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Original article

Adductor muscle thickness of the thumb: A new and reliable parameter for nutritional assessment of pediatric inpatients

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SUMMARY

Background & aims: The adductor pollicis muscle thickness (APMT) is a promising method for evaluation of muscle loss and, consequently, malnutrition in adult and elderly patients. However, to date, there have been no studies of its applicability to the pediatric population. Within this context, we sought to evaluate the association of APMT with anthropometric variables, body mass index (BMI), pediatric Subjective Global Assessment (SGA) of nutrition, nutritional screening, and clinical outcomes in hospitalized pediatric patients.
Methods: This was a cross-sectional study of inpatients aged 4–8.9 years, recruited via convenience sampling from a pediatric hospital in Porto Alegre, Rio Grande do Sul, Brazil. Data collection took place between December 2014 and February 2016. Patients admitted to the intensive care unit, those unable to feed orally, and those with cerebral palsy or Down syndrome were excluded from the study. General and socioeconomic information was collected and the SGA Ped and STRONGkids were administered at hospital admission. Clinical data were collected from the electronic medical record. Anthropometric parameters and APMT were measured by properly calibrated examiners. Data analysis was carried out in SPSS version 21.0. The significance level was set at 5%.
Results: The sample consisted of 447 patients. Most (55.9%) were male; the mean age was 6.2 ± 1.4 years. Low APMT was significantly associated with underweight, short stature, low body fat percentage, and poor muscle reserve ($p < 0.001$). There were also significant associations of moderate and severe malnutrition (assessed by the SGA Ped) and high nutritional risk (assessed by the STRONGkids instrument) with reduced APMT ($p < 0.001$). Regarding clinical outcomes, a longer hospital stay was observed in patients with reduced APMT ($p = 0.001$). A receiver operating characteristic (ROC) curve, plotted considering the SGA Ped as the gold standard, suggested APMT cutoff points of 10.2 mm for boys and 9.5 mm for girls. Stratification by age yielded APMT cutoff points of 9.8 mm for boys younger than 6 years and 10.2 mm for those older than 6 years, and 9.2 mm and 9.8 mm for girls younger and older than 6 years, respectively.
Conclusion: The APMT is an efficient parameter for the detection of malnutrition in hospitalized pediatric patients.

1. Introduction

There is still no accepted consensus as to which diagnostic tool is capable of satisfactorily identifying child malnutrition in clinical practice [1]. Malnutrition is a state in which a deficiency or imbalance of energy, proteins, and/or other nutrients causes measurable adverse effects on body and tissue composition [2] and on clinical and functional outcomes [1]. In hospitalized children, it is considered a risk factor for unfavorable outcomes, prolonged hospitalization, delayed recovery, and higher health care-related expenditures [3,4].

There are several methods for evaluating nutritional status in the hospitalized child, such as anthropometric and biochemical measurements, clinical history, and physical examination, all of which have specific limitations, advantages and disadvantages. Among the anthropometric measures, the adductor pollicis muscle

List of abbreviations: SGA, Subjective Global Assessment; AC, arm circumference; AMC, arm muscle circumference; SSF, subscapular skinfold; TSF, triceps skinfold; APMT, adductor pollicis muscle thickness; BMI, body mass index; %F, body fat percentage; STRONGkids, Risk Screening for Nutritional Status and Growth; LM, lean mass.

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thickness (APMT) has been suggested as a promising parameter to evaluate the muscle compartment, as it is a noninvasive, low-cost, objective, and rapidly administered measure [5].

Combined with anthropometric measurements, screening and subjective nutritional assessment instruments are often used to detect patients at nutritional risk and with malnutrition at the time of hospitalization [5]. These include the Screening for Risk for Nutritional Status and Growth (STRONGkids) [6] and SGA Ped [7].

The STRONGkids is a nutritional screening instrument that addresses four subjective elements: physical examination, identification of nutritional risk diseases, assessment of food intake, and gastrointestinal disorders and weight loss [6]. The SGA Ped is a more complex tool that takes longer to administer; it addresses physical examination findings, current and usual anthropometric measurements of the child, evaluation of food intake and gastrointestinal changes, and identification of diseases associated with nutritional risk. The purpose of this tool is to subjectively diagnose the nutritional status of pediatric patients by classifying them into three different categories: well nourished, moderately malnourished, or severely malnourished [7].

Considering that there is still no consensus on the best method for nutritional evaluation of the hospitalized child, studies of simple, non-invasive, low-cost methods, such as the APMT measure, may help expedite identification of patients who are at nutritional risk. Within this context, the present study was designed to evaluate the potential associations of APMT with other anthropometric variables, body mass index (BMI), SGA Ped, nutritional screening, and clinical outcomes in the nutritional diagnosis of hospitalized pediatric patients.

2. Methods

This cross-sectional study with a convenience sampling strategy recruited children aged 4.0–8.9 years from a pediatric hospital in Porto Alegre, Rio Grande do Sul, Brazil. Data collection took place between December 2014 and February 2016. Patients admitted to intensive care units were excluded, as were those unable to feed orally, those whose parents and/or caregivers declined to participate, and patients with cerebral palsy or Down syndrome.

The parents or legal guardians who agreed to have their children participate in the study provided written informed consent. The Research Ethics Committee of Brotherhood of Irmandade da Santa Casa de Misericórdia de Porto Alegre approved the project with opinion no. 906.461.

Patients were evaluated at the inpatient units within 72 h of hospital admission. Initially, general information was collected, such as gender, age, educational status, and socioeconomic condition of the family (defined through the Brazilian Economic Classification Criterion) [8]. Clinical outcomes were collected from the electronic medical record. The following variables were analyzed: length of hospital stay (days), final outcome (hospital discharge or death), and rehospitalization (defined as scheduled and unscheduled readmissions occurring within 6 months of discharge).

For diagnosis of nutritional status, the following parameters were used: conventional anthropometry, APMT, SGA Ped, and STRONGkids, all measured by the principal researcher and two duly trained assistant researchers, using calibrated instruments, according to the Guidance Manual for Data Collection. To ensure the quality of data collection, minimize possible verification biases and assess agreement between the evaluators, a pilot project was carried out with 30 patients, who were subsequently excluded from the analysis sample.

Anthropometric evaluation was performed with the weight and height [9] measured on the same day of the interview. Then, the weight-for-age (W/A), height-for-age (H/A), and BMI-for-age (BMI/A) z scores were calculated, indexed by the 2007–2006 World Health Organization (WHO) growth curves [10], with the aid of WHO software (Anthro version 3.2.2 [11] and WHO Anthro Plus [12]). Anthropometric nutritional diagnosis was determined by the BMI/A z score, according to the cut-off points proposed by WHO in 2009. Children with a BMI/A z score between −2 and +2 were considered to have normal weight; those with a z score less than −2, underweight; and those with a z score greater than +2, obese. As for height, z scores less than −2 were considered indicative of short stature, and those between −2 and +2 or greater than +2 as indicative of adequate height.

At the time of the interview, the arm circumference (AC) [13] and triceps (TSF) and subscapular (SSF) skinfold thicknesses [14] were also collected. From these values, the patients' arm muscle circumference (AMC) and body fat percentage (%F) were calculated. The AC, TSF, and AMC were measured according to recommended measurement techniques. Lange® brand skinfold calipers, with a constant spring pressure of 10 g/mm^2, a 0–60-mm scale, and precision of 1 mm, were used.

Once the aforementioned measurements had been obtained, the %F and lean mass (LM), or muscle, reserve were calculated according to the equation of Slaughter et al. (1988) [15] and classified using the cutoff points proposed by Lohman (1987) [16].

The %F was classified as low (<15% for girls and <10% for boys), adequate (11–20% for boys and 16–25% for girls), or high (>25% for girls and >20% for boys). The AMC was obtained with the formula

$$AMC(cm) = AC(cm) - (0.314 \times TS[mm])$$

and classified into percentiles according to Frisancho (1981) [17]. An AMC below the 5th percentile was classified as low muscle reserve, while values above the 95th percentile were considered indicative of high muscle reserve. All values in between (AMC between P5 and P95) denoted adequate muscle reserve.

The SGA Ped and STRONGkids tools were administered during the interview. The primary investigator and one of the assistant investigators performed subjective analysis of each item answered, according to Secker & Jeejeebhoy (2012) [18], to defined the classification of nutritional status by SGA Ped. Nutritional risk was assessed with the STRONGkids instrument by means of the sum of the scores of the four questionnaire items. A score of zero denoted low nutritional risk; scores between 1 and 3, moderate nutritional risk; and scores of 4 or 5, high nutritional risk [6].

APMT measurement was performed with the patient sitting, with the arm flexed approximately 90° in relation to the forearm, resting on the thigh, and the hand resting on the knee. Patients were instructed to keep their hands relaxed and their thumbs away from the other fingers, forming a 90° angle with the index finger. Using an adipometer, the muscle was pinched at the center of an imaginary triangle formed by the index finger and the thumb. The mean of three sequential measurements performed on the same day was considered for analysis [19]. Figure 1 illustrates the correct APMT measurement technique.

For statistical analyses, patients were stratified according to their underlying disease or condition. These were categorized as chronic (longstanding diseases that were not life-threatening in the short term, or exacerbations of symptoms that are usually less severe), acute (diseases of sudden onset, with evident symptoms and a clearly defined duration), or acute on chronic (patients with a chronic disease whose reason for hospitalization constituted an acute complication, not necessarily related to previous complications).

Quantitative variables were described as mean and standard deviation or median and interquartile range. Qualitative variables were described as absolute and relative frequencies. Student's *t*-tests or one-way analysis of variance (ANOVA) were used to

Fig. 1. APMT measurement with an adipometer.

compare means. In case of asymmetry, the Mann–Whitney *U* and Kruskal–Wallis tests were used, respectively. For comparison of proportions, Pearson's Chi-square or Fisher's exact tests were used as appropriate. To determine the best cutoff point for APMT according to gender and age groups, a receiver operating characteristic (ROC) curve was plotted, using the SGA Ped as the gold standard for moderate and severe malnutrition and the STRONGkids as the gold standard for high nutritional risk. To control for confounding factors in the prediction of length of hospital stay due to the nutritional risk as assessed with the APMT, a multiple linear regression model was used. Due to the asymmetry of this variable, logarithmic transformation was performed before the parametric test. We chose 6 years as the cutoff point for the variable age, as this value corresponds to the median age of the sample recruited for the present study. The significance level was set at 5% ($p < 0.05$), and all analyses were performed in SPSS Version 21.0.

3. Results

A total of 447 patients were evaluated. Table 1 describes the profile of the sample. The main reasons for hospitalization were surgical (23%), pulmonary (19.5%), and neurological diseases (13.4%).

According to BMI/A z scores, the majority of patients (76.1%) had normal weight; 4.0% were underweight and 19.9% were overweight. According to the SGA Ped classification, 87% were well nourished and 13% were moderately or severely malnourished. The STRONGkids screening classified 27.7% of patients as having low nutritional risk, 64.4% as medium risk, and 7.8% as high risk.

The mean APMT was 11.1 ± 2.9 mm in both genders, 10.2 mm being the suggested cutoff point for boys (Fig. 2) and 9.5 mm the suggested cutoff point for girls (Fig. 3), using SGA Ped as the gold standard. When we evaluated girls in isolation, very similar sensitivity and specificity (around 73%) were observed. In boys, the sensitivity was somewhat lower (69%), which may be associated with a higher rate of false-negative results. However, the accuracy was greater than 0.70 for both curves, demonstrating the adequacy of these cutoff points.

The results of ROC curve analysis for APMT, stratified by gender and age group and considering the SGA as gold standard, are described in Table 2.

When APMT was tested for correlation with BMI (Table 3), there was a statistically significant association between normal weight as determined by BMI and nutritional risk by APMT ($p < 0.001$). There were also statistically significant associations of short stature (measured by H/A z score), low muscle reserve (measured by AMC), and reduced F% with APMT-measured nutritional risk ($p < 0.001$).

Table 1
Sample profile.

Variable	n = 447
Gender, n (%)	
Male	250 (55.9)
Female	197 (44.1)
Age (years), mean ± SD	6.2 ± 1.4
Most common admitting specialties, n (%)	
Surgery	103 (23.0)
Pulmonology	87 (19.5)
Neurology	60 (13.4)
Oncology	35 (7.8)
Gastroenterology/Hepatology	30 (6.7)
BMI-for-age, n (%)	
Underweight	18 (4.0)
Normal weight	340 (76.1)
Overweight	89 (19.9)
Height-for-age, n (%)	
Short stature	26 (5.8)
Adequate stature	421 (94.2)
AMC classification, n (%)	
Low muscle reserve	33 (7.4)
Adequate muscle reserve	365 (81.7)
High muscle reserve	49 (11.0)
APMT, mean ± SD	11.1 ± 2.9
%F classification, n (%)	
Low	82 (18.3)
Adequate	256 (57.3)
High	109 (24.4)
SGA classification, n (%)	
Well-nourished	389 (87.0)
Mild malnutrition	55 (12.3)
Severe malnutrition	3 (0.7)
STRONGkids classification, n (%)	
Low nutritional risk	124 (27.7)
Moderate nutritional risk	288 (64.4)
High nutritional risk	35 (7.8)
Length of hospital stay (days), median (IQR)	6 (4–10)
Outcome, n (%)	
Discharge	444 (99.3)
Death	3 (0.7)
Readmissions, n (%)	100 (22.4)

AMC: arm muscle circumference; APMT: adductor pollicis muscle thickness; BMI: body mass index; %F: fat percentage; IQR: interquartile range; SD: standard deviation; SGA: Subjective Global Assessment of Nutrition; STRONGkids: Screening for Risk for Nutritional Status and Growth.

Likewise, associations were identified between high nutritional risk assessed with the STRONGkids instrument and APMT-measured nutritional risk, as well as between moderate and severe malnutrition (measured by the SGA Ped) and APMT ($p < 0.001$ for all associations). The relationship between nutritional risk and APMT was inversely proportional; as the APMT decreased, the nutritional risk increased. Regarding clinical outcomes, patients identified as being at risk by APMT had significantly greater length of hospital stay ($p = 0.002$) (Table 3). After adjusting for multivariate analysis, APMT remained associated with length of hospital stay, independent of other methods of nutritional assessment (BMI/A, H/A, AMC, %F, STRONGkids), with $p = 0.012$.

4. Discussion

APMT proved to be a promising parameter for nutritional assessment, correlating significantly with traditional methods. However, nutritional assessment remains a challenge, and much research has been carried out in an attempt to identify optimal tools for this purpose; current instruments still overestimate or underestimate nutritional risk [6]. In the present study, the prevalence of malnutrition in the sample was 13.0% according to SGA Ped (12.3% moderate malnutrition and 0.7% severe malnutrition). These values were lower than those reported by Secker &

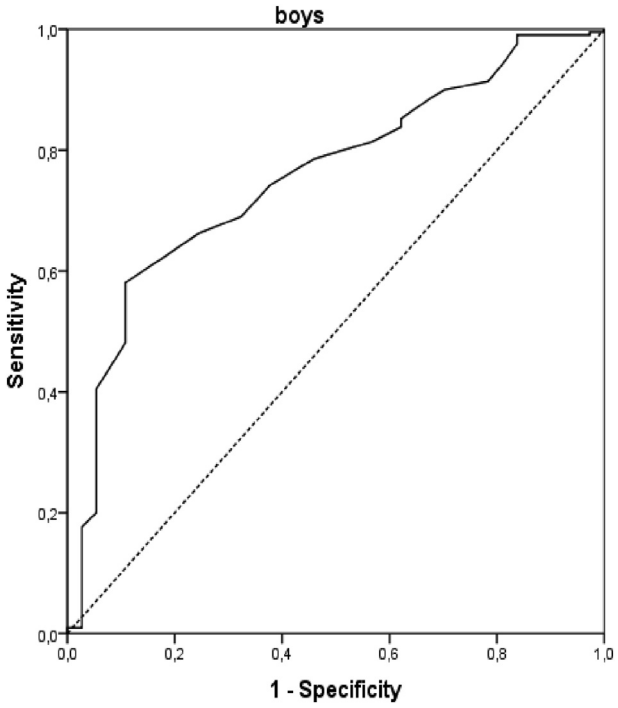

Fig. 2. Receiver operating characteristic (ROC) curve for APMT in boys, considering the SGA Ped as gold standard. Area under the curve: 0.756 (95%CI: 0.678–0.835). Cutoff point: 10.2 (Sensitivity: 69.0%, Specificity: 67.6%).

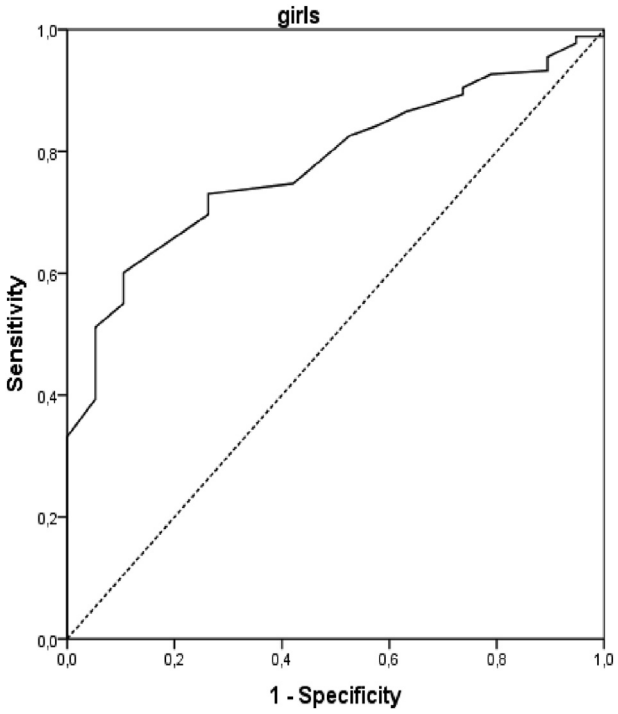

Fig. 3. Receiver operating characteristic (ROC) curve for APMT in girls, considering the SGA Ped as gold standard. Area under the curve: 0.779 (95%CI: 0.696–0.862). Cutoff point: 9.5 (Sensitivity: 73.0%, Specificity: 73.7%).

Jeejeebhoy [7], who found moderate and severe malnutrition rates of 36% and 15%, respectively. This discrepancy in values can be partially explained by the differences between the profile of the samples studied. Secker & Jeejeebhoy restricted their sample to surgical patients [7], while the present study enrolled patients with diverse clinical and surgical diagnoses. Another factor that may have influenced our malnutrition rates was the exclusion of ICU patients and those not fed orally. Based on these differences, we assumed that the patients in the Secker & Jeejeebhoy study were more critically ill and had more complications, which would partly explain the higher rate of malnutrition. In addition, the difference in age ranges assessed in these two may further explain the differences in malnutrition prevalence: the present study evaluated children aged 4–8.9 years, while Secker & Jeejeebhoy evaluated a much wider age range (31 days–17.9 years).

Table 2
Analysis of the ROC curve for APMT according to gender and age group, considering the SGA Ped as gold standard.

	AUC (95% CI)	p	Cutoff	Sensitivity	Specificity
Boys					
<6 years	0.72 (0.59–0.85)	0.005	9.8	69.1%	62.5%
≥6 years	0.79 (0.68–0.89)	<0.001	10.2	74.1%	73.4%
Girls					
<6 years	0.73 (0.56–0.90)	0.032	9.2	66.3%	62.5%
≥6 years	0.82 (0.74–0.91)	<0.001	9.8	74.5%	72.7%

Table 3
Associations between adductor pollicis muscle thickness and other parameters of interest.

Variable	At risk[a] (n = 149)	No risk (n = 298)	P
Gender, n (%)			0.973
Male	84 (55.6)	166 (55.7)	
Age (years), mean ± SD	6.1 ± 1.4	6.3 ± 1.6	0.155
Disease/condition, n (%)			0.126
Acute	68 (45.6)	146 (49.0)	
Chronic	15 (10.1)	34 (11.4)	
Acute on chronic	36 (24.2)	45 (15.1)	
Surgical	30 (20.1)	73 (24.5)	
BMI-for-age, n (%)			<0.001
Underweight	9 (6.0)	9 (3.0)	
Normal weight	127 (85.2)[b]	213 (71.5)	
Overweight	13 (8.7)	76 (25.5)[b]	
Height-for-age, n (%)			0.012
Short stature	15 (10.1)[b]	11 (3.7)	
Adequate stature	134 (89.9)	287 (96.3)	
AMC classification, n (%)			<0.001
Low muscle reserve	22 (14.8)[b]	11 (3.7)	
Adequate muscle reserve	119 (79.9)	246 (82.6)	
High muscle reserve	8 (5.4)	41 (13.8)[b]	
%F classification, n (%)			<0.001
Low	40 (26.8)[b]	42 (14.1)	
Adequate	94 (63.1)	162 (54.4)	
High	15 (10.1)	94 (31.5)[b]	
SGA classification, n (%)			<0.001
Well-nourished	111 (74.5)	278 (93.3)[b]	
Mild malnutrition	35 (23.5)[b]	20 (6.7)	
Severe malnutrition	3 (2.0)[b]	0 (0.0)	
STRONGkids classification, n (%)			<0.001
Low nutritional risk	25 (16.8)	99 (33.2)[b]	
Moderate nutritional risk	99 (66.4)	189 (63.4)	
High nutritional risk	25 (16.8)[b]	10 (3.4)	
Length of hospital stay (days), median (IQR)	7 (4–13)	6 (4–9)	0.002
Outcome, n (%)			1.000
Discharge	148 (99.3)	296 (99.3)	
Death	1 (0.7)	2 (0.7)	
Readmissions, n (%)	41 (27.5)	59 (19.8)	0.084

AMC: arm muscle circumference; BMI: body mass index; %F: fat percentage; IQR: interquartile range; SD: standard deviation; SGA: Subjective Global Assessment of Nutrition; STRONGkids: Screening for Risk for Nutritional Status and Growth.

[a] Cutoffs: girls age <6 years, <9.2 mm: girls age ≥6 years, <9.8 mm; boys age <6 years, <9.8 mm; boys age ≥6 years, <10.2 mm.

[b] Statistically significant by adjusted residuals test ($p < 0.05$).

APMT has been increasingly studied as a potential parameter for nutritional assessment in both health and illness [19]. An association between APMT and conventional nutritional parameters has already been observed in unhealthy adult populations [19–21], but had not yet been reported in hospitalized pediatric patients.

In the present study, APMT had satisfactory diagnostic properties for evaluation of nutritional risk when compared to the traditional SGA method, with an area under the ROC curve >0.7 for both genders. These data corroborate a cross-sectional study conducted with adult surgical patients that evaluated SGA, APMT, and other anthropometric and biochemical measures, and found APMT to be a reliable method for assessing the nutritional status of adult surgical patients when compared to SGA (area under the curve = 0.93) [22].

The average APMT among patients in the present study was 9.5 mm for girls (sensitivity: 73.0%; specificity: 73.7%) and 10.2 mm for boys (sensitivity: 69.0%; specificity: 67.6%). In general, values were lower than in other reports. This was expected, as all previous studies were performed in adult or elderly populations, which precludes direct comparison. Due to the lack of defined APMT cutoff points for the pediatric population, we could not correlate our findings with those of other studies that explored the use of this measure in other stages of the life cycle. One study that investigated APMT in healthy adults (mean age 44.9 ± 18.5 years) found an average of 26.1 ± 4.4 mm for men and 19.8 ± 3.3 mm for women [23].

APMT measurement correlated significantly with BMI-for-age, AMC, height-for-age, and body fat percentage. This is consistent with the findings of Bragagnolo et al., who found that APMT correlated with all classical anthropometric parameters [22].

The association between APMT and SGA was previously reported in a study conducted in critically ill patients [24]. Poziomyck et al. [25] studied 74 adult and elderly patients undergoing resection of gastrointestinal tract tumors, seeking to evaluate the most sensitive method for nutritional assessment in this group. SGA, APMT, BMI, AC, AMC, percentage of weight loss, and TSF were evaluated, in addition to biochemical tests. The authors found that APMT and SGA were reliable predictors of mortality and can be used in clinical practice [25]. Likewise, the present study revealed an association between moderate and severe malnutrition as measured by the SGA and reduced APMT, as well as an association of APMT with clinical outcomes (specifically, length of hospital stay). This finding is possibly explained by the presence of malnutrition and underlying disease, which may lead to a reduction in daily activities and possible catabolism, resulting in a progressive decrease in APMT [26]. Gonzalez et al. [27], who analyzed 361 adult surgical patients, found similar results. After controlling for confounding variables, the nutritional status evaluated by SGA was found to be a determinant of APMT, with substantial reductions in its values in moderately and severely malnourished patients [27]. Bragagnolo et al. [22] and Caporossi et al. [26] reported similar findings.

It is widely accepted in the literature that using the APMT measurement has several advantages, including the ease of application, low cost, readily accessible location of the muscle, and the diversity of applications in which APMT measurement is possible or useful. However, it is prudent to point out that the absence of a reference standard for this parameter in different clinical conditions, genders, and stages of the life cycle can lead to results that are not representative of the patient's actual nutritional status and do not take into account clinical condition and hydration status [5]. In addition, according to Gonzalez et al. [23], it is important to note that studies that identify or report values that are very different from the references indicated in the literature may be erroneous, due to inadequacies in calibration of the plicometer or variability among evaluators. Studies have shown that the error in skinfold measurement attributable to interobserver variability may be as high as 22.6% [28].

The main strength of this study is the fact that it evaluated a very restrictive age range (children aged 4–8.9 years), thus maintaining homogeneity in relation to the stage of sexual maturation of the participants [29], which helped reduce possible biases in nutritional assessment. Limitations include the cross-sectional design and our failure to account for biochemical parameters. Another weakness is that SGA Ped classifies patients only as well-nourished, moderately malnourished, or severely malnourished, which ends up overestimating the prevalence of well-nourished participants in the sample and, consequently, masks the prevalence of overweight and obesity. Conversely, STRONGkids considers that all patients have a degree of nutritional risk; even a nil score defines low rather than absent nutritional risk.

As children are more vulnerable to in-hospital malnutrition [30], it is essential that methods be implemented for screening and nutritional assessment in this population. The APMT measure could help provide a simple, safe, and inexpensive way to make an early diagnosis of nutritional risk, enabling a proactive and efficient nutritional intervention [5]. Our findings demonstrate that APMT is able to predict malnutrition in pediatric inpatients, with good sensitivity and specificity when compared to the gold standard (SGA Ped). However, further studies are needed to establish the precise role of APMT as a nutritional marker in hospitalized pediatric patients and to demonstrate its ability to predict morbidity and mortality in this population. Additional research with larger populations is necessary, especially to evaluate the proposed cutoff points for evaluation of hospitalized pediatric patients, considering different age ranges and genders.

Authorship statement

Protocol created and developed by Juliana Paludo Vallandro and Elza Daniel de Mello. Data collected by Juliana Paludo Vallandro, Laura Dresch Neumann, and Luciana Klein. Data analysis performed by Juliana Paludo Vallandro and Elza Daniel de Mello. Written by Juliana Paludo Vallandro, Luciana Klein, and Elza Daniel de Mello. All authors read and approved the final version of the manuscript.

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Conflict of interest

The authors declare that they have no conflicts of interest of any kind.

References

[1] Joosten KFM, Hulst JM. Malnutrition in pediatric hospital patients: current issues. Nutrition 2011;27:133–7. https://doi.org/10.1016/j.nut.2010.06.001.
[2] Lochs H, Alisson SP, Meier R, Pirlich M, Kondrup J, Schneider St, et al. Introductory to the ESPEN Guidelines on enteral nutrition: terminology, definitions and general topics. Clin Nutr 2006;25:180–6. https://doi.org/10.1016/j.clnu.2006.02.007.
[3] Bejon R, Mohammed S, Mwangi I, Atkinson SH, Osier F, Pishei N, et al. Fraction of all hospital admissions and deaths attributable to malnutrition among children in rural Kenya. Am J Clin Nutr 2008;88:1626–31. https://doi.org/10.3945/ajcn.2008.26510.
[4] Mehta NR, Corkins MR, Lyman B, Malone A, Goday OS, Carney LN, et al. Defining pediatric malnutrition: a paradigm shift toward etiology-related definitions. J Parenter Enter Nutr 2013;37(4):460–81.
[5] Valente KP, Silva NMF, Faioli AB, Barreto MA, De Moraes RAG, Guanndalini VR. Espessura do músculo adutor do polegar na avaliação nutricional de pacientes cirúrgicos. Einstein 2016;14(1):18–24. https://doi.org/10.1590/S1679-45082016AO3596.

[6] Hulst JM, Zwart H, Hop WC, Joosten KFM. Dutch national survey to test the STRONGkids nutritional risk screening tool in hospitalized children. Clin Nutr 2010;29:106–11. https://doi.org/10.1016/j.clnu.2009.07.006.
[7] Secker DJ, Jeejeebhoy KN. Subjective global nutritional assessment for children. Am J Clin Nutr 2007;85:1083–9.
[8] ABEP - Associação Brasileira de Empresas de Pesquisa [Internet]. Critério de Classificação Econômica Brasil. 2012. at http://www.abep.org/codigosCondutas.aspx. [Accessed 27 October 2014].
[9] Gordon CC, Chumlea WC, Roche AF. Stature, recumbent length, weight. In: Lohman TG, Roche AF, Martorell R, editors. Anthropometric standardizing reference manual. Champaign (Illinois): Human Kinetics Books; 1991. p. 3–8. 14.
[10] WHO Multicentre Growth Reference Study Group. WHO child growth standards based on length/height, weight and age. Acta Paediatr Suppl 2006;450:76–85.
[11] Software for assessing growth and development of the world's children. WHO Anthro for personal computers [software]. Version 2011. Geneva: World Health Organization; 2010. at http://www.who.int/childgrowth/software/en/. [Accessed 27 October 2014].
[12] Software for assessing growth of the world's children and adolescents. WHO AnthroPlus for personal computers [software]. Version 2009. Geneva: World Health Organization; 2009. at http://www.who.int/growthref/tools/en/. [Accessed 27 October 2014].
[13] Callaway CW, Chumlea WC, Bouchard C, Himes JH, Lohman TG, Martin AD, et al. Circumferences. In: Lohman TG, Roche AF, Martorell R, editors. Anthropometric standardizing reference manual. Champaign (Illinois): Human Kinetics Books; 1991. p. 39–54. 15.
[14] Harrison GG, Buskirk ER, Carter JEL, Johnston FE, Lohman TG, Pollock ML, et al. Skinfold thicknesses and measurements technique. In: Lohman TG, Roche AF, Martorell R, editors. Anthropometric standardizing reference manual. Champaign (Illinois): Human Kinetics Books; 1991. p. 55–80.
[15] Slaughter MH, Lohman TG, Boileau RA, Horswill CA, Stillman RJ, Van Loan MD, et al. Skinfold equation for estimation of body fatness in children and youth. Hum Biol Detroit 1988;60(5):709–23.
[16] Lohman TG. The use of skinfold to estimate body fatness on children and youth. JOPERD 1987;58:98–102.
[17] Frisancho AR. New norms of upper limb fat and a muscle areas for assessment pf nutritional status. Am J Clin Nutr 1981;34:2504–5. Bethesda.
[18] Secker DJ, Jeejeebhoy KN. How to perform subjective global nutritional assessment in children. J Acad Nutr Diet 2012;112:424–31. https://doi.org/10.1016/j.jada.2011.08.039.
[19] Pereira RA, Caetano AL, Cuppari L, Kamimura MA. Espessura do músculo adutor do polegar nos pacientes em hemodiálise. J Bras Nefrol 2013;35(3):177–84.
[20] Karst FP, Vieira RM, Barbiero S. Relação da espessura do músculo adutor do polegar e avaliação subjetiva global. Rev Bras Ter Intensiva 2015;27(4):369–75. https://doi.org/10.5935/0103-507X.20150062.
[21] Davila LSP, Reis FVF, dos Santos CH. Aplicabilidade da espessura do músculo adutor do polegar na avaliação nutricional de pacientes portadores de HIV/AIDS admitidos em Hospital Escola. Rev Panam Infectol 2014;16(1):25–31.
[22] Brognolo R, Caparossi FS, Dock-Nascimento DB, Aguilar-Nascimento JE, TCBC-MT. Espessura do músculo adutor do polegar: um método rápido e confiável na avaliação nutricional de pacientes cirúrgicos. Rev Col Bras Cir 2009;36(5):371–6. https://doi.org/10.1590/S0100-69912009000500003.
[23] Gonzalez MC, Duarte RR, Budziareck MB. Adductor pollicis muscle: reference values of its thickness in a healthy population. Clin Nutr 2010;29(2):268–71. https://doi.org/10.1016/j.clnu.2009.08.012.
[24] Caporossi FS, Bragagnolo R, Dock-Nascimento DB, Aguilar-Nascimento JE. Thickness of the adductor pollicis muscle as an anthropometric parameter in critically ill patients. Rev Bras Nutr Clin 2010;25:182–8.
[25] Poziomych AK, Weston AC, Lameu EB, Cassol OS, Coelho LJ, Moreira LF. Preoperative nutritional assessment and prognosis in patients with foregut tumors. Nutr Cancer 2012;64(8):1174–81. https://doi.org/10.1080/01635581.2012.721157.
[26] Caporossi FS, Caporossi C, Dock-Nascimento DB, Aguilar-Nascimento JE. Measurement of the thickness of the adductor pollicis muscle as a predictor of outcome in critically ill patients. Nutr Hosp 2012;27(2):490–5. https://doi.org/10.3305/nh.2012.27.2.5514.
[27] Gonzales MC, Pureza Duarte RR, Orlandi SP, Bielemann RM, Barbosa-Silva TG. Adductor pollicis muscle: a study about its use as a nutritional parameter in surgical patients. Clin Nutr 2015;34(5):1025–9. https://doi.org/10.1016/j.clnu.2014.11.006.
[28] Lohman TG, Pollock ML, Slaughter MH, Brandon LJ, Boileau RA. Methodological factors and the prediction of body fat in female athletes. Med Sci Sports Exerc 1984;16(1):92–6.
[29] Tanner JM. Growth at adolescence: with a general consideration of the effects of hereditary and environmental factors upon growth and maturation from birth to maturity. 2nd ed. Oxford: Blackwell Scientific Publications; 1962. p. 325.
[30] Lima CM, Tiengo A. Perfil nutricional e alimentar de crianças internadas no Hospital das Clínicas Samuel Libânio. Revista Ciências em Saúde 2012;2(2):45–56. https://doi.org/10.21876/rcsfmit.v2i2.93.