Nutrição Pediátrica com pontos de corte ajustados e Escore de Malnutrição Pediátrica de Yorkhill têm maior precisão diagnóstica do que outras ferramentas de triagem na avaliação do estado nutricional de crianças turcas hospitalizadas e na detecção da desnutrição aguda em particular.

Palavras-chave: *Criança hospitalizada. Desnutrição. Avaliação nutricional.*

INTRODUCTION

Pediatric malnutrition is "an imbalance between nutrient requirements and intake that results in cumulative deficits of energy, protein, or micronutrients that may negatively affect growth, development, and other relevant outcomes" [1]. Malnutrition in hospitalized pediatric patients is an abnormal condition that may occur due to acute or chronic disease-related factors such as increased energy and nutrient requirements, increased nutrient losses, and poor nutritional status at hospitalization [1,2]. The prevalence ranges from 6 to 41% for acute and 8 to 47% for chronic malnutrition [3].

Anthropometry and average growth charts can follow normal growth and detect nutritional deficiencies. However, they are not suitable and sufficient for the early detection of malnutrition risk developed due to an acute condition [4]. Therefore, it is critical to identify pediatric patients at risk for malnutrition to prevent the deterioration of nutritional status [5]. The European Society for Clinical Nutrition and Metabolism (ESPEN), and the European Society for Pediatric Gastroenterology Hepatology and Nutrition (ESPGHAN) [6,7], recommends simple and rapid nutritional risk screening to identify nutritionally at-risk patients.

Screening tools aim to identify children with average anthropometric measurement results at admission yet at risk of developing malnutrition due to an acute medical condition [8]. Although several pediatric nutritional risk screening tools, such as Screening Tool for Risk on Nutritional Status and Growth (STRONGkids), Screening Tool for the Assessment of Malnutrition in Pediatrics (STAMP), Pediatric Yorkhill Malnutrition Score (PYMS), and Simple Pediatric Nutrition Screening Tool (PNST), have been reported to be effective in identifying children at risk of malnutrition, there is still no consensus on the best nutritional tool for hospitalized children [4,5,9,10].

This study aimed to determine the prevalence of malnutrition risk and compare the anthropometric measurements with the nutritional status by using four nutritional screening tools in hospitalized pediatric patients, and to evaluate which pediatric screening tool is appropriate for Turkish children. This is one of the few studies in Turkey that compared different nutritional screening tools in the pediatric population.

METHODS

This prospective cross-sectional study was conducted at a tertiary medical center between January 2019 and January 2020. Turkish children aged one month to 17 years, staying in the pediatric wards with an anticipated length of stay >24 h, were included in this study. Patients were excluded if treated in the emergency department and intensive care unit. In addition, children whose anthropometric measurements could not be performed due to neurological problems or limb deficiency, who were of another ethnic origin, and who had missing data were excluded from the study. A total of 753 patients were screened for this study, and 604 of them who met the inclusion criteria were included in the analysis. On the 1st day of admission to the hospital, patient demographic data, including age, sex, anthropometric measurements, the reason for admission, diagnosis, and parents' education status, were recorded, and four nutritional risk screening tools, including STRONGkids, STAMP, PYMS, and PNST, were applied to appropriate age ranges.

Weight was measured using a baby scale (Model 834, Seca, Birmingham, UK) with a sensitivity of 0.01 kg for under 10 kg and a children scale (Model 769, Seca, Birmingham, UK) with a sensitivity of 0.1 kg for over 10 kg. Height was measured using a Harpenden stadiometer (Holtain Ltd., Crymych, UK) with a sensitivity of 0.1 cm in children >2 years. In children <2 years, recumbent length was measured using a baby stadiometer (Model 210, Seca, Birmingham, UK). Body Mass Index (BMI) was calculated by dividing weight (kg) by height squared (m^2). Weight-for-height (WFH), height-for-age (HFA), and BMI-for-age Z-scores were calculated by using the WHO AnthroPlus Software [11].

The diagnosis of malnutrition was based on the recommendations of World Health Organization (WHO) guidelines plotted on the national growth charts as the cut-off point. Moderate malnutrition was defined as <-2 Standard Deviation Score (SDS) of WFH or HFA, and severe malnutrition was <-3 SDS of WFH or HFA. Acute malnutrition was defined as <-2 SDS for WFH, and chronic malnutrition was defined as <-2 SDS for HFA. When WFH Z-score was not available, BMI-for-age Z-score was used. Moreover, BMI-for-age >2 Z-score was considered overweight or obese [12].

The STRONGkids was developed by Hulst et al. [9] to evaluate the nutritional risks of children aged one month - 18 years. The screening tool questions the child's general condition, whether there is a high-risk disease, food intake and loss, body weight loss, and reduction in weight gain. The risk of malnutrition is evaluated in the 0-5 points range. For malnutrition, 1-3 points represent a medium risk, and 4-5 points is a high-risk.

The STAMP was developed by McCarthy et al. [10] for use by nurses in determining the nutritional risks of hospitalized children aged 2-17 years. It includes three questions evaluating factors affecting nutritional status, food intake, and anthropometric measurements. Each component carries a score of up to 3, and the total score reflects the risk of malnutrition. A score of 2 or 3 indicates medium risk, and ≥4 is high-risk.

The PYMS was developed by Gerasimidis et al. [4] as a quick and easy screening tool to detect malnutrition risk of hospitalized children aged 1-16 years, in line with ESPEN's recommendations for screening tools. It consists of 4 questions related to current nutritional status, food intake, recent changes in nutritional status, and acute diseases that will adversely affect nutritional status, with a maximum score of 7 points. A score of 0 indicates low-risk, 1 is medium risk, and 2 or above is high-risk.

The PNST was developed by White et al. [5] to determine nutritional risk in pediatric inpatients aged 0-16 years and includes four "yes-no" questions related to unintentional weight loss, insufficient weight gain, less food intake, and the patient's underweight/overweight status. Participants were evaluated using original [5] and adjusted [13] cutoffs as at risk of malnutrition or not at risk. The original cutoff is at least 2 "yes" answers, while the adjusted cutoff is 1 or more "yes" answers.

Ethics committee approval was obtained from the local ethics committee (approval nº 2018/1544), and informed consent was obtained from the parents of the children.

Power analysis was calculated in the statistical software G*Power (version 3.1), and the sample size of 604 participants provided 99.9% power based on a significance level of 0.05 and a prevalence of malnutrition of 24.2%. In addition, when sample power was estimated using malnutrition identified by WHO guidelines in relation to the malnutrition risk by the STRONGkids, STAMP, PYMS, and PNST tools obtained by Logistic regression, the sample size of 604 participants provided 99.9% power for all parameters at an alpha level of 0.05.

The IBM® SPSS® software (version 22.0) was used for statistical analysis. Categorical variables were summarized as numbers (percentage, %) and compared using the Chi-square test. Continuous variables were presented as median, minimum-maximum, and 25^{th} - 75^{th} percentiles. Normality was assessed by the Kolmogorov – Smirnov test. Since continuous variables do not follow a normal distribution, the Mann-Whitney U test was used for two-group comparisons, and the Kruskal-Wallis test was used for more groups.

Diagnostic parameters (sensitivity, specificity, and positive and negative predictive values) of STRONGkids, STAMP, PYMS, and PNST were calculated using the web-based software MedCalc's Diagnostic Test Evaluation Calculator and expressed as percentages. The 2×2 crosstab tables were constructed to assess the ability of STRONGkids, STAMP, PYMS, and PNST to detect malnutrition risk as compared with WHO diagnostic criteria. Confidence Intervals (CI) for sensitivity and specificity were "exact" Clopper-Pearson CI, while CI for the predictive values were the standard logit confidence intervals given by Mercaldo et al. 2007 [14].

Logistic regression analyses were performed to determine the associations between malnutrition identified by WHO guidelines (as a reference standard) and malnutrition risk by the STRONGkids, STAMP, PYMS and PNST tools, mother's education level, and age. Odds Ratios (OR) and 95% CI were reported. For all statistical analyses, $p<0.05$ was considered statistically significant.

RESULTS

Patient characteristics

A total of six hundred-four patients were included in this study. The patients' median age was four years (1 month – 17 years) and 54.6% were boys, 303 (50.2%) patients were under 5, and 170 (28.1%) patients were under 2 years old. The median BMI Z-score was -0.31 SDS (range − 6.90 to 4.96 SDS), and 7.5% of children were overweight or obese.

Reasons for admission were treatment (53.6%), examination (37.3%), operation (5.6%), and control (3.5%), respectively. Additionally, patients were admitted to the hospital due to reasons related to general medicine (31.3%), infectious disorders (18.2%), neurology (8.6%), surgery (8.4%), gastroenterology (8.1%), nephrology (7.9%), hemato-oncology (5.6%), endocrinology (5%), cardiology (4.8%), and immune-allergic disorders (2.0%), respectively.

The 7.1% of mothers were illiterate, and the education levels of 61.1%, 17.1%, and 14.7% were primary, secondary, undergraduate and more, respectively. The 3.0% of fathers were illiterate, and the education levels of 60.9%, 19.5%, and 16.6% were primary, secondary, undergraduate and more, respectively. The patients' demographic characteristics by scores of STRONGkids, STAMP, PYMS, and PNST were shown in Table 1.

Table 1 – Baseline characteristics of the participants by the Screening Tool for Risk on Nutritional Status and Growth, Screening Tool for the Assessment of Malnutrition in Pediatrics, Pediatric Yorkhill Malnutrition Score, and Pediatric Nutrition Screening Tool scores.

Variables†	STRONGkids			STAMP			PYMS			PNST (Original cutoffs)		PNST (Adjusted cutoffs)	
	Low-risk (n: 304)	Medium risk (n: 246)	High-risk (n: 54)	Low-risk (n: 246)	Medium risk (n: 107)	High-risk (n: 57)	Low-risk (n: 243)	Medium risk (n: 80)	High-risk (n: 150)	No risk (n: 430)	At risk (n: 150)	No risk (n: 318)	At risk (n: 262)
Age (years)	5 (1.5, 12)	4 (1.5, 10)	4 (1.2, 9.5)	8 (3.5, 13)	6 (4, 10)	7 (3.3, 10)	6 (2.6, 12)	7 (3.1, 12)	5 (3, 10)	4 (1.5, 10)	4 (1.1, 9)	4 (1.5, 10)	4 (1.1, 9.3)
<5 years	146 (48.2)	129 (42.6)	28 (9.2)	74 (55.6)	35 (26.3)	24 (18.0)	98 (50.0)	29 (14.8)	69 (35.2)	222 (73.3)	81 (26.7)	160 (52.8)	143 (47.2)
≥5 years	158 (52.5)	117 (38.9)	26 (8.6)	172 (62.1)	72 (26.0)	33 (11.9)	145 (52.3)	51 (18.4)	81 (29.2)	208 (75.1)	69 (24.9)	158 (57.0)	119 (43.0)
Sex (%)													
Male	167 (50.6)	130 (39.4)	33 (10.0)	133 (58.6)	61 (26.9)	33 (14.5)	132 (50.2)	42 (16.0)	89 (33.8)	240 (75.0)	80 (25.0)	176 (55.0)	144 (45.0)
Female	137 (50.0)	116 (42.3)	21 (7.7)	113 (61.7)	46 (25.1)	24 (13.1)	111 (52.9)	38 (18.1)	61 (29.0)	190 (73.1)	70 (26.9)	142 (54.6)	118 (45.4)
BMI Z-score (SDS)	-0.10 (-1.01, 0.95)[a]	-0.49 (-1.56, 0.58)[b]	-1.27 (-2.61, 0.003)[c]	0.11 (-0.90, 1.07)[a]	-0.52 (-1.51, 0.57)[b]	-0.79 (-1.99, 0.44)[b]	0.16 (-0.75, 1.05)[a]	0.16 (-0.73, 1.45)[a]	-1.14 (-2.43, 0.22)[b]	-0.14 (-1.03, 0.92)[a]	-0.93 (-2.36, 0.39)[b]	-0.03 (-0.85, 0.80)[a]	-0.86 (-2.38, 0.62)[b]
Malnutrition	52 (35.6)	70 (47.9)	24 (16.4)*	28 (32.6)	36 (41.9)	22 (25.6)*	26 (26.0)	12 (12.0)	62 (62.0)*	83 (58.9)	58 (41.1)*	36 (25.5)	105 (74.5)*
Moderate malnutrition	29 (36.3)	39 (48.8)	12 (15.0)*	22 (44.0)	18 (36.0)	10 (20.0)*	15 (27.3)	6 (10.9)	34 (61.8)*	48 (64.0)	27 (36.0)*	21 (28.0)	54 (72.0)*
Severe malnutrition	23 (34.8)	31 (47.0)	12 (18.2)*	6 (16.7)	18 (50.0)	12 (33.3)*	11 (24.4)	6 (13.3)	28 (62.2)*	35 (53.0)	31 (47.0)*	15 (22.7)	51 (77.3)*
Acute malnutrition	25 (27.5)	46 (50.5)	20 (22.0)*	13 (27.7)	20 (42.6)	14 (29.8)*	6 (10.5)	0 (0.0)	51 (89.5)*	41 (47.7)	45 (52.3)*	5 (5.8)	81 (94.2)*
Chronic malnutrition	32 (45.1)	32 (45.1)	7 (9.9)	15 (32.6)	21 (45.7)	10 (21.7)*	20 (38.5)	12 (23.1)	20 (38.5)	51 (71.8)	20 (28.2)	31 (43.7)	40 (56.3)*

Note: *Chi-square test, $p<0.05$. [a,b,c] Labeled means in a row without a common letter differ. †Values are given as the number (percentage, %) for qualitative variables and median (25th and 75th percentiles) for quantitative variables. BMI: Body Mass Index; PNST: Pediatric Nutrition Screening Tool; PYMS: Pediatric Yorkhill Malnutrition Score; SDS: Standard Deviation Score; STAMP: Screening Tool for the Assessment of Malnutrition in Pediatrics; STRONGkids: Screening Tool for Risk on Nutritional Status and Growth.

Prevalence of malnutrition

The prevalence of malnutrition in all participants was 24.2%, with 13.2% moderate and 10.9% severe. Malnutrition in children <5 years (31.0%) was more prevalent than in those ≥5 years (17.3%) (p<0.001), while it was higher in patients <2 years (32.4%) than in those ≥2 years (21.0%) (p=0.003). The prevalence of acute and chronic malnutrition was 15.1% and 11.8% (20.5% and 14.2% for patients <5 years; 22.9% and 14.7% for patients <2 years), respectively (Table 2). Findings of malnutrition risk by STRONGkids, STAMP, PYMS, and PNST scores were shown in Table 1.

Table 2 – Prevalence of malnutrition identified by World Health Organization guidelines.

Variables	Total		<5 years		≥5 years		p^*	<2 years		≥2 years		p^*
	n	%	n	%	n	%		n	%	n	%	
Malnutrition	146	24.2	94	31.0	52	17.3	<0.001	55	32.4	91	21.0	0.003
Moderate	80	13.2	48	15.8	32	10.6	<0.001	25	14.7	55	12.7	0.002
Severe	66	10.9	46	15.2	20	6.6		30	17.6	36	8.3	
Acute malnutrition	91	15.1	62	20.5	29	9.6	<0.001	39	22.9	52	12.0	0.001
Chronic malnutrition	71	11.8	43	14.2	28	9.3	0.062	25	14.7	46	10.6	0.159

Note: *Chi-square test. Based on the 604 hospitalized children who had the anthropometric measurements.

Malnutrition risk screening

Sensitivity, specificity, and positive and negative predictive values of the STRONGkids, STAMP, PYMS, and PNST tools cutoff scores for malnutrition risk are shown in Table 3. The STRONGkids, STAMP, and PYMS tools classified 40.7%, 26.1%, and 16.9% of patients as medium risk and 8.9%, 13.9%, and 31.7% as high-risk, respectively. When assessed by the PNST tool, 25.9% (original cutoffs) and 45.2% (adjusted cutoffs) of patients were at risk of malnutrition. The STRONGkids, STAMP, and PYMS tools identified 64.4%, 67.4%, and 74.0% of the malnourished patients in the medium – and high-risk groups, while the PNST tool based on original cutoffs had a lower recognition rate (41.1%) than those screening tools. However, when using the adjusted cutoffs, the PNST tool had the highest recognition rate (74.5%).

Table 3 – Sensitivity, specificity, positive and negative predictive values for the Screening Tool for Risk on Nutritional Status and Growth, Screening Tool for the Assessment of Malnutrition in Pediatrics, Pediatric Yorkhill Malnutrition Score, and Pediatric Nutrition Screening Tool score cutoffs in the identification of malnourished children.

Measure	Sensitivity	Specificity	PPV	NPV
	%			
Malnutrition				
STRONGkids	64.4	55.0	31.3	82.9
STAMP	67.4	67.3	35.4	88.6
PYMS	74.0	58.2	32.2	89.3
PNST (original cutoffs)	41.1	79.0	38.7	80.7
PNST (adjusted cutoffs)	74.5	64.2	40.1	88.7
Acute malnutrition				
STRONGkids	72.5	54.4	22.0	91.8
STAMP	72.3	64.2	20.7	94.7
PYMS	89.5	57.0	22.2	97.5
PNST (original cutoffs)	52.3	78.7	30.0	90.5
PNST (adjusted cutoffs)	94.2	63.4	30.9	98.4
Chronic malnutrition				
STRONGkids	54.9	51.0	13.0	89.5
STAMP	67.4	63.5	18.9	93.9
PYMS	61.5	53.0	13.9	91.8
PNST (original cutoffs)	28.2	74.5	13.3	88.1
PNST (adjusted cutoffs)	56.3	56.4	15.3	90.3

Note: NPV: Negative Predictive Value; PNST: Pediatric Nutrition Screening Tool; PPV: Positive Predictive Value; PYMS: Pediatric Yorkhill Malnutrition Score; STAMP: Screening Tool for the Assessment of Malnutrition in Pediatrics; STRONGkids: Screening Tool for Risk on Nutritional Status and Growth.

Furthermore, the PNST tool with adjusted cutoffs had the most effective recognition rate (94.2%) of acute malnutrition, while the STAMP tool had the highest rate (67.4%) of chronic malnutrition.

Associations of malnutrition with screening tools

Logistic regression results regarding associations between malnutrition and malnutrition risk by the STRONGkids, STAMP, PYMS, and PNST tools are shown in Table 4.

Table 4 – Associations between malnutrition identified by World Health Organization guidelines (as a reference standard) and malnutrition risk by the Screening Tool for Risk on Nutritional Status and Growth, Screening Tool for the Assessment of Malnutrition in Pediatrics, Pediatric Yorkhill Malnutrition Score, and Pediatric Nutrition Screening Tool, and age.

Variables†	Malnutrition	Acute Malnutrition	Chronic Malnutrition
	OR (95% CI)		
STRONGkids			
Medium risk	1.93 (1.28-2.90)	2.57 (1.53-4.32)	1.27 (0.75-2.14)
High-risk	3.88 (2.10-7.17)*	6.57 (3.30-13.05)*	1.27 (0.53-3.04)
STAMP			
Medium risk	3.95 (2.25-6.92)	4.12 (1.97-8.64)	3.76 (1.85-7.63)
High-risk	4.89 (2.52-9.49)*	5.84 (2.57-13.28)*	3.28 (1.39-7.74)*
PYMS			
Medium risk	1.47 (0.71-3.08)	0.00 (0.00-0.00)	1.97 (0.92-4.23)
High-risk	5.88 (3.49-9.90)*	20.35 (8.46-48.95)*	1.72 (0.89-3.31)
PNST (original cutoffs)			
At risk	2.64 (1.76-3.96)*	4.07 (2.53-6.54)*	1.14 (0.66-1.99)
PNST (adjusted cutoffs)			
At risk	5.24 (3.42-8.02)*	28.01 (11.15-70.40)*	1.67 (1.01-2.75)*
Age			
<2 years	1.80 (1.21-2.68)*	2.19 (1.38-3.47)*	1.45 (0.86-2.45)
<5 years	2.15 (1.47-3.17)*	2.41 (1.50-3.88)*	1.61 (0.97-2.67)
Mother's education level			
Illiterate	3.18 (1.37-7.36)*	3.48 (1.28-9.45)	3.16 (1.02-9.79)
Primary	1.83 (0.99-3.39)	1.89 (0.87-4.11)	1.97 (0.81-4.77)
Secondary	1.46 (0.69-3.05)	1.59 (0.64-3.99)	1.65 (0.59-4.67)

Note: *p-trend <0.05. †Values are Odd ratio (95% Confidence Interval) estimated through logistic regression. Reference categories are "low-risk" for STRONGkids, STAMP, and PYMS, "no risk" for PNST, "≥2 years" and "≥5 years" for age, and "undergraduate and more" for mother's education level. PNST: Pediatric Nutrition Screening Tool; PYMS: Pediatric Yorkhill Malnutrition Score; STAMP: Screening Tool for the Assessment of Malnutrition in Pediatrics; STRONGkids: Screening Tool for Risk on Nutritional Status and Growth.

A categorization as having a high nutritional risk by the PYMS tool was associated with an increased risk of malnutrition (OR: 5.88) than the STRONGkids (OR: 3.88) and STAMP (OR: 4.89) tools. These positive associations were more remarkable for acute malnutrition (OR: 6.57 for STRONGkids, 5.84 for STAMP, and 20.35 for PYMS) than chronic malnutrition (OR: 1.27 for STRONGkids, 3.28 for STAMP, and 1.72 for PYMS). Moreover, classifying the at-risk category by the PNST tool was related to raised odds of malnutrition (OR: 2.64 for original and 5.24 for adjusted cutoffs). This positive association was also observed for acute malnutrition (OR: 4.07 for original cutoffs, and 28.01 for adjusted cutoffs) and chronic malnutrition (OR: 1.14 for original cutoffs, and 1.67 for adjusted cutoffs). However, the associations with chronic malnutrition were statistically significant for only STAMP and PNST with adjusted cutoffs.

Associations of malnutrition with age and mother's educational levels

Being <2 years old significantly increased the risk of malnutrition 1.8 times, while this risk more than doubled in children <5 years old. The same pattern of results was statistically significant for only acute malnutrition (OR: 2.19 for patients <2 years, and 2.41 for patients <5 years) (Table 4).

Having an illiterate level of a mother's education was associated with the three times raised odds of malnutrition and acute and chronic malnutrition (Table 4). However, there was no relationship between the father's education level and malnutrition (data was not shown).

DISCUSSION

This is one of the few studies conducted in Turkey that compared different screening tools to determine malnutrition risk in the Turkish pediatric population. Given the attention to the consequences of malnutrition on hospitalized children, the findings of this study may signify the importance of using a nutritional risk screening tool in pediatric hospitals and help identify the appropriate screening tool for Turkish children.

In this study, the prevalence of acute and chronic malnutrition was found as 15.1% and 11.8%, respectively, in line with the relevant results of the previous studies conducted in Turkey (11.2% and 16.6%, respectively) [8]. However, local studies in the literature also reported a lower rate of chronic malnutrition and a higher rate of acute malnutrition (4.7% and 20.1%, respectively) [15,16]. The differences between the results may be attributed to using different parameters to assess the nutritional status of patients.

It is well known that children, especially the young are more susceptible and vulnerable to malnutrition than adults [17,18]. In this present study, the prevalence of acute and chronic malnutrition was found to be more common in children <5 years and < 2 years than in children aged ≥5 years and ≥2 years (31% *vs.* 17.3%, $p<0.001$; 32.4% *vs*. 21%, $p=0.003$ respectively). These results are consistent with previous studies [8,9,19,20].

Studies on pediatric screening tools used in identifying children with malnutrition risk have mostly focused on the diagnostic properties of screening tools by assessing the high-risk versus low-risk or high-risk versus moderate and low-risk children [10,15,19,21,22]. The screening tools should be able to distinguish the children at real risk of malnutrition from those exempted from the detailed nutritional assessment because they are not malnourished at the initial assessment. In a study conducted in Turkey, Pars et al. [23] found that PYMS had the highest sensitivity (96.8%), specificity (65.0%) and NPV (99.2%), STRONGkids had the lowest specificity (30.0%), and STAMP had the lowest sensitivity (70.0%). In this study, it was determined that PNST (adjusted cutoffs) had the highest sensitivity (74.5%), PNST (original cutoffs) had the highest specificity in detecting malnutrition (acute and chronic) risk. On the other hand, the PNST (with original cutoff values) screening tool had the lowest sensitivity (41.1%), and the STRONGKids had the lowest specificity (55.0%) among the screening tools investigated within the scope of this study.

In a recent study, Carter et al. [13] demonstrated that PNST was unsuitable based on threshold values for clinical use. They adjusted the threshold values of PNST for nutritional risk using receiver operating characteristics curve analysis. They consequently determined that the PNST tool with adjusted cutoff values had more robust inter-rater reliability and concurrent validity than STRONGkids. Similarly, in this study, PNST with original cutoff values had the lowest sensitivity (41.1%) among all screening tools, while PNST with adjusted cutoff values had the highest sensitivity (74.5%).

In this study, the rates of patients identified as moderate- or high-risk patients by the PYMS, PNST with adjusted cutoffs, STAMP, STRONGkids, and PNST with original cutoffs were 74.5%, 74.0%, 67.4%, 64.4%, and 41.1%, respectively. In comparison, the rates reported in different studies using pediatric screening tools vary greatly [8,13,20,22-25]. Inconsistencies between relevant results can be attributed to differences between target populations and a lack of consensus on the best method to assess nutritional status and the best definition of pediatric malnutrition, therefore, on which gold standard should be used to validate any screening tool [8,13,19,22-25]. In our study, we used the recommendations of WHO guidelines as a reference standard for diagnosing moderate, severe, acute, and chronic malnutrition. However, assessing the nutritional status of children with moderate, acute malnutrition is a challenge as no single indicator can be used alone [17].

Gerasimidis et al. [4] demonstrated that children at high-risk for malnutrition had significantly lower BMI values and that low BMI was associated with being assessed in the high-risk category. Similarly, as shown in Table 4, patients with acute malnutrition (WFL/H or BMI-for-age <-2 SDS) constituted the majority of patients in this study's high malnutrition risk category, regardless of the screening tool used.

Different authors have argued that screening tools based on anthropometric measurements (*e.g.*, PYMS and STAMP) detect a greater number of children with abnormal anthropometric measurement results compared to screening tools that do not include anthropometric measurements (*e.g.*, STRONGkids and PNST) [26,27]. However, in this study, it was determined that only the PYMS tool was associated with an increased risk of malnutrition (OR: 5.88) compared to the STAMP (OR: 4.89) and STRONGkids (OR: 3.88) tools. These positive associations were more remarkable for acute malnutrition (OR: 6.57 for STRONGkids, 5.84 for STAMP, and 20.35 for PYMS) than chronic malnutrition (OR: 1.27 for STRONGkids, 3.28 for STAMP, and 1.72 for PYMS). In addition, associations with chronic malnutrition were statistically significant only for STAMP and PNST with adjusted cutoff values.

It is well known that children are more susceptible and vulnerable to malnutrition than adults due to their low energy reserves, higher energy requirements per unit of body weight, and higher nutrient requirements [17]. Malnutrition can occur in children of any age, but as the WHO emphasized, younger children are more vulnerable [18]. In line with the results of previous studies [8, 19, 20], the prevalence of acute and chronic malnutrition was found to be more common in children <5 years old and <2 years old compared to children aged ≥5 years and ≥2 years, respectively (31.0% *vs.* 17.3%, $p<0.001$; 32.4% *vs.* 21.0%, $p=0.003$). Being <2 years old significantly increased the risk of malnutrition 1.8 times, while this risk more than doubled in children <5 years old. Also, having the education level of an illiterate mother was associated with a threefold increased likelihood of malnutrition and acute and chronic malnutrition.

In addition to providing new information on the prevalence and risk of malnutrition in a group of Turkish pediatric inpatients, another major strength of this study is that all eligible children admitted to the tertiary pediatric hospital where this study was conducted were included in the study and studied throughout the study period. Furthermore, to our knowledge, this is the first study in that four nutritional screening tools (STRONGkids, STAMP, PYMS, and PNST) were simultaneously compared to determine malnutrition risk in Turkish pediatric patients. Another strength of this study is that the same researcher conducted all anthropometric measurements. In this way, the possible negative effects of interobserver variability on the study results were avoided. Lastly, considering that most studies on pediatric screening tools focus on the differences between risk categories, screening tools' sensitivity, specificity, NPV, and PPV values given in this study will likely guide other studies.

The primary limitation of this study was assessing patients' nutritional status based only on baseline anthropometric measurements (weight and height) without the use of other indicators such as skinfold thickness or body composition, as it might have contributed to the misclassification of some patients as high-risk, particularly in the presence of chronic malnutrition. Secondly, in the initial analysis, the lack of a complete nutritional assessment which includes body composition analysis, biochemical parameters, and food diary records for cross-checking nutritional risk screening tools, may be considered an additional limitation of this study. However, given that this study aimed to determine the adequacy and effectiveness of previously approved screening tools, it is also possible not to consider the lack of a complete nutritional assessment a limitation. Finally, this study is a cross-sectional study without data on the longitudinal analysis of patients' clinical course and dietary changes over time, including weight loss. Despite the limitations stated, the findings of this study will likely provide guidance for studies to be carried out in the future to determine the risk of malnutrition in hospitalized children in Turkey.

CONCLUSION

In conclusion, the findings of this study indicated that PNST (with adjusted cutoff values) and PYMS screening tools have higher diagnostic accuracy compared to other screening tools in assessing the nutritional status of hospitalized Turkish children and detecting the hospitalized Turkish children with acute malnutrition in particular. Considering that early detection of malnutrition risk in children admitted to the hospital can improve health outcomes and quality of life, routine use of an easily applicable and appropriate nutritional risk screening tool in hospitalized pediatric patients should be encouraged, and all children who are identified to be at risk of malnutrition should be referred to a dietitian for nutritional intervention.

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CONTRIBUTORS

D GUNES KAYA and Z CAFEROGLU AKIN contributed to the conception and study design. D GUNES KAYA and E CELIK contributed to the data collection. Z CAFEROGLU AKIN contributed to the analysis and interpretation of results. D GUNES KAYA, Z CAFEROGLU AKIN, and B ORUCOGLU contributed to the draft manuscript preparation. All authors reviewed the results and approved the final version of the manuscript.