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Sarcopenia and malnutrition in children with extrahepatic portal vein obstruction

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ABSTRACT

Objectives: Malnutrition is an imbalance between nutrient requirements and intake and sarcopenia is defined as a clinical condition characterized by the reduction of muscle mass and function. Our study aims to determine the frequency of sarcopenia and malnutrition and to establish the relationship between sarcopenia and clinical outcomes in children with extrahepatic portal vein obstruction (EHPVO).
Methods: This was a retrospective, single-center study evaluating children with EHPVO between 2000 and 2024, with an abdominal CT scan performed. Psoas muscle surface area was measured at two intervertebral lumbar disc levels, L3-4 and L4-5.
Results: Seventy patients aged between 1 and 16 years whose CT images were available were included in the study. The frequency of sarcopenia among the patients included in the study was 58.6%, as calculated from the L3-4 and/or L4-5 levels. Eighteen-point six percent of the patients were classified as underweight, 17.1% were wasted, and 15.7% were stunted. Furthermore, 31.4% of the patients were either underweight and/or wasted and/or stunted, conditions that are classified as malnutrition. The frequency of sarcopenic malnutrition was 24.3%. When the patients with EHPVO are stratified according to the presence of sarcopenia, no significant differences in demographic and laboratory features have been observed between the two groups.
Conclusions: To our knowledge, this is the first study that analyses the frequency of sarcopenia and its relation with malnutrition in children with EHPVO. The frequency of sarcopenia was similar to those observed in cirrhotic pediatric patients in recent studies. Because of the retrospective design of the study, it was not possible to assess functional muscle parameters of the patients. The major challenges in diagnosing sarcopenia in children include the absence of a gold standard test and reference data for healthy body composition.
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Introduction

Pediatric malnutrition is an imbalance between nutrient requirements and intake resulting in cumulative deficits of energy, protein, or micronutrients that may negatively affect growth, development, and other relevant outcomes [1]. Malnutrition is common in children with cirrhosis with a prevalence of 61% and extrahepatic portal vein obstruction (EHPVO) with a prevalence of 66% [2,3]. Sarcopenia is defined as a clinical condition characterized by the reduction of muscle mass and function. Sarcopenia typically affects geriatric patients with chronic diseases, but it has recently been recognized in the pediatric literature with a growing interest. Some methods for determining sarcopenia include dual-energy x-ray absorptiometry (DEXA), bio-electric impedance analysis (BIA), and cross-sectional imaging of the abdomen with computed tomography (CT) and magnetic resonance imaging (MRI) techniques. Total body muscle mass is commonly estimated by measuring the cross-sectional area of selected or all muscles at the lumbar levels using CT or MRI. Alternatively, mid-thigh muscle measurement has also been employed as a surrogate marker. In addition, functional tests including handgrip strength and the 400-meter walk test are available to assess muscle function. The gold standard technique is CT or MRI despite their cost, radiation exposure, and need for anesthesia. Our study aims to determine the frequency of sarcopenia and malnutrition and to establish the relationship between sarcopenia and clinical outcomes in children with EHPVO.

The study was approved by the local research ethics committee at Gazi University with the study number of 2024 – 397.

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Materials and methods

This was a retrospective, single-center study conducted at Gazi University, Department of Pediatric Gastroenterology, Hepatology, and Nutrition (Ankara, Turkey), evaluating all children (1–16 years old) with EHPVO between 2000 and 2024, with an abdominal CT scan performed. Abdominal CT was performed in all subjects to confirm the diagnosis of EHPVO and/or prior to splenorenal shunt surgery. Patients with chronic diseases other than EHPVO were excluded from the study. Additionally, children under 12 months and over 16 years of age were excluded due to the absence of a validated definition of sarcopenia for these age groups.

Demographic (age, sex), anthropometric (weight, height, body mass index), clinical (grade of esophageal varices, gastrointestinal bleeding), and laboratory (full blood count, alanine transaminase, aspartate transaminase, gamma-glutamyl transferase, total bilirubin, international normalized ratio, serum albumin) data were collected from patient charts. Anthropometric, endoscopic, and laboratory parameters were recorded within the month preceding or following CT imaging.

For each patient, the nutritional status assessment was performed based on weight, height, and body mass index, and z-scores were calculated according to reference values for Turkish children [4]. Underweight was defined as a weight-for-age z-score below −2 SD, wasting was defined as a body mass index (BMI) z-score below −2 SD, while stunting was defined as a height-for-age z-score below −2 SD, in accordance with the World Health Organization (WHO) standards. Patients with either underweight and/or wasting and/or stunting were classified as malnourished.

In each patient, the axial plane passing through the inter-somatic disk between L3 and L4, L4 and L5 were evaluated for the quantitative analysis of psoas muscle. All CT images were analyzed with Extreme Pacs version 3.4 by trained radiologists. Psoas muscle surface area (PMSA) was measured at two intervertebral lumbar disc levels, L3-4 and L4-5. Total PMSA (tPMSA) was expressed as a sum of the left and right PMSA at each level and corrected for height, described as tPMSA/m^2 defined as psoas muscle index (PMI). Previously published reference values of total psoas area measures derived from CT of children undergoing trauma scans were used [5]. Sarcopenia was defined as a t-PMSA z-score for age and sex less than −2 SD.

SPSS 26.0 software (SPSS, Chicago, IL, US) was used for data analysis. Quantitative results are presented as means ± SD or median with minimum-maximum (min-max) values and compared using the Mann–Whitney U-test or Student's t-test. Categorical data are presented as counts and percentages and compared using Fisher's exact test or Pearson's Chi-square test. Correlations between continuous variables were assessed using Spearman correlation analysis and expressed as r (*P*-value). A two-sided *P*-value < 0.05 was considered statistically significant.

Ethics statement

Due to the retrospective design of the study and the use of archived data, permissions were obtained from individuals who contributed to the archive without the need for patient-informed consent. The study was approved by the local research ethics committee at Gazi University with the study number of 2024 – 397.

Results

One hundred and twenty-five patients with EHPVO were followed in our department from 2000 to 2024. Seventy patients aged between 1 and 16 years whose CT images were available were included in the study. Demographic and anthropometric characteristics of patients with EHPVO are shown in Table 1.

The frequency of sarcopenia among the patients included in the study was 58.6%, as calculated from the L3-4 and/or L4-5 levels. As analyzed separately by spinal levels, the frequency of sarcopenia was found to be 52.9% at the L3-4 level and 37.1% at the L4-5 level. There were strong correlations between those calculated from L3-4 and L4-5 levels for tPMSA, tPMSA z-score, and PMI ($P < 0.001$, r = 0.963; $P < 0.001$, r = 0.641; $P < 0.001$, r = 0.938, respectively).

Eighteen-point six percent of the patients were classified as underweight, 17.1% were wasted, and 15.7% were stunted. Furthermore, 31.4% of the patients were either underweight and/or wasted and/or stunted, conditions that are classified as malnutrition. Sarcopenia was more commonly observed in patients with malnutrition ($P = 0.032$). The frequency of sarcopenic malnutrition was 24.3% (Fig. 1). Two of our patients were obese and none of them were sarcopenic. There were correlations between t-PMSA z-scores at the L3-4 level and both weight and height z-scores, as well as between t-PMSA z-scores at the L4-5 level and both weight and body mass index z-scores. The correlations between t-PMSA z-scores at both levels and z-scores of anthropometric measurements are presented with scatter plot graphs in Figure 2.

Table 1
Demographic and anthropometric characteristics of patients with EHPVO

Variables	*n* = 70
Sex, M, *n* (%)	43 (61.4)
Age (years) †	9.1 ± 4.3
Weight-for-age z-score†	−0.76 ± 1.44
Height-for-age z-score†	−0.37 ± 1.84
BMI z-score†	−0.74 ± 1.48
Malnutrition, *n* (%)	22 (31.4)
Underwent splenorenal shunt surgery, *n* (%)	51 (72.9%)
t-PMSA (mm^2), L3-4*	750 (154-3062)
t-PMSA (mm^2), L4-5*	1003 (259-3893)
PMI (mm^2/m^2), L3-4*	466 (196-1932)
PMI (mm^2/m^2), L4-5*	615 (182-2432)

BMI, body mass index; t-PMSA, total psoas muscle surface area; L, lumbar; PMI, psoas muscle index.
†Mean ± SD.
*Median (min-max).

In Table 2, when the patients with EHPVO are stratified according to the presence of sarcopenia, no significant differences in demographic and laboratory features have been observed between the two groups. As expected, significant differences were observed in the anthropometric measurements, including weight, height, and BMI z-scores, between sarcopenic and nonsarcopenic patients ($P = 0.003$, $P = 0.018$, $P = 0.011$, respectively).

Discussion

To our knowledge, this is the first study that analyses the frequency of sarcopenia and its relation with malnutrition in children with EHPVO. We show that the frequency of sarcopenia in children with EHPVO was 52.9% and 37.1% from the L3-4 and L4-5 levels according to age and gender-matched healthy pediatric trauma patients. This prevalence was similar to those observed in cirrhotic pediatric patients (23–56%) in recent studies [6,7]. Given that our center is a referral center for splenorenal shunt procedures and predominantly manages severe cases of portal hypertension, this may explain the elevated incidence of sarcopenia observed in our patient population.

In pediatric patients with chronic diseases, sarcopenia may coexist with malnutrition, amplifying its negative impact on the

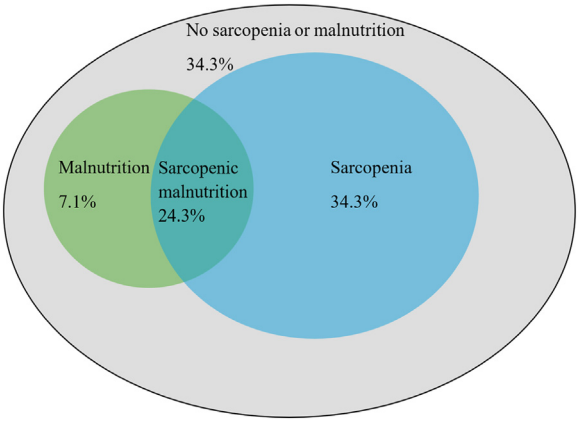


Fig. 1. Distribution of sarcopenia and malnutrition in patients with EHPVO.

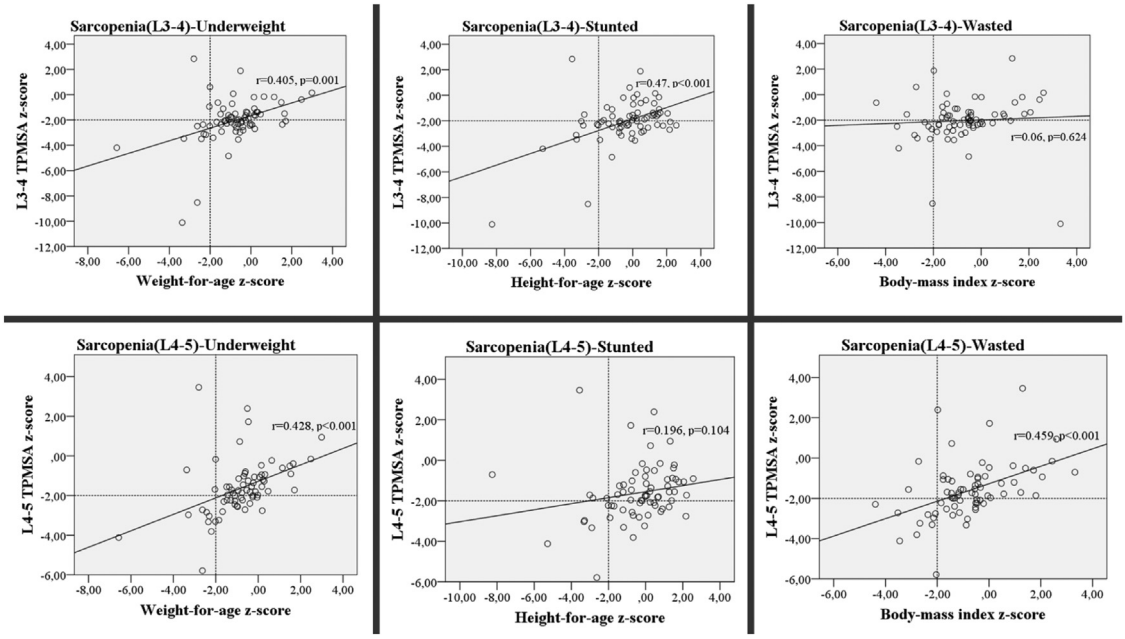


Fig. 2. Correlations between t-PMSA z-scores at L3-4 and L4-5 levels and z-scores of anthropometric measurements. TPMSA, total psoas muscle surface area; L, lumbar.

patients' prognosis. The frequency of malnutrition in patients with EHPVO was 31.4%. As patients with EHPVO have no liver damage, it may suggest that portal hypertension is the main cause of the development of malnutrition and sarcopenia.

The mechanism of malnutrition is not fully understood in patients with EHPVO. Portal hypertensive enteropathy leading to malabsorption might be the first reason. Jejunal biopsy specimens in patients with portal hypertension showed an increase in the size of vessels compared with controls and in the number of vessels per villus suggests that the mucosal and vascular changes of jejunopathy are part of the spectrum found throughout the gastrointestinal tract in patients with portal hypertension [8]. A protein−losing enteropathy has been described in a cirrhotic patient with portal hypertension, which resolved after the insertion of a transjugular intrahepatic portosystemic stent-shunt [9]. Secondly, growth hormone (GH) and insulin-like growth factor I (IGF-I) axis could be disrupted. Mehrotra et al. reported elevated GH and decreased IGF-I levels in children with EHPVO, suggesting GH resistance [10]. That is reasonable, as IGF-I is produced in the liver and is known to exert anabolic effects; consequently, any abnormality that disrupts physiological hepatic blood flow could hinder the normal production of IGF-I and its subsequent anabolic effects. Other endocrine disturbances resulting from portal hypertension may also contribute to impaired growth.

Malnutrition is frequently observed in children with chronic diseases. For example, the rate of malnutrition in cirrhotic children can reach up to 50% [7]. Hulst et al. determined that weight loss was present in 35% of the patients with a hospital stay of 4 days or longer and that could be related to decreased oral intake, pain, prolonged fasting periods, and chronic disease [11]. Recurrent hospitalizations contribute to malnutrition, while malnutrition also extends the duration of hospital stays. In a multicenter study from Europe, length of stay was 1.3 days longer for children with malnutrition [12]. The major cause of hospitalization in patients with portal hypertension is variceal bleeding. Sarcopenia is significantly and independently related to a high 2-year rebleeding rate in cirrhotic adult patients who received endoscopic therapy for preventing variceal rebleeding [13]. In our cohort, the frequency of variceal bleeding episodes did not differ between patients with and without sarcopenia. This absence of difference may be explained by the relatively small number of patients, which restricts the ability to demonstrate a significant association. Although the impact of sarcopenia on clinical outcomes could not be demonstrated in our cohort as in adult studies, early diagnosis and management remain of considerable importance. Moreover, in this patient population, the presence of sarcopenia may merit consideration as an additional criterion in the decision-making process for splenorenal shunt surgery.

Gielchinsky et al. reported that early satiety was observed in approximately 15% of patients with Gaucher disease presenting with massive splenomegaly [14]. Splenomegaly resulting from EHPVO can exert pressure on the stomach, leading to symptoms such as early satiety and loss of appetite, which may contribute to the development of malnutrition in patients [15].

The etiopathogenesis of sarcopenia and malnutrition is similar, although there are distinct differences between them. One such difference is the patients' exercise status. For instance, due to concerns about splenic rupture, exercise restrictions are often applied

Table 2
Comparisons between sarcopenic and nonsarcopenic patients with EHPVO

	Sarcopenic (n = 41)	Nonsarcopenic (n = 29)	P
Sex, M, n (%)	22 (53.7)	21 (72.4)	0.112
Age, years*	9.08 ± 4.48	9.25 ± 4.24	0.873
Weight-for-age z-score*	−1.22 ± 1.38	−0.11 ± 1.28	**0.001**
Height-for-age z-score*	−0.81 ± 2.04	0.23 ± 1.31	**0.018**
BMI z-score*	−1.12 ± 1.34	−0.21 ± 1.53	**0.011**
Malnutrition, n (%)	17 (41.5)	5 (17.2)	**0.032**
Hemoglobin, g/dL*	10.2 ± 2.2	10.9 ± 1.7	0.152
WBC, $\times 10^3/\mu L$*	5.7 ± 4.5	5.7 ± 3.7	0.995
Platelet, $\times 10^3/\mu L$*	137 ± 116	143 ± 127	0.846
Grade of esophageal varices	2.2 ± 1	2.5 ± 0.5	0.156
Esophageal variceal bleeding episodes	1.9 ± 2	2.4 ± 1.7	0.272

WBC, white blood cells; BMI, body mass index.
*Mean ± SD.

to patients with severe splenomegaly. Splenic injuries have been reported in cases with splenomegaly due to infectious mononucleosis. There are some recommendations for activity restriction for a minimum of four weeks or until the resolution of splenomegaly [16,17]. As a result, despite gaining weight, these patients may experience significant reductions in muscle mass. In our study, 34.3% of the patients exhibited sarcopenia without malnutrition, a finding that can be elucidated by this explanation.

The primary limitation of our study was its retrospective design and the small cohort size; however, it represents an important initial step in defining sarcopenia in children with EHPVO. Sarcopenia definitions include not only morphometric criteria but also functional parameters such as handgrip strength or physical performance measures. However, due to the retrospective design of our study, functional assessments were not available and thus could not be incorporated into our analysis. Additionally, there are no validated PMSA reference values for Turkish children. Therefore, we utilized reference values from Canadian children as criteria for diagnosing sarcopenia. This may introduce ethnic and constitutional bias, which could affect the accuracy and generalizability of our findings. Another limitation of the study is that the majority of the CT scans were performed on advanced-stage patients, particularly those scheduled for splenorenal shunt surgery, which may have led to an overestimation of sarcopenia prevalence.

Conclusion

This study provides valuable insights into the frequency of sarcopenia and malnutrition in children with EHPVO. The observed association between portal hypertension and the development of both sarcopenia and malnutrition suggests the need for early screening and intervention strategies. Despite the limitations of our study, including its retrospective nature and small sample size, these results highlight the importance of addressing sarcopenia and malnutrition in the management of children with EHPVO. The major challenges in diagnosing sarcopenia in children include the absence of a gold standard test and reference data for healthy body composition. In our study, we observed a high prevalence of sarcopenia among children with EHPVO; however, its clinical implications remain uncertain, likely due to the limited sample size and reduced statistical power. Future prospective studies with larger cohorts and longitudinal follow-up, evaluating not only muscle mass but also muscle function, are needed to better define the clinical relevance of sarcopenia in this population.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Hakan Ozturk: Writing – original draft, Software, Methodology, Data curation, Conceptualization. **Nezih Yayli:** Software, Methodology, Formal analysis. **Sinan Sari:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Formal analysis, Conceptualization. **Odul Egritas Gurkan:** Writing – review & editing, Supervision. **Oznur Leman Konus Boyunaga:** Methodology, Investigation. **Buket Dalgic:** Writing – review & editing, Visualization, Supervision.

References

[1] Mehta NM, Corkins MR, Lyman B, Malone A, Goday PS, Carney LN, et al. Defining pediatric malnutrition: a paradigm shift toward etiology-related definitions. JPEN J Parenter Enteral Nutr 2013;37(4):460–81.
[2] Widodo AD, Soelaeman EJ, Dwinanda N, Narendraswari PP, Purnomo B. Chronic liver disease is a risk factor for malnutrition and growth retardation in children. Asia Pac J Clin Nutr 2017;26(Suppl 1):S57–60.
[3] Lautz TB, Eaton S, Keys L, Ito J, Polo M, Wells JCK, et al. Metabolic profile of children with extrahepatic portal vein obstruction undergoing meso-Rex bypass. J Surg Res 2018;223:109–14.
[4] Neyzi O, Bundak R, Gokcay G, Gunoz H, Furman A, Darendeliler F, et al. Reference values for weight, height, head circumference, and body mass index in Turkish children. J Clin Res Pediatr Endocrinol 2015;7(4):280–93.
[5] Lurz E, Patel H, Lebovic G, Quammie C, Woolfson JP, Perez M, et al. Paediatric reference values for total psoas muscle area. J Cachexia Sarcopenia Muscle 2020;11(2):405–14.
[6] Mangus RS, Bush WJ, Miller C, Kubal CA. Severe sarcopenia and increased fat stores in pediatric patients with liver, kidney, or intestine failure. J Pediatr Gastroenterol Nutr 2017;65(5):579–83.
[7] Veraldi S, Pietrobattista A, Soglia G, Monti L, Alterio T, Mosca A, et al. Sarcopenia in children with chronic liver disease: prevalence and impact on liver transplant outcomes. Front Pediatr 2022;10:1033570.
[8] Nagral AS, Joshi AS, Bhatia SJ, Abraham P, Mistry FP, Vora IM. Congestive jejunopathy in portal hypertension. Gut 1993;34(5):694–7.
[9] Stanley AJ, Gilmour HM, Ghosh S, Ferguson A, McGilchrist AJ. Transjugular intrahepatic portosystemic shunt as a treatment for protein-losing enteropathy caused by portal hypertension. Gastroenterology 1996;111(6):1679–82.
[10] Mehrotra RN, Bhatia V, Dabadghao P, Yachha SK. Extrahepatic portal vein obstruction in children: anthropometry, growth hormone, and insulin-like growth factor I. J Pediatr Gastroenterol Nutr 1997;25(5):520–3.
[11] 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(1):106–11.
[12] Hecht C, Weber M, Grote V, Daskalou E, Dell'Era L, Flynn D, et al. Disease associated malnutrition correlates with length of hospital stay in children. Clin Nutr 2015;34(1):53–9.
[13] Liu Y, Chang H, Zeng Y, Liu Y, Li J, Chen Y, et al. Impact of sarcopenia on variceal rebleeding in patients after endoscopic therapy: a multicenter retrospective cohort study based on propensity score matching. Ann Med 2024;56(1):2349180.
[14] Gielchinsky Y, Elstein D, Hadas-Halpern I, Lahad A, Abrahamov A, Zimran A. Is there a correlation between degree of splenomegaly, symptoms and hypersplenism? A study of 218 patients with Gaucher disease. Br J Haematol 1999;106(3):812–6.
[15] Khanna R, Sarin SK. Idiopathic portal hypertension and extrahepatic portal venous obstruction. Hepatol Int 2018;12(Suppl 1):148–67.
[16] Baird A, Pun C, Asfaw A. Grade III splenic laceration after a ground-level fall in a pediatric patient: the need for return-to-play/activities protocols for individuals with splenic injury or splenomegaly. Cureus 2023;15(7):e42610.
[17] Sergent SR, Johnson SM, Ashurst J, Johnston G. Epstein-Barr virus-associated atraumatic spleen laceration presenting with neck and shoulder pain. Am J Case Rep 2015;16:774–7.