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Sadık Kılıçturgay
Department of General Surgery, Uludağ University School of Medicine, Bursa, Türkiye
Email: info@clinscinutr.org

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Birgül Dağ, General Secretary
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Clinical Science of Nutrition is an international, peer-reviewed, open access journal. It publishes research articles, reviews, case reports, and letters to the editor on all aspects of nutrition and dietetics.

Clinical Science of Nutrition is a triannual journal that is published in English in April, August, and December.

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Clinical Science of Nutrition is covered in the following abstracting and indexing databases;

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Aims and Scope

The journal aims to contribute to the literature by publishing high impact content and become one of the leading publications of the field while functioning as an open discussion forum on significant issues of current interest. Clinical Science of Nutrition also aims to have significant input in emphasizing the increasing importance of clinical nutrition in Turkey and the region, identifying the effects of differences between societies on study results in a clearer way and converting clinical applications into scientific publications as well as forming a bridge between West and East.

The scope of Clinical Science of Nutrition includes original research articles, review articles, case reports, conference reports, and letters to the editor as well as editorials, abstracts from international and national congresses, panel meetings, conferences and symposia. As an online-only publication, in addition to traditional manuscript submissions, Clinical Science of Nutrition is also able to process video, audio and interactive software submissions. Authors are encouraged to submit their content in the most appropriate medium to best convey their findings to the audience of Clinical Science of Nutrition.

The journal covers all aspects of nutrition and dietetics including prevalence of malnutrition and its effects on clinical results; nutritional support and delivery methods and their advantages and disadvantages; nutritional support products and their side effects; immune system and nutritional support; ERAS protocol and nutritional support; home parenteral and enteral nutrition; nutrition support teams and their necessity, challenges and potential solutions of nutritional support.

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Bee bread (Perga) modulates serum thiol/disulfide homeostasis and oxidative stress in obese mice

Nursena Nahya Servi[1], Ayhan Dağ[1], Abdullah Taşkın[2], Seyhan Taşkın[3]

[1]Department of Nutrition and Dietetics, Faculty of Health Sciences, Lokman Hekim University, Ankara, Türkiye
[2]Department of Nutrition and Dietetics, Faculty of Health Sciences, Harran University, Şanlıurfa, Türkiye
[3]Department of Physiology, Faculty of Medicine, Harran University, Şanlıurfa, Türkiye

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ABSTRACT

Objective: This study aimed to evaluate the effects of bee bread (BB) supplementation on thiol/disulfide homeostasis in an experimental obesity model and to investigate its potential as a functional dietary intervention against obesity-induced oxidative stress(OS).

Methods: An experimental obesity model was established in male C57BL/6 mice, and the animals were divided into control, obesity, BB1 (250 mg/kg), and BB2 (500 mg/kg) groups. Following the intervention, native thiol, total thiol, disulfide levels, and thiol oxidation-reduction ratios (TOR) were measured.

Results: Native thiol and total thiol levels were significantly lower in the obesity group compared to the control group ($p<0.001$), indicating reduced antioxidant capacity. Disulfide levels, oxidized thiol ratio (OT), and thiol oxidation ratio (TOR) were significantly higher in the obesity group ($p=0.008$, $p=0.005$, and $p=0.005$, respectively), reflecting an increased state of OS. Notably, BB supplementation at a dose of 500 mg/kg (BB2) resulted in a significant reduction in disulfide levels ($p=0.008$) and an improvement in redox balance. This was supported by increased reduced thiol ratios and decreased OT values.

Conclusion: Bee bread supplementation partially restored thiol/disulfide homeostasis disrupted by obesity and demonstrated antioxidant effects likely attributed to its rich phenolic and flavonoid content. These findings suggest that BB may serve as a promising natural product in the management of obesity-related OS disorders and contribute novel insights into the use of functional apitherapy in obesity treatment.

Keywords: bee bread, high fat diet, perga, obesity, oxidative stress

Introduction

Obesity is a major public health concern with a multifactorial etiology and an increasing global prevalence.[1,2] The World Health Organization defines obesity as an excessive accumulation of adipose tissue that may adversely affect health, and uses a body mass index (BMI) of ≥30 kg/m² as a diagnostic criterion.[3] The Lancet Diabetes & Endocrinology Commission defines clinical obesity as a chronic disease in which adipose tissue impairs organ function, whereas preclinical obesity refers to a state in which disease risk is elevated but organ functions are not yet affected.[4] The pathophysiology of obesity is associated with OS,

Corresponding author: Nursena Nahya Servi
Email: nursenanahya@gmail.com

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increased production of reactive oxygen species (ROS), and inadequate antioxidant defense systems; this imbalance leads to mitochondrial dysfunction in adipose tissue and cellular-level damage.[5] As adipose tissue mass increases in individuals with obesity, the production of reactive oxygen species (ROS) is elevated, resulting in heightened OS at the cellular level.[6,7] Dynamic thiol-disulfide homeostasis (TDH) is an emerging area of research that has garnered increasing attention. Dynamic TDH refers to the reversible oxidation of thiol groups in proteins and represents the balance between thiols (–SH) and disulfides (–SS–). Thiols are organic compounds containing a sulfhydryl group composed of sulfur and hydrogen atoms. Disulfides are the most important class of dynamic, redox-reactive covalent bonds formed between two thiol group.[8-14] Thiol groups (–SH), which possess antioxidant properties, react with free radicals to form disulfide bonds (–SS). During this process, native thiol levels decrease while disulfide levels increase, thereby disrupting the thiol/disulfide balance[15] he thiol/disulfide balance reflects the oxidation and reduction (redox) state of sulfur-containing groups in proteins.[8] In this context, strategies aimed at reducing OS have become a significant area of investigation for the prevention and management of obesity-related complications. Beebread is a product produced by honeybees (*Apis mellifera* L.) through the fermentation of pollen, nectar, honey, and enzymes. More than 300 compounds have been identified in beebread.[16,17] Its antioxidant properties make beebread a promising candidate in combating OS.[18,19] Polyphenols and other bioactive compounds can mitigate cellular damage by neutralizing ROS and supporting the activity of antioxidant enzymes.[20,21] Although recent studies have highlighted the potential benefits of beebread on metabolic health[10-14,22], its effects on obesity-related OS and associated metabolic disorders remain insufficiently explored.This study aims to investigate the effects of beebread on thiol-disulfide homeostasis in an obesity model, thereby shedding light on potential natural therapeutic approaches targeting the molecular regulation of OS. By examining the impact of beebread on obesity-induced OS through the lens of thiol-disulfide balance, this research seeks to provide new perspectives on the applicability of natural antioxidants in the management of metabolic diseases.

Main Points

- Bee bread (Perga) improves serum thiol/disulfide balance in diet-induced obesity.
- The financial and social impacts of obesity affect both individuals and society, and its treatment and prevention should be made a critical clinical and social priority.
- Consumption of bee bread (perga) may be beneficial for regulating oxidative stress in obesity.

Materials and Methods

Chemicals

Bee bread was commercially obtained from "BEEO" (a company located in the Istanbul Technical University Bee Technopark) in Istanbul, Turkey. The nutrient composition of BB is presented in Table 1. Bee bread was stored at -20 °C. Bee bread, which has a structure that dissolves easily in water, was prepared as a solution in distilled water.

Experimental design

The protocol of this study was approved by the Harran University Local Ethics Committee for Animal Experiments (Protocol No: 2024/001/14). The experimental model is presented in Figure 1. In this study, male C57BL/6 mice, bred at the Guinea Pig Experimental Animals Laboratory Center, were used. The animals were housed in transparent cages under controlled environmental conditions: a 12-hour light/dark cycle, a room temperature of 21±2 °C, and relative humidity of 50–60%. Food and water were

Table 1. Nutritional contents of bee bread.

Nutritional elements	Content (100g)	*RI%
Energy	1508 kJ/359 kcal	18
Fat (g)	9,8	14
Saturated fat (g)	4,1	20,5
Carbohydrate (g)	43	16,5
Sugars (g)	25	27,8
Protein (g)	19	38
Salt (mg)	0,02	0,3
Vitamin ve Minerals		**NRV%
İron (mg)	23,8	170
Zinc (mg)	4,6	46
Vitamin B2 (mg)	1,4	85

Reference intake of an avarege adult (8400 kJ/ 2000 kcal) (*RI: Reference Intake, **NRV: Nutrient Reference Value)

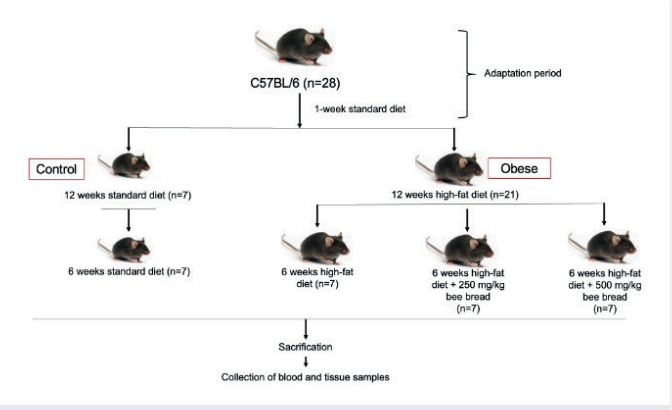

Figure 1. Experimental model

checked regularly every day, and body weights were monitored weekly throughout the study period. Before the experiment began, all mice were fed standard rodent chow *ad libitum* for one week to allow for adaptation. Subsequently, 7 randomly selected C57BL/6 mice were assigned to the control group and fed a standard rodent diet, while the remaining 21 mice were fed a high-fat diet (HFD), in which 60% of the total calories were derived from fat, for a duration of 12 weeks. The obesity model was considered to be successfully established if the body weight of the mice fed the high-fat diet was at least 20% higher than that of the mice fed the standard rodent diet.[23] Bee bread, which is easily soluble in water, was dissolved in distilled water. It was administered to the mice once daily via gastric gavage at doses of 250 and 500 mg/kg.

The groups were planned as follows: Control: Mice fed with a standard rodent diet; Obese: Mice fed with a high-fat diet; Bee Bread 1 (BB1): Obese + BB (250 mg/kg/day); Bee Bread 2 (BB2): Obese + BB (500 mg/kg/day).

After completion of the experimental protocol, blood samples were collected from the rats whose body weights had been recorded. Following exsanguination under ketamine and xylazine anesthesia, the samples were analyzed according to the methods described below.

Biochemical analysis

Measurement of thiol/disulfide levels

The thiol/disulfide levels were performed with a new method previously described by Erel and Neselioglu. First, disulfide bonds were reduced to reactive thiol groups in the presence of sodium borohydride.[24] Later, total thiol and native thiol levels were determined using Ellman reagents.[25] The disulfide levels was obtained by dividing the difference between the total and native thiol by two. Oxidized thiol, reduced thiol, and thiol-oxidation reduction parameters were calculated according to the formula below. Oxidized Thiol Ratio [Disulfide/Total thiol] X100, Reduced Thiol Ratio [Native thiol/Total Thiol]X100, Thiol Oxidation Reduction Ratio [Didulfide/ Native thiol] X100. Results were expressed as μmol/L.

Statistical analysis

Statistical analyses were performed using the SPSS 25.0 software package (IBM SPSS Inc., Chicago, IL, USA). Data normality was assessed with Shapiro-Wilk and Kolmogorov-Smirnov tests. Normally distributed variables were reported as mean±standard deviation, non-normally distributed as median. Group comparisons used One-way ANOVA for parametric data and Kruskal-Wallis H for non-parametric data. Levene's Test checked variance homogeneity in normal distributions. Post-hoc tests included Tukey HSD for homogeneous variances and Games-Howell for non-homogeneous variances. Non-parametric pairwise comparisons used Bonferroni correction. A confidence interval (CI) of 95% was considered, and $p < 0.05$ was accepted as statistically significant.

Results

Table 2 presents a comparative analysis of serum thiol/disulfide homeostasis parameters among the experimental groups (Control, Obese, BB1, BB2). The native thiol levels in the control group (582.3 ± 66.8 μmol/L) were found to be significantly higher compared to the Obese, BB1, and BB2 groups (332.6 ± 88.9 μmol/L; 294.9 ± 96.9 μmol/L; and 323.2 ± 44.5 μmol/L, respectively) ($p<0.001$). The total thiol levels in the control group (812.9 ± 132.2 μmol/L) were significantly higher compared to the BB1 (561.9 ± 58.5 μmol/L) and BB2 (508.6 ± 37.2 μmol/L) groups. Additionally, total thiol levels in the obese group (729.5 ± 96.0 μmol/L) were also significantly higher than those in the BB1 and BB2 groups ($p<0.001$).

The disulfide level in the obese group (198.4 ± 60.7 μmol/L) was found to be significantly higher compared to the BB2 group (92.6 ± 15.0 μmol/L) ($p = 0.008$) (Figure 2).

Table 2. Comparison of serum thiol/disulfide homeostasis parameters in experimental groups.

	Control (n=7)	Obese (n=7)	Bee Bread 1 (n=7)	Bee Bread 2 (n=7)	p value
Native thiol, (µmol/L)	582.3±66.8 $^{\alpha,\beta,\delta}$	332.6±88.9	294.9±96.9	323.2±44.5	<0.001
Total thiol (µmol/L)	812.9±132.2 $^{\beta,\delta}$	729.5±96.0 $^{\Omega,\varepsilon}$	561.9±58.5	508.6±37.2	<0.001
Disulfide (µmol/L)	115.3±68.7	198.4±60.7 $^{\varepsilon}$	133.5±55.4	92.6±15.0	0.008
OT (%)	13.4±6.5 $^{\alpha}$	26.9±6.4 $^{\varepsilon}$	23.4±9.2	18.2±3.2	0.005
RT (%)	73.1±13.1 $^{\alpha}$	46.0±12.8 $^{\varepsilon}$	53.0±18.4	63.4±6.5	0.005
TOR (%)	19.8[25.7] $^{\alpha}$	61.6[28.0]	36.0[81.4]	28.6[11.6]	0.010

Data are expressed as mean ± SD and median [IQR] were appropriate. P < 0.05 was accepted as significant. Significant differences were identified as follows: α: Control vs Obesity, β: Control vs Bee Bread 1, δ: Control vs Bee Bread 2, Ω: Obesity vs Bee Bread 1, ε: Obesity vs Bee Bread 2 (OT: Oxidative Thiol Ratio; RT: Reduced Thiol Ratio; TOR: Thiol Oxidation Reduction Ratio)

The oxidized thiol ratio (OT) was significantly higher in the obese group (%26.9 ± 6.4) compared to the control group (%13.4 ± 6.5) (p = 0.005). Furthermore, the OT value in the BB2 group (%18.2 ± 3.2) was significantly lower than that in the obese group (p = 0.005) (Figure 3).

The reduced thiol ratio (RT) was found to be significantly lower in the obese group (%46.0 ± 12.8) compared to the control group (%73.1 ± 13.1) (p = 0.005). Moreover, the RT value in the BB2 group (%63.4 ± 6.5) was significantly higher than that in the obese group (p = 0.005) (Figure 4).

The thiol oxidation-reduction ratio (TOR) was found to be significantly lower in the control group (19.8% [25.7]) compared to the obesity group (61.1% [28.0]) (p=0.005). Although the thiol oxidation-reduction ratio was lower in the BB1 and BB2 groups compared to the obesity group, it was not found to be significant.

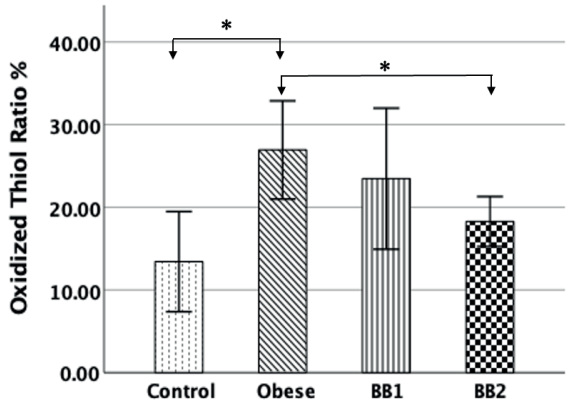

Figure 3. Evaluation of oxidized thiol levels across the groups

*p < 0.05 was accepted as significant.

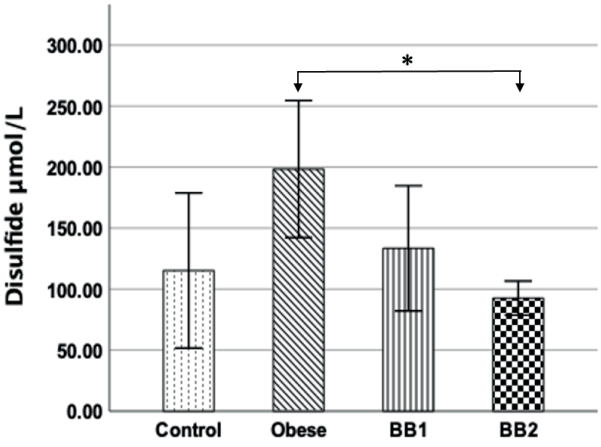

Figure 2. Evaluation of disulfide levels across the groups

*p < 0.05 was accepted as significant.

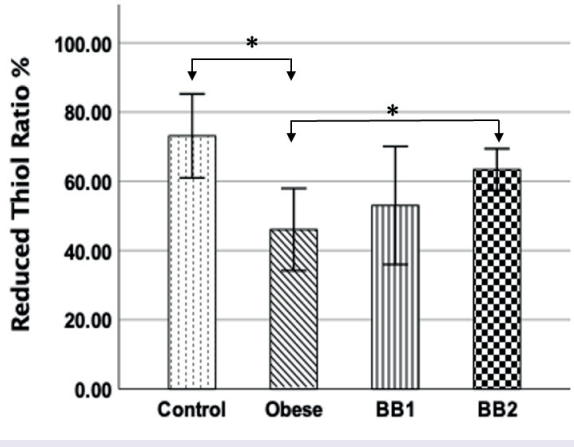

Figure 4. Evaluation of reduced thiol levels across the groups

*p < 0.05 was accepted as significant.

Discussion

Obesity is a chronic disease characterized by excess adiposity, which leads to structural and functional consequences, thereby increasing the risk of comorbidities and premature mortality.[26] Obesity has financial and social impacts that can affect not only the individual patient but the entire society.[27] Therefore, studies aimed at the treatment or prevention of obesity have become a target of great clinical and social importance.

Many methods developed to treat obesity are related to nutritional components. Apitherapy is a type of biotherapy that uses bees and their products (honey, pollen, propolis, BB, royal jelly, bee venom, beewax, apilarnil) as medicinal or preventative of diseases progression. *Apitherapy* derives its name from the Latin word *"Apis"* (bee).[28] Honey bees are the "golden insects" that produce honey and other vital bee Products.[29] Bee products promote healing through reducing inflammation, enhancing circulation, and inducing a healthy immunological response.[28] Bee bread, a hive product formed from a mixture of pollen, honey, and bee salivary secretions, has attracted attention due to its potential health benefits.[30] Bee bread has been proven to possess antioxidant, antifungal, antibacterial, and antitumoral activities. Additionally, it has been shown to be effective in alleviating various pathological conditions such as hyperglycemia, hyperlipidemia, inflammation, and OS.[16,31] The main components of BB include carbohydrates, proteins, and vitamins, as well as minerals, fatty acids, enzymes, natural antibiotics, antioxidants, and hormones.[31,32] Bee bread is considered a beneficial nutritional supplement. This abundance of natural antioxidants in the BB mitigates the ROS generation.[31] In recent years, there has been significant interest in the use of BB for the treatment of various Diseases.[9-14,22] Considering the known biological activities of BB, we conducted this study to evaluate its effects on obesity within the context of thiol/disulfide homeostasis, hypothesizing that this redox balance may serve as a potential biomarker for the diagnosis and monitoring of obesity. Although various studies have explored the biological properties and effects of BB, the relationship between obesity and thiol/disulfide levels has not been investigated. To the best of our knowledge, this is the first study to investigate.

In this study, based on thiol/disulfide homeostasis measurements conducted after the completion of the experimental protocol in obese mice, native thiol and total thiol levels were found to be significantly lower in the obesity group compared to the control group ($p<0.001$). This finding suggests that obesity diminishes antioxidant capacity and promotes the oxidation of thiol groups. Such an impact of obesity on oxidative stress may play a critical role in the development of obesity-related comorbidities, such as cardiovascular diseases and diabetes. Consistent with our results, Öklü et al.[33] demonstrated that native and total thiol levels decrease as body mass index (BMI) increases. Similarly, another study[34] reported that serum total antioxidant capacity was significantly lower in obese individuals compared to their non-obese counterparts. Furthermore, a separate investigation[15] found statistically significant reductions in native and total thiol levels in obese subjects compared to controls, indicating that obesity disrupts thiol redox homeostasis. These consistent findings across studies suggest that thiol/disulfide homeostasis could serve as a potential biomarker for assessing oxidative stress in obesity.

The disulfide level appeared to be increased in the obese group compared to the control group, but it was found to be significantly higher compared to the BB2 group ($p=0.008$). This finding indicates that obesity promotes the conversion of thiols to disulfides, likely driven by heightened oxidative stress (OS). Conversely, the reduced disulfide levels in the BB2 group suggest that the intervention mitigates OS and enhances antioxidant defense mechanisms. Disulfide bonds, formed through the oxidation of thiol groups under conditions of OS, serve as a reliable marker of oxidant activity.[24] Thus, the lower disulfide levels in the BB2 group underscore the intervention's beneficial effect on restoring redox balance. Consistent with these observations, the thiol/disulfide homeostasis system has been widely explored as an indicator of OS in various clinical contexts. For instance, a study in patients with stable coronary artery disease demonstrated that elevated disulfide levels were associated with impaired collateral vessel development, suggesting that thiol/disulfide balance could serve as a prognostic biomarker in cardiovascular conditions.[35] Similarly, in patients with acute coronary syndrome, thiol levels and thiol/disulfide ratios were highlighted as potential antioxidant biomarkers for disease evaluations.[36] These findings align with our study, where increased OS in obesity shifts the thiol/disulfide equilibrium, reinforcing the potential of these parameters as diagnostic and monitoring tools. Additionally, research on individuals with type 2 diabetes has shown that higher serum thiol (R-SH) levels correlate with improved metabolic control and reduced complications, further supporting the role of thiol/disulfide homeostasis in

assessing systemic redox status.[37] Moreover, Taşkın et al. emphasized that preserving thiol groups and minimizing disulfide formation during exercise serve as critical biochemical indicators of reduced OS.[38] While thiol/disulfide homeostasis has been extensively studied in exercise, diabetes, and cardiovascular disease models, its evaluation in the context of obesity, particularly with BB supplementation, distinguishes our study. This novel application highlights the potential of thiol/disulfide parameters as sensitive biomarkers for assessing the efficacy of antioxidant interventions in obesity-related oxidative stress, warranting further investigation into their clinical applicability.

The oxidized thiol ratio was significantly higher in the obesity group compared to the control group (p=0.005), reflecting an increase in oxidative stress (OS). In contrast, the oxidized thiol ratio was significantly lower in the BB2 group compared to the obesity group (p=0.005), indicating that BB2 supplementation effectively mitigates OS and restores oxidative balance. Similarly, the reduced thiol ratio was significantly lower in the obesity group compared to the control group (p=0.005), underscoring a diminished antioxidant capacity in obesity. However, the reduced thiol ratio was significantly higher in the BB2 group compared to the obesity group (p=0.005), suggesting that BB2 supplementation bolsters the antioxidant defense system and promotes thiol/disulfide homeostasis. These findings align with prior research demonstrating that disruptions in thiol redox balance are associated with obesity-related oxidative stress.[33,34] The ability of BB2 supplementation to reverse these alterations highlights its potential as a therapeutic intervention for mitigating oxidative damage in obesity. Notably, the consistent improvement in both oxidized and reduced thiol ratios in the BB2 group underscores the intervention's role in enhancing systemic redox status, a finding that distinguishes our study from existing literature, which has primarily focused on thiol homeostasis in other conditions such as diabetes or cardiovascular Disease.[35-37] These results suggest that the thiol/disulfide balance could serve as a sensitive biomarker for evaluating the efficacy of antioxidant interventions in obesity, warranting further exploration in clinical settings to validate its translational potential.

The thiol oxidation-reduction ratio (TOR) was significantly lower in the control group compared to the obese group (p=0.005), reflecting heightened oxidative stress (OS) in obesity due to increased thiol oxidation. This finding is consistent with our earlier observations of elevated oxidized thiol ratios (p=0.005), reduced thiol ratios (p=0.005), and increased disulfide levels (p=0.008) in obese subjects, underscoring the disruption of thiol/disulfide homeostasis in obesity. Notably, the TOR was lower in both the BB1 and BB2 intervention groups compared to the obesity group, with a more pronounced decrease in the BB2 group, although these differences did not reach statistical significance. This trend aligns with our prior findings that BB2 supplementation significantly reduces oxidized thiol ratios (p=0.005) and disulfide levels (p=0.008) while increasing reduced thiol ratios (p=0.005), suggesting that BB2 supplementation mitigates OS and enhances antioxidant defense in obesity. These results are consistent with a recent study in obese children, which reported significantly lower levels of native thiol, total thiol, and the native/total thiol ratio, along with higher levels of disulfide, disulfide/native thiol ratio, and disulfide/total thiol ratio in metabolically unhealthy obese (MUO) children compared to controls. These findings indicate a pronounced oxidative imbalance in metabolically compromised obesity. The same study proposed that thiol/disulfide homeostasis may serve as a reliable biomarker of oxidant-antioxidant status in MUO children, supporting our hypothesis that these parameters are sensitive indicators of redox status in obesity.[15] Our findings extend this framework by evaluating BB1 and BB2 supplementation in an obesity model, a novel approach compared to prior studies focused on diabetes, cardiovascular disease, or exercise.[33,35-38] The lack of statistical significance in TOR differences for BB1 and BB2 groups may reflect factors such as sample size, intervention duration, or variability in response to supplementation. Nevertheless, the consistent trends across thiol-related parameters in our study, particularly with BB2, highlight its potential as a therapeutic intervention for restoring redox homeostasis. These findings suggest that thiol/disulfide homeostasis, including TOR, could serve as a valuable biomarker for assessing the efficacy of antioxidant interventions in obesity, particularly in metabolically unhealthy individuals.

Thiol oxidation-reduction ratio (TOR) was found to be significantly lower in the control group compared to the obesity group (p=0.005), which reveals the increased OS level with obesity. Although a more significant decrease in TOR value was observed in the BB2 group, this difference was not found to be statistically significant, although TOR values were lower in both the BB1 and BB2 groups compared to the obesity group. This result suggests that the BB2 group may positively affect the oxidative balance. Although there is no study examining BB specifically for obesity-related thiol/disulfide levels, as in this study, there are several studies in the literature

showing that BB reduces OS by exhibiting antioxidant properties.[13,39,40]

Conclusion

In conclusion, the obtained data show that obesity increases OS by disrupting thiol/disulfide homeostasis, and BB treatment has the potential to partially restore this balance. Both BB1 and especially BB2 application exhibited positive effects in terms of reducing obesity-related OS. The decrease in disulfide level and the increase in reduced thiol ratio in the BB2 group revealed that this group presented a more advantageous oxidative profile compared to the obesity group. In this study, it was observed that BB2 applied at a dose of 500 mg/kg was more effective, but it was concluded that additional or long-term interventions may be needed to fully restore thiol/disulfide homeostasis.

In this study, it was shown that bee bread (perga) application corrected obesity-related thiol-disulfide imbalances and significantly reduced disulfide levels; this effect is thought to be due to the redox balance modulating capacity of phenolic compounds, flavonoids and other bioactive antioxidants naturally found in perga. These results provide new and original contributions to the literature regarding the use of functional natural products in the management of obesity-related OS disorders.

Acknowledgments

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Ethical approval

This study has been approved by the Harran University Local Ethics Committee for Animal Experiments (approval date 14.02.2024, number 2024/001/14). Written informed consent was obtained from the participants.

Author contribution

The authors declare contribution to the paper as follows: Study conception and design: NNS, AD, AT, ST; data collection: NNS, AT, ST; analysis and interpretation of results: NNS, AD, AT, ST; draft manuscript preparation: NNS, AD, AT, ST. All authors reviewed the results and approved the final version of the article.

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Conflict of interest

The authors declare that there is no conflict of interest.

References

1. Roberto CA, Swinburn B, Hawkes C, et al. Patchy progress on obesity prevention: emerging examples, entrenched barriers, and new thinking. *Lancet*. 2015;385:2400-2409. [Crossref]
2. Perdomo CM, Cohen RV, Sumithran P, Clément K, Frühbeck G. Contemporary medical, device, and surgical therapies for obesity in adults. *Lancet*. 2023;401:1116-1130. [Crossref]
3. World Health Organization (WHO). Obesity and overweight. 2024; Available at: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight (Accessed on Apr 20, 2025).
4. Rubino F, Cummings DE, Eckel RH, et al. Definition and diagnostic criteria of clinical obesity. *Lancet Diabetes Endocrinol*. 2025;13:221-262. [Crossref]
5. Manna P, Jain SK. Obesity, oxidative stress, adipose tissue dysfunction, and the associated health risks: causes and therapeutic strategies. *Metab Syndr Relat Disord*. 2015;13:423-444. [Crossref]
6. Yu J, Qiu J, Zhang Z, et al. Redox biology in adipose tissue physiology and obesity. *Adv Biol (Weinh)*. 2023;7:e2200234. [Crossref]
7. Fernández-Sánchez A, Madrigal-Santillán E, Bautista M, et al. Inflammation, oxidative stress, and obesity. *Int J Mol Sci*. 2011;12:3117-3132. [Crossref]
8. Erel Ö, Erdoğan S. Thiol-disulfide homeostasis: an integrated approach with biochemical and clinical aspects. *Turk J Med Sci*. 2020;50:1728-1738. [Crossref]

9. Othman Z, Ghazali WS, Noordin L, Yusof NAMohd, Mohamed M. Hypolipidaemic and cardioprotective effects of bee bread harvested from stingless bee (Heterotrigona Itama) in High-Fat Diet-Induced Obese Animal Model. *IIUM Medical Journal Malaysia*. 2025;24. **[Crossref]**
10. Martiniakova M, Blahova J, Kovacova V, et al. Bee bread can alleviate lipid abnormalities and impaired bone morphology in obese zucker diabetic rats. *Molecules*. 2021;26:2616. **[Crossref]**
11. Suleiman JB, Abu Bakar AB, Noor MM, et al. Bee bread mitigates downregulation of steroidogenic genes, decreased spermatogenesis, and epididymal oxidative stress in male rats fed with high-fat diet. *Am J Physiol Endocrinol Metab*. 2021;321:E351-E366. **[Crossref]**
12. Othman ZA, Zakaria Z, Suleiman JB, et al. Bee bread ameliorates vascular inflammation and impaired vasorelaxation in obesity-induced vascular damage rat model: the role of eNOS/NO/cGMP-Signaling pathway. *Int J Mol Sci*. 2021;22:4225. **[Crossref]**
13. Suleiman JB, Mohamed M, Abu Bakar AB, Zakaria Z, Othman ZA, Nna VU. Therapeutic effects of bee bread on obesity-induced testicular-derived oxidative stress, inflammation, and apoptosis in high-fat diet obese rat model. *Antioxidants (Basel)*. 2022;11:255. **[Crossref]**
14. Doğanyiğit Z, Yakan B, Soylu M, Kaymak E, Silici S. The effects of feeding obese rats with bee bread on leptin and ghrelin expression. *Turkish Journal of Zoology*. 2020;44:114-125. **[Crossref]**
15. Mengen E, Uçaktürk SA, Kocaay P, Kaymaz Ö, Neşelioğlu S, Erel Ö. The Significance of thiol/disulfide homeostasis and ischemia-modified albumin levels in assessing oxidative stress in obese children and adolescents. *J Clin Res Pediatr Endocrinol*. 2020;12:45-54. **[Crossref]**
16. Bakour M, Laaroussi H, Ousaaid D, et al. Bee bread as a promising source of bioactive molecules and functional properties: an Up-To-Date review. *Antibiotics (Basel)*. 2022;11:203. **[Crossref]**
17. Baky MH, Abouelela MB, Wang K, Farag MA. Bee pollen and bread as a super-food: a comparative review of their metabolome composition and quality assessment in the context of best recovery conditions. *Molecules*. 2023;28:715. **[Crossref]**
18. Habryka C, Socha R, Juszczak L. The influence of bee bread on antioxidant properties, sensory and quality characteristics of multifloral honey. *Applied Sciences*. 2023;13:7913. **[Crossref]**
19. Othman ZA, Noordin L, Ghazali WS, Omar N, Mohamed M. Nutritional, phytochemical and antioxidant analysis of bee bread from different regions of Malaysia. *Indian J Pharm Sci*. 2019;81:955-960. **[Crossref]**
20. Sun S, Liu Z, Lin M, Gao N, Wang X. Polyphenols in health and food processing: antibacterial, anti-inflammatory, and antioxidant insights. *Front Nutr*. 2024;11:1456730. **[Crossref]**
21. Rudrapal M, Khairnar SJ, Khan J, et al. Dietary polyphenols and their role in oxidative stress-induced human diseases: insights into protective effects, antioxidant potentials and mechanism(s) of action. *Front Pharmacol*. 2022;13:806470. **[Crossref]**
22. Doğanyiğit Z, Yakan B, Kaymak E. The Effects of feeding obese rats by bee bread on IL-6 expression in rat Stomach. [ITALIC] Proc West Mark Ed Assoc Conf[/ITALIC. 2018;2:1570. **[Crossref]**
23. An T, Liu JX, Yang XY, Lv BH, Wu YX, Jiang GJ. Supplementation of quinoa regulates glycolipid metabolism and endoplasmic reticulum stress in the high-fat diet-induced female obese mice. *Nutr Metab (Lond)*. 2021;18:95. **[Crossref]**
24. Erel O, Neselioglu S. A novel and automated assay for thiol/disulphide homeostasis. *Clin Biochem*. 2014;47:326-332. **[Crossref]**
25. Ellman G, Lysko H. A precise method for the determination of whole blood and plasma sulfhydryl groups. *Anal Biochem*. 1979;93:98-102.
26. Elmaleh-Sachs A, Schwartz JL, Bramante CT, Nicklas JM, Gudzune KA, Jay M. Obesity management in adults: a review. *JAMA*. 2023;330:2000-2015. **[Crossref]**
27. Harris L, Hamilton S, Azevedo LB, et al. Intermittent fasting interventions for treatment of overweight and obesity in adults: a systematic review and meta-analysis. *JBI Database System Rev Implement Rep*. 2018;16:507-547. **[Crossref]**
28. El-Didamony SE, Gouda HI, Zidan MM, Amer RI. Bee products: an overview of sources, biological activities and advanced approaches used in apitherapy application. *Biotechnol Rep (Amst)*. 2024;44:e00862. **[Crossref]**
29. Faqihi RA, Taha EA. Apitherapy as an alternative medicine: article review. *African Journal of Biological Sciences*. 2022;18:43-57. **[Crossref]**
30. Nahya N. The Bee bread as super food: an up-to-date review in terms of chronic diseases. *Advances in Chronic Diseases*. 2024;1:37-43. doi:10.5281/zenodo.10903147
31. Khalifa SA, Elashal M, Kieliszek M, et al. Recent insights into chemical and pharmacological studies of bee bread. *Trends Food Sci Technol*. 2020;97:300-316. **[Crossref]**
32. Ćirić J, Haneklaus N, Rajić S, Baltić T, Lazić IB, Đorđević V. Chemical composition of bee bread (perga), a functional food: a review. *Journal of Trace Elements and Minerals*. 2022;2:100038. **[Crossref]**
33. Öklü K, Çifçi A, Gün Güneş A, Durmaz Ceylan Ş, Erel Ö. Evaluation of the effect of obesity on oxidative stress with thiol/disulphide balance. *Intercontinental Journal of Internal Medicine*. 2023;1:8-14. **[Crossref]**
34. Anaya-Morua W, Villafan-Bernal JR, Ramírez-Moreno E, et al. Total antioxidant capacity in obese and non-obese subjects and its association with anthropo-metabolic markers: systematic review and meta-analysis. *Antioxidants (Basel)*. 2023;12:1512. **[Crossref]**

35. Doğan Y, Yilmaz Y, Keleşoğlu S, et al. Are thiols useful biomarkers for coronary collateral circulation in patients with stable coronary artery disease? *J Clin Med*. 2023;12:6361. **[Crossref]**

36. Ergün G, Keleşoğlu Ş, Tekin K, et al. A new biomarker in the distinction between stable coronary artery disease and acute coronary syndrome: thiols. *Journal of Contemporary Medicine*. 2022;12:526-531. **[Crossref]**

37. Schillern EE, Pasch A, Feelisch M, et al. Serum free thiols in type 2 diabetes mellitus: a prospective study. *J Clin Transl Endocrinol*. 2019;16:100182. **[Crossref]**

38. Taşkın S, Çelik H, Taşkın A. The effect of anthocyanin administration on redox balance in acute exercise: an experimental study. *Cukurova Medical Journal*. 2024;49:471-478. **[Crossref]**

39. Bakour M, Al-Waili NS, El Menyiy N, et al. Antioxidant activity and protective effect of bee bread (honey and pollen) in aluminum-induced anemia, elevation of inflammatory makers and hepato-renal toxicity. *J Food Sci Technol*. 2017;54:4205-4212. **[Crossref]**

40. Ilie CI, Spoiala A, Geana EI, et al. Bee bread: a promising source of bioactive compounds with antioxidant properties-first report on some antimicrobial features. *Antioxidants (Basel)*. 2024;13:353. **[Crossref]**

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Evaluation of micronutrient adequacy in adult enteral formulas in Türkiye: a comparison with DRI, ESPEN, and National Guideline (TUBER-2022)

Nurhayat Tuğra Özer[1]

[1]Department of Nutrition and Dietetics, Faculty of Health Sciences, Ağrı İbrahim Çeçen University, Ağrı, Türkiye

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ABSTRACT

Objective: Enteral nutrition (EN) is a cornerstone of nutritional support for patients unable to meet their dietary needs orally, yet concerns remain regarding the adequacy of micronutrient provision in commercial enteral formulas. The aim of the study is to evaluate the micronutrient content of commonly used adult enteral formulas in Turkiye by comparing their composition with the recommendations provided in international and national guidelines.

Methods: Thirty-eight commercially available adult enteral formulas, encompassing standard, immune-modulating, and disease-specific types were analyzed. The micronutrient content was calculated based on the labelled values and subsequently adjusted for daily energy intakes of 1500 and 1800 kcal. These values were then compared with Dietary Reference Intakes (DRIs), ESPEN micronutrient guidelines, and TUBER-2022 recommendations.

Results: At a 1500 kcal/day EN intake, 89.1% of the formulas (33/37) failed to meet the recommended intake for vitamin K, 86.5% (32/37) for vitamin D, and 94.6% (35/37) for magnesium based on DRI and ESPEN guidelines. Additionally, 37.8% (14/37) of the formulas did not meet the iron requirement specifically for females according to DRI and ESPEN recommendations. According to ESPEN's recommendations for high demand, all formulas were found to be insufficient in multiple micronutrients, including vitamins A, D, E and B-complex vitamins, as well as iron, zinc, selenium, chromium and molybdenum. Furthermore, one immune-modulating formula exceeded the tolerable upper intake levels for five micronutrients (folic acid, calcium, magnesium, zinc, and manganese) according to both the DRI and the TUBER-2022.

Conclusion: Commonly used enteral formulas in Turkey may inadequately supply essential micronutrients, particularly to vulnerable populations with increased requirements. These findings emphasize the need for routine clinical monitoring, individualized supplementation strategies and reformulation of products, especially with regard to vitamin D and magnesium content, to align with ESPEN's higher intake recommendations.

Keywords: enteral nutrition, micronutrient, DRI, ESPEN, TUBER

Introduction

Enteral nutrition (EN) is a key part of nutritional management for patients who cannot meet their dietary requirements through oral intake, but who have an intact and functional gastrointestinal tract. EN plays a critical role in preserving gut integrity, supporting immune function and mitigating the risks of malnutrition in various clinical contexts.[1] The increasing variety and range of commercial enteral formulas provide clinicians

Corresponding author: Nurhayat Tuğra Özer
Email: ntozer@agri.edu.tr

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with options tailored to specific patient needs, including standard, immune-modulating and disease-specific formulations.[2]

Enteral formulas are typically developed based on the Dietary Reference Intakes (DRIs). They are designed to deliver essential nutrients—including macronutrients, micronutrients, and antioxidants—to meet the daily nutritional needs of diverse patient populations, ranging from critically ill, hypermetabolic individuals to stable patients receiving long-term home enteral nutrition.[3] However, DRIs primarily represent reference intake values intended for healthy individuals and general population groups.[4] Despite the widespread use of enteral formulas, concerns persist regarding whether their micronutrient content adequately meets the nutritional demands outlined by current clinical guidelines.

Micronutrients, including vitamins, minerals and trace elements, are essential for many physiological processes, including immune defense, enzymatic activity and metabolism. Both micronutrient deficiencies and excesses may adversely affect clinical outcomes, particularly in vulnerable populations such as older adults, individuals with chronic diseases.[5,6] Patients receiving prolonged enteral nutrition are particularly susceptible to micronutrient imbalances, which can result in significant clinical complications, including deficiencies and toxicities.[7-9]

To ensure optimal patient care, it is essential to systematically assess the micronutrient profiles of commercially available enteral formulas by comparing them with established international and national dietary guidelines.[10] Key reference standards include the Dietary Reference Intakes (DRIs)[11], the micronutrient guideline of the European Society for Clinical Nutrition and Metabolism (ESPEN)[5], and the Turkish Nutrition Guideline (TUBER-2022).[12] The DRIs[11] provide nutrient intake recommendations primarily based on healthy populations and serve as a general reference for adequate nutrient consumption. In contrast, ESPEN guideline[5] focus specifically on clinical nutrition, offering tailored recommendations for patients with diverse medical conditions and metabolic demands. TUBER-2022[12], as a national guideline, integrates local nutritional considerations and population-specific data to guide clinical nutrition practices in Türkiye. These standards provide recommendations for appropriate micronutrient intake in clinical nutrition practice.

Main Points

- The majority of adult enteral formulas available in Turkey do not meet the recommended intake levels for key micronutrients, particularly vitamin D, vitamin K, magnesium, and iron.
- In comparison with the higher intake recommendations set out by ESPEN, a more extensive insufficiency of micronutrients was identified.
- These findings emphasise the necessity of revising product formulations and strengthening clinical strategies to align with international and national nutritional standards.

In Türkiye, the use of enteral nutrition formulas is steadily increasing; however, there is limited data available regarding their micronutrient adequacy compared to international and national guidelines. This study aims to evaluate the micronutrient contents of commonly used adult enteral formulas in Türkiye and compare them with the recommendations of DRI, ESPEN, and TUBER-2022, thereby providing clinicians with essential information to guide formula selection and optimize nutritional management.

Methods

This study evaluated 38 adult EN formulas produced by three different manufacturers and available commercially in Türkiye. The formulas were categorized into three groups: 21 standard EN formulas, six immune-modulating formulas, and 11 disease-specific formulas (for diabetes, pulmonary disease, renal disease, and malabsorption). Nutritional data were extracted from product labels available on official websites or technical documents provided by manufacturers.

In this study, nutrient reference values were obtained from several authoritative sources to ensure comprehensive assessment. The DRI[11] provided Recommended Dietary Allowance (RDA), which represents the average daily intake sufficient to meet the nutrient requirements of nearly all healthy individuals, and Tolerable Upper Intake Level (UL), indicating the maximum daily intake unlikely to cause adverse health effects. The ESPEN[5] supplied minimum and maximum nutrient requirements, defining safe intake ranges applicable in clinical nutrition settings. Additionally, the TUBER-2022[12] offered Adequate Intake (AI), recommended when RDA values are not established, along with UL values to identify upper intake limits.

The micronutrient content of each product was calculated based on the labelled values and standardized to daily energy intakes of 1500 and 1800 kcal/day.[10,13] These values were then compared with the recommendations of the DRIs[11], ESPEN micronutrient guideline[5], and the TUBER-2022.[12] The average micronutrient levels were then assessed, and nutrients that did not meet the recommended levels were examined in detail across all enteral formulas.

Data analysis was performed using RStudio software (version 2022.07.1, RStudio PBC, Boston, MA, USA). Continuous variables were presented as median (minimum–maximum). Micronutrients that did not meet the recommended intake thresholds were identified and analyzed in more detail across formula categories. This study was designed as a descriptive analysis aiming to compare micronutrient contents with established guidelines; therefore, no statistical hypothesis testing was conducted.

Results

The micronutrient contents of the evaluated enteral formulas at a 1500 kcal intake, along with the corresponding reference values and tolerable upper intake levels based on DRI, ESPEN, and TUBER-2022 guidelines, are summarized in Table 1. Additionally, Figure 1 illustrates the percentages of micronutrient provision relative to the recommended daily intake levels.

According to the DRI, the enteral formulas provided 56.10–67.32% of the recommended daily potassium intake, 59.46–71.36% of chloride, 67.17–80.61% of magnesium, 76.79–92.14% of sodium, and 81.20–97.43% of vitamin K when administered at energy levels of 1500-1800 kcal per day. Eleven other micronutrients met or exceeded daily requirements and remained well below the established tolerable upper intake levels, indicating a safe intake range for these nutrients.

Based on ESPEN guidelines, the formulas provided 62.58–75.10% of the recommended daily vitamin D intake, 66.39–79.66% of the recommended daily iron intake, and 81.20–97.44% of the recommended daily vitamin K intake, all at the same energy levels. Other micronutrients were supplied in adequate amounts.

When evaluated in reference to the TUBER-2022 guidelines, the formulas provided 54.50–65.40% of the recommended potassium intake and 57.59–69.11% of the recommended sodium intake. Other micronutrients met or exceeded daily requirements while remaining safely below the upper intake limits, suggesting no potential risk of excessive intake.

However, when evaluated according to the higher intake recommendations outlined in ESPEN guidelines, the enteral formulas were insufficient in providing several key micronutrients at a 1500 kcal/day intake. These included vitamins A, D, and E, B-complex vitamins (thiamine, riboflavin, niacin, vitamin B6, biotin, folic acid, and vitamin B12), as well as the minerals iron, zinc, selenium, chromium, and molybdenum (Figure 2).

Detailed evaluation of vitamin D, vitamin K, iron, and magnesium contents at both 1500 kcal and 1800 kcal intake levels revealed persistent inadequacies across most formulas, as presented in Figure 3. With the exception of one immune-modulating formula, the remaining products failed to provide sufficient vitamin D intake according to ESPEN recommendations at 1500 kcal/day. Additionally, based on DRI and TUBER-2022 criteria, 45.9% (17 out of 37) of the enteral formulas were inadequate in meeting the daily vitamin D requirement at this energy level.

Although 81.1% (30 out of 37) of the formulas met the vitamin K requirement according to TUBER-2022 guidelines, adequacy rates significantly declined when compared to the standards of DRI and ESPEN, with only 10.8% (4 out of 37) meeting the recommended levels. In contrast, 89.1% (33 out of 37) of the formulas failed to meet the vitamin K requirements according to DRI and ESPEN guidelines (Figure 3).

Regarding magnesium, only one immune-modulating formula (2.6%) met the minimum requirements defined by both DRI and TUBER-2022 at an intake of 1500 kcal/day.

All enteral formulas provided sufficient iron at 1500 kcal/day for males based on both DRI and TUBER-2022 recommendations. However, 37.8% (14 out of 37) of the formulas did not meet the iron requirement for females according to DRI and the lower reference range of ESPEN. Furthermore, one formula achieved the higher iron intake recommended by ESPEN for this energy level (Figure 3).

Finally, among the 38 evaluated formulas, one immune-modulating formula exceeded the UL for five micronutrients (folic acid, calcium, magnesium, zinc, and manganese) according to both DRI and TUBER-2022 guidelines.

Table 1. Micronutrient Content of Enteral Formulas at 1500 kcal/day Compared to Recommendations from DRIs, ESPEN Guidelines, and TUBER-2022.

	Overall (n=38)	Standard formula (n=21)	Immon-modulating formula (n=6)	Disease-specific formula (n=11)	DRI		ESPEN		TUBER	
					RDA (m/f)	UL	Min-max	High	AI	UL
Vitamin A (mcg)	1230 (280-1792)	1230 (280-1650)	1444 (600-1792)	1230 (675-1769)	900/700	3000	900-1500	1500	750/650	3000
Vitamin D (mcg)	14.8 (9.3-57.0)	15.0 (9.7-22.5)	10.0 (9.3-57.0)	14.0 (10.2-23.2)	15	100	25	30	15	100
Vitamin E (mg)	28.1 (18.8-229.8)	24.8 (18.8-32.2)	44.2 (25.0-229.8)	29.0 (19.5-207.2)	15	1000	15	40	13/11	300
Vitamin K (µg)	97.3 (63.8-150.0)	98.4 (63.8-139.1)	98.7 (76.4-150.0)	81.0 (75.0-150.0)	120/90	ND	120	120	70	ND
Thiamine (mg)	2.3 (1.5-5.8)	2.3 (1.5-2.5)	2.2 (1.8-3.4)	2.3 (1.8-5.8)	1.2/1.1	ND	1.5	100	0.6	ND
Riboflavin (mg)	2.5 (1.7-7.6)	2.5 (1.7-3.3)	2.7 (2.3-7.6)	2.5 (2.0-3.6)	1.3/1.1	ND	1.2	10	1.6	ND
Niacin (mg)	25.5 (10.2-33.0)	25.5 (10.6-28.9)	21.8 (10.2-30.0)	26.0 (13.0-33.0)	16/14	35	18	40	9.9	ND
Pantothenic acid (mg)	9.0 (6.8-13.3)	8.3 (6.8-13.0)	11.9 (7.6-13.3)	9.0 (7.2-12.8)	5	ND	5	7.5	5	ND
Vitamin B6 (mg)	2.7 (2.0-7.9)	2.6 (2.5-3.8)	2.6 (2.0-7.9)	2.9 (2.5-4.3)	1.3-1.7/1.3-1.5	100	1.5	7.5	1.7/1.6	ND
Biotin (µg)	60.0 (46.9-105.2)	60.0 (46.9-70.1)	91.8 (57.7-105.2)	60.0 (48.0-93.8)	30	ND	30	75	40	ND
Folic acid (µg)	400 (265-1209)	396 (300-447)	324 (266-1209)	414 (300-558)	400	1000	330-400	500	330	1000
Vitamin B12 (µg)	5.4 (3.1-9.6)	4.8 (3.1-6.9)	6.2 (3.5-9.6)	5.9 (3.2-9.4)	2.4	ND	2.5	7.5	4	ND
Vitamin C (mg)	150 (100-1512)	150 (116-180)	278 (100-1512)	156 (105-829)	90/75	2000	100	200	110/95	2000
Sodium (mg)	1246 (510-1589)	1147 (1306-2274)	1471 (605-1589)	1293 (510-1532)	1500	ND	ND	ND	2000	ND
Potassium (mg)	1958 (1306-2700)	1815 (1306-2274)	1990 (1814-2700)	1950 (1442-2419)	3400/2600	ND	ND	ND	3500	ND
Chloride (mg)	1388 (569-2097)	1125 (569-2020)	1677 (630-1803)	1668 (649-2097)	2300	3600	ND	ND	ND	ND
Calcium (mg)	1159 (677-2722)	1088 (677-1820)	1188 (1062-2721)	1200 (764-2025)	1000	2500	ND	ND	1150	2500
Phosphorus (mg)	989 (668-2202)	974 (668-1200)	1061 (956-2202)	987 (679-1200)	700	4000	ND	ND	550	4000
Magnesium (mg)	299 (125-508)	278 (125-345)	332.5 (250-509)	315 (191-345)	420/320	350	ND	ND	350/300	350
Iron (mg)	20.0 (11.3-36.3)	20.3 (11.3-24.0)	19.4 (16.0-36.3)	19.7 (15.6-24.0)	8/18	45	18-30	ND	11	45
Zinc (mg)	17.6 (12.8-54.4)	17.2 (12.8-19.3)	22.1 (17.5-54.4)	17.5 (14.1-18.4)	11/8	40	10-20	20	9.4-16.3/7.5-12.7	25
Copper (µg)	2442 (1500-8226)	2435 (1500-6800)	2564 (2257-8226)	2318 (1500-2700)	900	10000	1000-3000	1000-3000	1600/1300	5000
Iodine (µg)	195 (120-302)	195 (120-240)	219 (188-302)	189 (150-258)	150	1100	150-300	150-300	150	600
Selenium (µg)	86.8 (51.0-387.1)	86.0 (67.5-105.0)	79.9 (62.4-387.7)	95.5 (51.0-109.2)	55	400	50-150	200	70	300
Chromium (µg)	100.3 (48.8-174.8)	97.6 (48.8-165.0)	139.8 (85.0-157.3)	128.3 (75.0-174.8)	35/25	ND	35-150	200	ND	ND
Molybdenum (µg)	150 (105-238)	150 (113-195)	221 (144-238)	150 (105-177)	45	2000	50-250	250	65	600
Manganese (mg)	4.6 (2.0-15.7)	4.8 (2.0-5.6)	3.8 (2.7-15.7)	4.8 (3.0-5.3)	2.3/1.8	11	2-3	2-3	3	11

AI: Adequate intake, M: male, f: female, UL: tolerable upper intake levels., DRI: Dietary Reference Intakes, ESPEN: European Society for Clinical Nutrition and Metabolism, TUBER: Türkiye Nutrition Guideline.

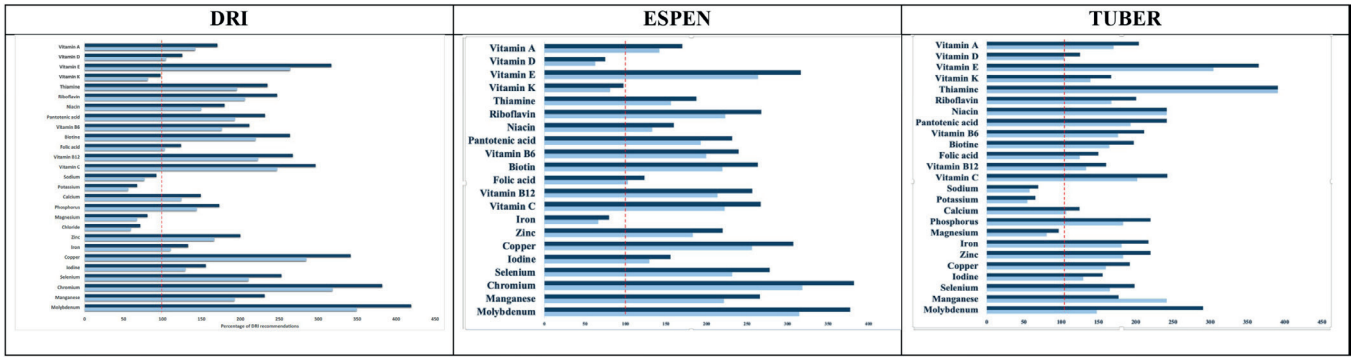

Figure 1. Proportion of key micronutrient provision by adult enteral formulas relative to recommended daily intake levels according to DRI, ESPEN, and TUBER-2022 Guidelines

The figure illustrates the proportion of key micronutrients supplied by adult enteral formulas available in Türkiye, expressed as a percentage of the recommended daily intake levels based on DRI, ESPEN, and TUBER-2022 guidelines. The red dashed line indicates the 100% adequacy threshold for micronutrient intake.

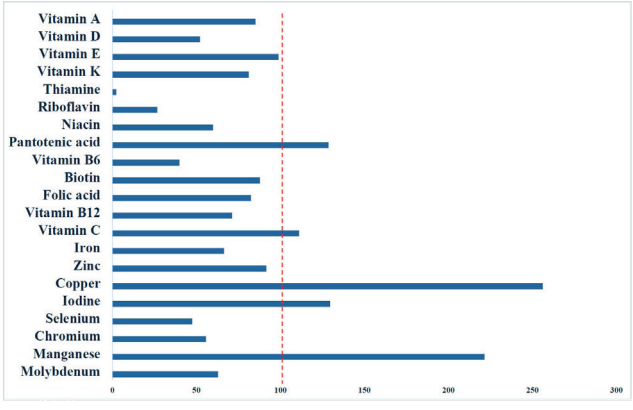

Figure 2. Percentage of micronutrient provision relative to ESPEN high requirement recommendations

The figure illustrates the percentage of recommended intake levels for key micronutrients provided by adult enteral formulas at a 1500 kcal/day intake, specifically evaluated in accordance with ESPEN's high-demand recommendations, which apply to critically ill patients and those with acute malnutrition. The red dashed line represents 100% adequacy.

Discussion

To the best of our knowledge, this is the first study to investigate the micronutrient content of enteral formulas available in Türkiye. The study demonstrated that the intake of vitamin D, vitamin K, magnesium, iron, sodium, potassium, and chloride provided by a 1500 kcal/day enteral formula is insufficient when compared to established reference values. Among these micronutrients, vitamin D, vitamin K, magnesium, and iron were particularly inadequate in most formulas, as assessed according to the DRI, ESPEN, and TUBER-2022 guidelines, with variations depending on formula type and gender-specific requirements. Additionally, when the higher intake recommendations proposed by ESPEN were considered, inadequacies extended to a broader range of micronutrients, including vitamin A, vitamin E, B-complex vitamins, zinc, selenium, chromium, and molybdenum.

Current guideline emphasize that micronutrient intake is directly influenced by daily energy intake.[5] Existing literature has predominantly focused on the micronutrient intake of hospitalized patients, particularly those in intensive care unit (ICU). A systematic review including nine studies assessing micronutrient intake in ICU patients reported that vitamin B12, vitamin D, vitamin C, vitamin A, thiamine, iron, folate, zinc, and selenium were adequately provided by enteral feeding volumes averaging 826–1600 mL/day, in accordance with the DRIs (7). It is important to note that DRIs typically offer more conservative recommendations tailored to healthy or apparently healthy populations. In contrast, ESPEN guidelines encompass more comprehensive micronutrient recommendations that specifically address the needs of critically ill patients, which may explain discrepancies observed between the two frameworks.

Despite the widespread use of enteral nutrition, studies evaluating micronutrient intake in comparison with ESPEN guidelines remain limited. A study conducted among 81 ICU patients demonstrated that an average enteral nutrition intake of 1037 kcal/day was insufficient

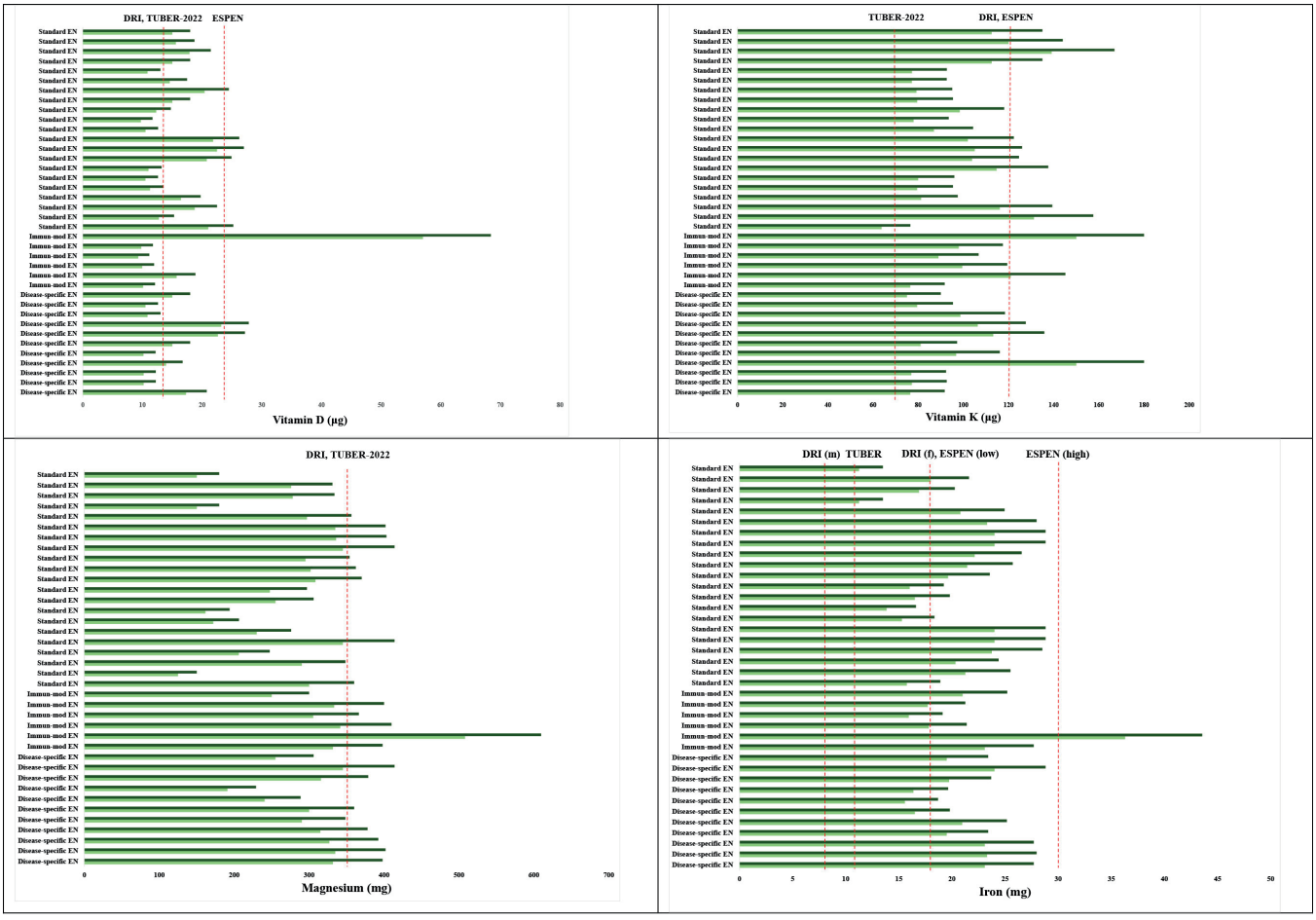

Figure 3. The amount of vitamin D, vitamin K, magnesium and iron in enteral formulas

This figure presents the individual contents of micronutrients found to be inadequate—vitamin D, vitamin K, magnesium, and iron—in all evaluated adult enteral formulas available in Türkiye. The red dashed line indicates the 100% adequacy threshold based on recommended intake levels.

to meet ESPEN recommendations for several micronutrients, including vitamins A, D, C, E, as well as selenium, manganese, and zinc.[14] Similarly, a previous study involving 226 ICU patients demonstrated that even when enteral nutrition intake exceeded 1500 kcal/day, the provision of niacin and vitamin D remained insufficient when evaluated in accordance with standard ESPEN guidelines.[15]

Nevertheless, when assessing micronutrient intake, it is crucial to evaluate the actual micronutrient amounts contained in enteral formulas. An evaluation of formula composition reveals that micronutrient inadequacies persist even at commonly recommended energy intakes of 1500–1800 kcal/day. Supporting our findings, Yang et al.[10] investigated the micronutrient content of 31 widely used commercial enteral formulas in China and similarly reported that vitamin D, vitamin K, and iron intakes at 1500 kcal/day were inadequate according to ESPEN guidelines, despite being sufficient according to the Chinese DRI standards. Likewise, another study evaluating 62 widely used commercial enteral formulas in relation to dietary reference values for European and Italian populations found that at a 1500 kcal/day intake, these formulas provided insufficient amounts of vitamin K and fluoride, while some exceeded the tolerable upper intake levels for zinc and vitamin A.[13] These results collectively indicate that enteral formulas may not consistently ensure adequate micronutrient provision unless caloric intake exceeds specific thresholds. Therefore, the potential need for additional micronutrient supplementation, particularly in patients on long-term enteral nutrition, should be carefully considered.

Patients receiving long-term EN are at increased risk of adverse clinical outcomes due to potential micronutrient

deficiencies.[9] Our findings indicate that EN formulas may inadequately supply vitamin D, vitamin K, magnesium, and iron. Vitamin D, vitamin K, and magnesium are essential for maintaining bone health, muscle function, and immune regulation.[5,16] Deficiencies in these micronutrients have been linked to complications such as impaired immune responses, increased risk of infections, and susceptibility to falls and fractures, although the current study did not assess clinical outcomes at the patient level.[17-19] Additionally, the iron content of the evaluated enteral formulas was notably lower than the reference values, particularly for women of reproductive age. Inadequate iron intake has been associated in the literature with various adverse clinical outcomes, including increased risks of cardiovascular disease, diabetes, certain cancers (such as breast and colorectal cancer), and depression. However, these potential associations were not directly evaluated in this study.[20]

It is particularly important to consider the high-requirement recommendations outlined by ESPEN for critically ill patients and individuals with acute malnutrition. These recommendations are intended for short-term repletion (typically not exceeding 15 days) to avoid the need for intravenous micronutrient supplementation.[5] However, our findings indicate that most of the evaluated enteral formulas fall considerably short of meeting these elevated requirements. This insufficient intake may increase the risk of adverse clinical outcomes, highlighting the importance of careful monitoring, consideration of appropriate supplementation, and possibly reformulation of existing products to better meet clinical needs. Further research assessing patient-level outcomes is warranted.

Furthermore, our data indicated inadequate sodium, potassium, and chloride content in enteral formulas. However, these electrolytes are naturally present in drinking water, and patients receiving enteral nutrition may meet their requirements through additional water intake. Moreover, we did not identify any data indicating adverse clinical outcomes specifically associated with deficiencies of these electrolytes under these conditions.

This study has several limitations that should be acknowledged. First, the micronutrient data were derived from manufacturers' product labels rather than direct laboratory analyses; thus, potential discrepancies between declared and actual nutrient content cannot be ruled out. Second, the analysis was limited to formulas available in the Turkish market, which may limit the generalizability of findings to other countries or regions. Third, only the theoretical nutrient content based on standardized daily energy intakes (1500 and 1800 kcal/day) was evaluated; actual patient intake may vary due to interruptions in feeding, gastrointestinal tolerance, or clinical conditions. Additionally, this study did not assess the bioavailability or clinical outcomes associated with micronutrient intake, which may further influence nutritional adequacy. Finally, no statistical comparisons or hypothesis testing were performed, as the primary aim of the study was to provide a descriptive evaluation and guideline-based comparison. Additionally, the relatively small sample sizes within each formula subgroup limited the feasibility of meaningful statistical analysis.

In conclusion, this study highlights that adult enteral formulas commonly used in clinical practice may not sufficiently meet the recommended intake levels of several essential micronutrients, particularly when assessed according to ESPEN guidelines. Micronutrient inadequacies, especially in vitamin D, vitamin K, magnesium, and iron, persist even at energy intakes of 1500–1800 kcal/day. These deficiencies may have significant clinical implications, especially for patients on long-term enteral nutrition or those with increased micronutrient requirements, such as critically ill individuals. The potential need for additional micronutrient supplementation should be carefully considered in routine clinical practice to prevent adverse health outcomes. Furthermore, the findings emphasize the importance of revisiting the formulation of enteral products to ensure they adequately address the micronutrient needs of ICU patient populations. Further research is warranted to explore the clinical impact of these inadequacies and to establish optimal supplementation strategies. Specifically, well-designed interventional studies are needed to evaluate the effectiveness and safety of micronutrient supplementation in different patient populations receiving enteral nutrition. Such studies would provide valuable evidence to guide clinical decision-making and improve patient outcomes.

Ethical approval

Ethical review and approval were waived for this study, as it exclusively analyzed product contents and did not involve experiments with humans or animals.

Author contribution

The author declare contribution to the paper as follows: Study conception and design: NTÖ; data collection:

NTÖ; analysis and interpretation of results: NTÖ; draft manuscript preparation: NTÖ. The author reviewed the results and approved the final version of the article.

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Conflict of interest

The authors declare that there is no conflict of interest.

References

1. Boullata JI, Carrera AL, Harvey L, et al. ASPEN safe practices for enteral nutrition therapy. *JPEN J Parenter Enteral Nutr*. 2017;41:15-103. [Crossref]
2. Church A, Zoeller S. Enteral nutrition product formulations: a review of available products and indications for use. *Nutr Clin Pract*. 2023;38:277-300. [Crossref]
3. Doley J. Enteral Nutrition Overview. *Nutrients*. 2022;14:2180. [Crossref]
4. Chung M, Balk EM, Ip S, et al. Reporting of systematic reviews of micronutrients and health: a critical appraisal. *Am J Clin Nutr*. 2009;89:1099-1113. [Crossref]
5. Berger MM, Shenkin A, Schweinlin A, et al. ESPEN micronutrient guideline. *Clin Nutr*. 2022;41:1357-1424. [Crossref]
6. Koekkoek WA, Hettinga K, de Vries JH, van Zanten AR. Micronutrient deficiencies in critical illness. *Clin Nutr*. 2021;40:3780-3786. [Crossref]
7. Breik L, Tatucu-Babet OA, Ridley EJ. Micronutrient intake from enteral nutrition in critically ill adults: a systematic review of randomised controlled trials. *Aust Crit Care*. 2022;35:564-574. [Crossref]
8. Breik L, Tatucu-Babet OA, Paul E, Duke G, Elliott A, Ridley EJ. Micronutrient intake from enteral nutrition in critically ill adult patients: a retrospective observational study. *Nutrition*. 2022;95:111543. [Crossref]
9. Osland EJ, Polichronis K, Madkour R, Watt A, Blake C. Micronutrient deficiency risk in long-term enterally fed patients: a systematic review. *Clin Nutr ESPEN*. 2022;52:395-420. [Crossref]
10. Yang H, Hou L, Sun HM, Ye SH. Comparison of micronutrients in adult enteral formulas widely used in clinical practice. *Food Sci Nutr*. 2023;11:6096-6105. [Crossref]
11. National Institutes of Health. Nutrient recommendations: Dietary Reference Intakes (DRI). 2023. Available at: https://ods.od.nih.gov/HealthInformation/nutrientrecommendations.aspx
12. Republic of Türkiye, Ministry of Health, General Directorate of Public Health. Türkiye Beslenme Rehberi (TUBER) 2022. Available at: https://hsgm.saglik.gov.tr/tr/web-uygulamalarimiz/357.html
13. Iacone R, Scanzano C, Alfonsi L, et al. Daily macro and micronutrient supply for patients on total enteral nutrition: are they in keeping with new dietary reference intakes for the Italian population? *Nutr Metab Cardiovasc Dis*. 2014;24:e15-e17. [Crossref]
14. Kasti AN, Theodorakopoulou M, Katsas K, et al. Factors associated with interruptions of enteral nutrition and the impact on macro- and micronutrient deficits in ICU patients. *Nutrients*. 2023;15:917. [Crossref]
15. Ozer NT, Onuk S, Temel Ş, Yüksel RC, Sungur M, Günoğan K. Association between nutritional Status, energy-protein-micronutrient intake, and mortality in critically ill patients receiving enteral nutrition. *J Crit Intensive Care*. 2025;16:18-26. [Crossref]
16. Capozzi A, Scambia G, Lello S. Calcium, vitamin D, vitamin K2, and magnesium supplementation and skeletal health. *Maturitas*. 2020;140:55-63. [Crossref]
17. Hao G, Zhang B, Gu M, et al. Vitamin K intake and the risk of fractures: a meta-analysis. *Medicine (Baltimore)*. 2017;96:e6725. [Crossref]
18. Cashman KD. Vitamin D deficiency: defining, prevalence, causes, and strategies of addressing. *Calcif Tissue Int*. 2020;106:14-29. [Crossref]
19. Rondanelli M, Faliva MA, Tartara A, et al. An update on magnesium and bone health. *Biometals*. 2021;34:715-736. [Crossref]
20. Huang Y, Cao D, Chen Z, et al. Iron intake and multiple health outcomes: umbrella review. *Crit Rev Food Sci Nutr*. 2023;63:2910-2927. [Crossref]

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Dynamic changes in serum glutamine levels and clinical outcomes in acute ischemic stroke: a prospective analysis

Kübra Kurtoğlu[1], Mehmet Uğur Çevik[2], Nuriye Mete[1], Muttalip Özbek[3], Hamza Gültekin[2], Eşref Akıl[2], Mehmet Ufuk Aluçlu[2], İsmail Yıldız[4]

[1]Department of Biochemistry, Faculty of Medicine, Dicle University, Diyarbakır, Türkiye
[2]Department of Neurology, Faculty of Medicine, Dicle University, Diyarbakır, Türkiye
[3]Mardin Kızıltepe State Hospital, Mardin, Türkiye
[4]Department of Statistics, Faculty of Medicine, Dicle University, Diyarbakır, Türkiye

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ABSTRACT

Background: This is the first study to focus exclusively on a pure ischemic stroke cohort, exploring serum glutamine levels and their association with oxidative stress markers and clinical outcomes.

Methods: 50 patients diagnosed with ischemic stroke were included in our study. We used methods such as LC-MS/MS to measure glutamine levels with high accuracy. Oxidative stress markers, including total antioxidant capacity (TAC) and total oxidant status (TOS), were also analyzed. Stroke severity was assessed using the National Institutes of Health Stroke Scale (NIHSS), and functional outcomes were evaluated using the modified Rankin Scale (mRS) at 90 days.

Results: Serum glutamine levels varied significantly based on stroke severity. Patients with NIHSS ≥16 demonstrated significantly lower glutamine levels compared to those with NIHSS <16. Dynamic changes in glutamine levels were observed, with levels decreasing between days 1 and 4 and increasing between days 4 and 10 . Patients undergoing therapeutic interventions (tPA or endovascular therapy) showed more stable glutamine levels compared to untreated patients (P = 0.028). Elevated TOS levels independently predicted mortality (hazard ratio [HR]: 2.34, 95% CI: 1.45–3.79, P = 0.002), while persistently low glutamine levels were associated with poor outcomes (HR: 0.89, 95% CI: 0.78–0.98, P = 0.03).

Conclusion: The observed fluctuations in glutamine levels provide valuable insights into stroke severity, recovery, and mortality, suggesting their potential role in clinical prognosis. Our findings suggest that glutamine could play a critical role as a biomarker and therapeutic target in ischemic stroke, particularly in patients with NIHSS> 16.

Keywords: serum glutamine, ischemic stroke, biomarkers, clinical outcomes, oxidative stress, LC-MS/MS

Introduction

Stroke is the second leading cause of death and the third leading cause of disability worldwide, posing a significant public health problem with profound socioeconomic consequences.[1] Among all strokes, ischemic stroke accounts for 87% of cases and is characterized by acute neuronal injury, inflammation, and oxidative stress.[2]

Corresponding author: Muttalip Özbek
Email: ozbekmuttalip21@gmail.com

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Despite significant advances in acute stroke care, identifying biomarkers that predict clinical outcomes and guide therapeutic interventions remains critical.

Glutamine, the most abundant amino acid in the human body, plays a central role in metabolic and immune processes, including serving as a precursor for glutathione, glutathione regulates oxidative stress and maintains intracellular redox.[3] Balance a key antioxidant that mitigates oxidative damage during ischemia.[4-6] Although glutamine is synthesized endogenously under normal conditions, its levels can deplete during hypermetabolic states such as sepsis, trauma, and severe illness, which leads to its classification as a conditionally essential amino acid.[6-10] Glutamine also contributes to nitrogen balance, pH regulation, and immune cell function, making it a critical player in physiological stress responses.[11-13] However, its role in ischemic stroke—particularly the dynamic changes in its levels—has been underexplored.

Oxidative stress, driven by an imbalance between oxidants and antioxidants, is a major contributor to secondary neuronal injury in ischemic stroke.[14] Markers such as total oxidant status (TOS) and total antioxidant capacity (TAS) provide valuable insights into the oxidative environment and its relationship with disease severity.[15,16] Numerous studies explore oxidative stress in stroke, yet little is known about how glutamine dynamics interplay with these parameters.[13] This gap highlights the need for further research into how these factors influence stroke outcomes.

Previous studies, such as the Redox trial, have primarily focused on heterogeneous patient populations, measuring glutamine levels only at single time points.[17]

Main Points

- Serum glutamine levels serve as an independent biomarker for both stroke severity and prognosis in acute ischemic stroke.
- Early reductions in glutamine levels are associated with increased oxidative stress and poor clinical outcomes.
- Patients treated with IV-tPA or endovascular therapy exhibited more stable glutamine levels, indicating the metabolic benefits of these interventions.
- Monitoring glutamine levels may guide personalized treatment strategies and support future research into glutamine-focused therapeutic approaches.

In contrast, this study exclusively examines primary and clean ischemic stroke patients, offering a homogeneous cohort. By sequentially measuring serum glutamine levels on Days 1, 4, and 10, it aims to provide a comprehensive view of glutamine's trajectory and its relationship with oxidative stress, stroke severity, and clinical outcomes.

By longitudinally analyzing serum glutamine levels in ischemic stroke patients, this study offers new perspectives on its role as a biomarker and a possible therapeutic avenue. We hope that these findings will inspire further research and pave the way for better patient care.

Materials and Methods

Study design and patient selection

This prospective study was conducted at Dicle University Faculty of Medicine Hospital between June 2023 and November 2023. Fifty patients with a confirmed diagnosis of acute ischemic stroke were included. In the power analysis conducted prior to determining the sample size, assuming $\alpha = 0.05$ and an effect size of $d = 0.8$ (Cohen's large effect size), a sample size of 46 patients was determined to provide 95% power. Diagnosis was based on clinical presentation, neurological examination, and neuroimaging studies conducted within 24 hours of symptom onset. Patients were subsequently admitted to the Neurology Intensive Care Unit for further management. All patients received standard polymeric enteral nutrition products during the study period to ensure consistent nutritional treatment. In this study, the IV-tPA/EVT group consisted of patients who received either intravenous tissue plasminogen activator (IV-tPA) or mechanical intervention, while the Antithrombotic Therapy Only group included those managed conservatively with antiplatelet or anticoagulant medications. Antithrombotic therapy aims to prevent clot formation and reduce the risk of recurrence in ischemic stroke. The study was approved by the Ethics Committee of Dicle University (Approval No: 149 / May 17, 2023), and informed consent was obtained from all participants or their legal representatives.

The inclusion criteria encompassed patients aged 18 years or older, admitted to the intensive care unit due to ischemic stroke, with a hospital stay of at least 10 days, and who had blood samples taken within the first 24 hours of admission. Exclusion criteria included acute or chronic kidney or liver diseases, pregnancy, use of antioxidant

supplements (vitamin C or vitamin E), or treatment with glutamine-enriched nutritional solutions.

Biochemical assays

To ensure precise and sensitive measurement, serum glutamine levels were assessed at three-time points—days 1, 4, and 10—using the advanced LC-MS/MS (Liquid chromatography–mass spectrometry/mass spectrometry technique. Oxidative stress markers, including total oxidant status (TOS) and total antioxidant capacity (TAC), were measured using validated biochemical assays. The oxidative stress index (OSI) was calculated as the ratio of TOS to TAC.

Stroke severity and outcomes assessment

Stroke severity was primarily evaluated using the National Institutes of Health Stroke Scale (NIHSS) at admission, which provides a robust measure of initial stroke impact and severity. NIHSS scores were analyzed as key predictors of clinical outcomes, with higher scores indicating greater stroke severity. In patients with NIHSS scores above 16, glutamine levels were observed to decrease more significantly, further emphasizing the relationship between NIHSS and metabolic disturbances. Functional outcomes, assessed at 90 days post-stroke using the modified Rankin Scale (mRS), were used as a secondary measure to categorize recovery. Patients achieving mRS ≤ 2 were classified as having favorable outcomes, while those with mRS > 2 were classified as having poor outcomes. Mortality within 90 days was also recorded and correlated with initial NIHSS scores to highlight its prognostic significance. To minimize bias, outcome assessments were performed by blinded evaluators who were unaware of the patient's serum glutamine and oxidative stress levels.

Statistical analysis

Descriptive statistics were used to summarize baseline demographic and clinical data. Continuous variables were presented as means ± standard deviations or medians with interquartile ranges, depending on their distribution. Categorical variables were expressed as frequencies and percentages. Group comparisons were performed using the Mann-Whitney U test or chi-square test as appropriate.

Univariate and multivariate Cox regression analyses were conducted to identify predictors of mortality and functional outcomes. Variables with a P-value < 0.1 in univariate analysis were included in multivariate models. Statistical significance was set at P < 0.05. Analyses were performed using SPSS software version 29.0 (IBM, Armonk, NY).

Results

A total of 50 ischemic stroke patients were included in the study. The median age was 65 years (range: 45–85 years), and 60% were male. The median NIHSS score at admission was 14 (range: 4–24), with 90-day mortality recorded at 20%. Baseline demographic and clinical characteristics of patients with acute ischemic stroke. The table presents data on sex distribution, median age, NIHSS scores, stroke etiology, and treatment modalities. Patients are categorized based on treatment type (IV-tPA/EVT vs. antithrombotic therapy) and 90-day mRS outcomes in Table 1.

Comparative analysis of oxidative stress parameters (TAS, TOS, OSI) among survivors and non-survivors, as well as patients with NIHSS <16 and ≥16. Data are presented as mean ± standard deviation. Significant differences are highlighted, emphasizing the role of oxidative stress in stroke outcomes in Table 2.

Mean serum glutamine levels (μmol/L) were measured on Days 1, 4, and 10 for all patients. Temporal changes in these levels during the study period were assessed using repeated measures ANOVA, with the results detailed in Table 3, positioned below to illustrate these dynamic fluctuations and statistical comparisons comprehensively.

Serum glutamine levels varied significantly based on stroke severity. Patients with severe stroke (NIHSS ≥16) demonstrated significantly lower glutamine levels compared to those with mild-to-moderate stroke (median: 540 μmol/L vs. 620 μmol/L, P = 0.01). Oxidative stress parameters showed corresponding changes, with elevated Total Oxidant Status (TOS) and reduced Total Antioxidant Capacity (TAC) in the severe stroke group (P <0.05 for both).

Dynamic changes in serum glutamine levels during the study period were also observed. Between days 1 and 4, glutamine levels decreased by a mean of-30.0 μmol/L (standard deviation: 135.1; P = 0.124). However, an increase of 24.7 μmol/L was noted between days 4 and 10, and changes between days 1 and 10 were minimal (-5.3 μmol/L; P = 0.845).

Table 1. Baseline demographic and clinical characteristics of the study population

Variable	n	(%)
Sex		
Female	20	(40)
Male	30	(60)
Age (Median ± Range)		65 (45-85)
NIHSS		
<16	21	(42)
≥16	29	(58)
Stroke Aetiology		
Cardioembolic	18	(36)
Large vessel occlusion	17	(34)
Small vessel occlusion	4	(8)
Cryptogenic	9	(18)
Other	2	(4)
Treatment		
Endovascular and IV tPA Treatments	32	(64)
EVT (Endovascular Thrombectomy)	30	(60)
IV tPA (Intravenous Tissue Plasminogen Activator)	2	(4)
Antithrombotic or Anticoagulant Treatment	18	(36)
mRS at 3 Months		
Fully independent (mRS < 3)	29	(58)
Dependent (3 ≤ mRS ≤ 5)	6	(12)
Mortality (mRS = 6)	15	(30)

Serum glutamine levels (µmol/L) at Days 1, 4, and 10 in patients treated with IV-tPA/EVT versus those receiving antithrombotic therapy only. The table includes within-group comparisons over time and between-group comparisons at each time point, highlighting the stabilizing effect of IV-tPA/EVT on glutamine levels in Table 4. Patients undergoing treatment (tPA or endovascular therapy) exhibited distinct patterns of serum glutamine changes compared to those not receiving treatment. Treated patients demonstrated more stable glutamine levels over the study period, while untreated patients showed a marked decline. A significant difference in glutamine changes between days 1 and 10 was observed between treated and untreated groups (29.1 µmol/L vs. -66.5 µmol/L, P = 0.028).

In univariate Cox regression analysis, elevated TOS levels were associated with a higher risk of mortality (hazard ratio [HR]: 2.34, 95% CI: 1.45–3.79, P = 0.002). Serum glutamine levels independently predicted favorable 90-day functional outcomes (mRS ≤ 2, HR: 0.89, 95% CI: 0.78–0.98, P = 0.03). Multivariate analysis confirmed the independent prognostic value of serum glutamine levels, along with age and NIHSS score at admission.

Additionally, serum glutamine levels on admission were found to correlate inversely with stroke severity as determined by NIHSS score. Patients with persistently low glutamine levels throughout the study period were more likely to exhibit poor outcomes, emphasizing the importance of glutamine depletion as a prognostic factor. Furthermore, the significant association between oxidative stress markers (elevated TOS and reduced TAC) and glutamine levels highlights the interplay between metabolic and oxidative pathways in ischemic stroke severity and progression.

Figure 1. Glutamine concentrations (µmol/L) were measured on Days 1, 4, and 10 across different patient/follow-up categories. Day 1 (blue): The highest glutamine levels were generally observed. Day 4 (orange): A significant decline was noted in most categories, consistent with a stress response or catabolic state. Day 10 (green): Partial recovery or stabilization was observed in some categories (particularly 1, 6, 9, 10, and 11). These changes highlight time-dependent, individualized metabolic responses and inter-category heterogeneity.

Table 2. Relationship between oxidative stress parameters, NIHSS, and mortality

Parameter	Survivors (n=40)	Non-survivors (n=10)	P	NIHSS <16 (n=21)	NIHSS ≥16 (n=29)	P
TAS (mmol Eq/L)	1.22 ± 0.29	1.34 ± 0.52	0.307	1.25 ± 0.31	1.21 ± 0.50	0.992
TOS (µmol Eq/L)	24.9 ± 14.0	22.1 ± 30.8	0.857	22.3 ± 12.5	25.9 ± 19.6	0.191
OSI	20.4 ± 5.2	28.3 ± 10.1	0.045	19.8 ± 4.5	24.6 ± 7.8	0.023

Data are presented as mean ± standard deviation., P values compare survivors vs. non-survivors and NIHSS <16 vs. NIHSS ≥16. TAS: Total Antioxidant Status; TOS: Total Oxidant Status; OSI: Oxidative Stress Index.

Table 3. Mean glutamine levels of all patients by day.

Day	Mean Glutamine Level (µmol/L)	Standard Deviation	P-value
Day 1	611.0	155.7	
Day 4	600.8	210.6	
Day 10	605.7	137.8	0.353

Values are presented as mean ± standard deviation. P-value refers to a comparison across all three-time points, assessed using Repeated Measures ANOVA.

Table 4. Glutamine levels in treated and untreated patients

Parameter	Treated (n=32)	P*	Untreated (n=18)	P*	P (Treated vs. Untreated)
Glutamine at Day 1 (µmol/L)	589.8 ± 169.5	0.304	648.8 ± 122.8	0.094	0.163
Glutamine at Day 4 (µmol/L)	578.3 ± 130.3		585.9 ± 130.6		0.845
Glutamine at Day 10 (µmol/L)	618.9 ± 145.3		582.3 ± 123.7		0.352
Change (Day 1 to Day 4)	-11.5 ± 141.5	0.245	29.1 ± 146.3	0.221	0.180
Change (Day 4 to Day 10)	40.6 ± 147.0		-3.6 ± 122.9		0.263
Change (Day 1 to Day 10)	29.1 ± 146.3		-66.5 ± 139.5		0.028

Data are presented as mean ± standard deviation. P** compares values within the group across time points. P compares values between treated and untreated groups at the same time points.

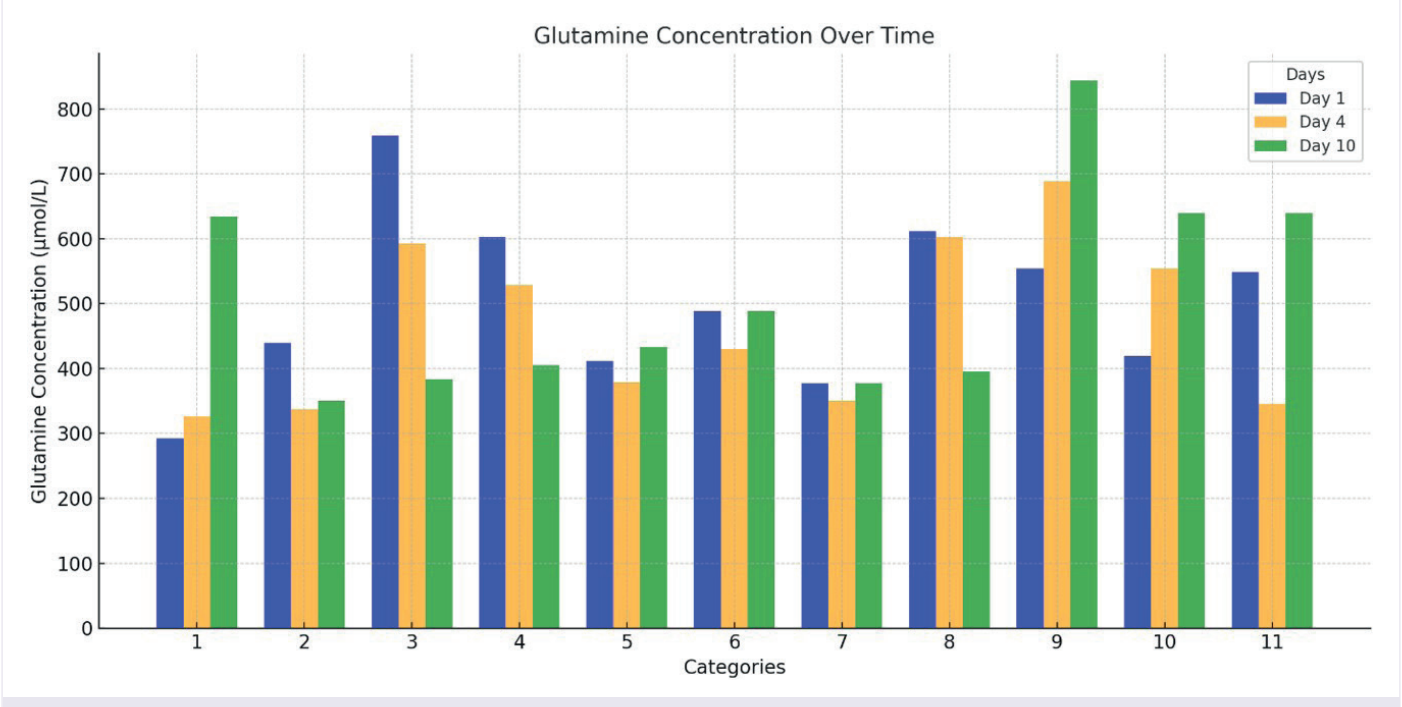

Figure 1. Changes in glutamine concentration (µmol/L) measured across different categories on Day 1, Day 4, and Day 10

Discussion

This study provides novel insights into the dynamic changes in serum glutamine levels and their association with clinical outcomes in acute ischemic stroke patients. Our findings demonstrate that lower serum glutamine levels are significantly associated with greater stroke severity and worse functional outcomes, emphasizing the potential role of glutamine as a biomarker for ischemic stroke prognosis.

Oxidative stress plays a critical role in the pathophysiology of ischemic stroke.[14-16] Elevated total oxidant status (TOS) and reduced total antioxidant capacity (TAS) observed in this study align with prior evidence highlighting heightened oxidative stress in severe stroke cases. However, integrating serum glutamine levels with oxidative stress parameters offers a unique perspective on the metabolic disturbances influencing stroke severity and recovery. Glutamine, known for its role in glutathione synthesis and nitrogen balance maintenance, appears to reflect a systemic response to acute stress, consistent with findings in critically ill populations.[6,11,12]

The decline in glutamine levels during the early hospitalization phase observed in this study likely reflects its utilization in critical processes such as immune modulation and stress response. This trajectory supports previous studies reporting reduced glutamine levels in hypercatabolic states, including sepsis and trauma.[8,11]

The subsequent increase in glutamine levels after day 4, particularly among patients undergoing therapeutic interventions such as endovascular therapy or tissue plasminogen activator (tPA) administration, suggests a metabolic recovery facilitated by these treatments.[17]

A key finding of this study is the independent predictive value of serum glutamine levels for functional outcomes at 90 days, alongside established predictors such as age and NIHSS score. This underscores glutamine's potential utility as a biomarker to guide clinical decisions and tailor therapeutic strategies for ischemic stroke patients.[4,5] These results complement earlier studies demonstrating the prognostic significance of glutamine in critically ill patients.[11,12,17-19]

Employing blinded evaluators and applying standardized protocols for patient inclusion mitigated potential sources of bias. However, the single-center design may limit the generalizability of the findings.

While the findings are promising, the single-center design and relatively small sample size may limit the generalizability of the results. Multicenter studies with larger cohorts are needed to confirm these findings and enhance external validity. Moreover, the lack of longitudinal glutamine measurements beyond 10 days and the absence of a control group without stroke warrant a cautious interpretation of the results. Future research with larger, multicenter cohorts and extended follow-up periods is needed to validate these findings and further explore the mechanistic pathways linking glutamine metabolism to stroke outcomes.

In conclusion, our study highlights the prognostic significance of serum glutamine levels in acute ischemic stroke. Glutamine serves not only as a marker for stroke severity but also as a potential target for therapeutic intervention. These findings open new avenues for research into integrating glutamine-focused strategies into comprehensive stroke management protocols, addressing both the metabolic and oxidative stress components of ischemic stroke.

Conclusion

This study underscores the critical role of serum glutamine levels as a biomarker for ischemic stroke severity and prognosis. Our findings demonstrate that dynamic changes in glutamine levels during the acute phase of stroke are strongly associated with stroke severity, as measured by the NIHSS score, and functional outcomes at 90 days. The integration of glutamine measurements with oxidative stress parameters provides a novel perspective on the metabolic and physiological disturbances in ischemic stroke, highlighting new avenues for research and clinical intervention. Specifically, persistently low glutamine levels were found to correlate with poor outcomes, while treated patients exhibited more stable glutamine levels over time compared to untreated patients.

The self-controlled design of this study enabled the analysis of dynamic glutamine changes within the same patient cohort, minimizing inter-patient variability. This focus on a well-defined, primary ischemic stroke group enhances the specificity and relevance of our findings, differentiating this study from prior research involving heterogeneous or mixed patient populations.

Future studies should validate these findings in larger, multicenter cohorts and explore the mechanistic

pathways linking glutamine metabolism to neuronal recovery and functional improvement. Additionally, the potential role of glutamine supplementation in improving metabolic and oxidative outcomes warrants further investigation, particularly in patients with severe stroke and persistently low glutamine levels. These efforts will enhance our understanding of stroke pathophysiology and improve patient outcomes through personalized medicine approaches.

Ethical approval

This study has been approved by the the Ethics Committee of Dicle University (approval date 17.05.2023, number 149). Written informed consent was obtained from the participants.

Author contribution

The authors declare contribution to the paper as follows: Study design and analysis: KK; data collection design and conception: MUÇ; draft manuscript preparation study and design: NM; analysis interpretetion of results analysis design and study: MÖ; design study and data collection: HG; interpretation of results analysis and conception: EA; draft manuscript preparation data collection design and study: MUA; analysis design and conception: İY.

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Conflict of interest

The authors declare that there is no conflict of interest.

References

1. Feigin VL, Brainin M, Norrving B, et al. World Stroke Organization (WSO): global stroke fact sheet 2022. *Int J Stroke*. 2022;17:18-29. [Crossref]
2. Go S, Worman D. Stroke, transient ischemic attack, and cervical artery dissection. In: Tintinalli JE, editor. Emergency medicine: a comprehensive study guide. 7th ed. New York: McGraw-Hill; 2010:1122-1135.
3. Sen CK. Nutritional biochemistry of cellular glutathione. *J Nutr Biochem*. 1997;8:660-672. [Crossref]
4. Cengiz M, Borku Uysal B, Ikitimur H, et al. Effect of oral l-Glutamine supplementation on Covid-19 treatment. *Clin Nutr Exp*. 2020;33:24-31. [Crossref]
5. Santos HO, Tinsley GM, da Silva GAR, Bueno AA. Pharmaconutrition in the clinical management of COVID-19: a lack of evidence-based research but clues to personalized prescription. *J Pers Med*. 2020;10:145. [Crossref]
6. Altman BJ, Stine ZE, Dang CV. From Krebs to clinic: glutamine metabolism to cancer therapy. *Nat Rev Cancer*. 2016;16:619-634. [Crossref]
7. Cruzat VF, Pantaleão LC, Donato J, de Bittencourt PI, Tirapegui J. Oral supplementations with free and dipeptide forms of L-glutamine in endotoxemic mice: effects on muscle glutamine-glutathione axis and heat shock proteins. *J Nutr Biochem*. 2014;25:345-352. [Crossref]
8. Kao C, Hsu J, Bandi V, Jahoor F. Alterations in glutamine metabolism and its conversion to citrulline in sepsis. *Am J Physiol Endocrinol Metab*. 2013;304:E1359-E1364. [Crossref]
9. Rogero MM, Borges MC, Pires ISO, Borelli P, Tirapegui J. Effect of glutamine supplementation and in vivo infection with Mycobacterium bovis (Bacillus Calmette-Guérin) in the function of peritoneal macrophages in early-weaned mice. *Ann Nutr Metab*. 2007;51(Suppl. 1):173-174. [Crossref]
10. Mortada H, Alhindi N, Abukhudair A, Alanazi S, AlSahli A, Arab K. The Effects of glutamine supplementation on reducing mortality and morbidity among burn patients: a systematic review and meta-analysis of randomized controlled trials. *JPRAS Open*. 2022;35:6-17. [Crossref]
11. Karinch AM, Pan M, Lin CM, Strange R, Souba WW. Glutamine metabolism in sepsis and infection. *J Nutr*. 2001;131: 2535S-2538S. [Crossref]
12. Rodas PC, Rooyackers O, Hebert C, Norberg Å, Wernerman J. Glutamine and glutathione at ICU admission in relation to outcome. *Clin Sci (Lond)*. 2012;122:591-597. [Crossref]
13. Newsholme P, Procopio J, Lima MM, Pithon-Curi TC, Curi R. Glutamine and glutamate-their central role in cell metabolism and function. *Cell Biochem Funct*. 2003;21:1-9. [Crossref]
14. Leinonen JS, Ahonen JP, Lönnrot K, et al. Low plasma antioxidant activity is associated with high lesion volume and neurological impairment in stroke. *Stroke*. 2000;31:33-39. [Crossref]
15. Menon B, Ramalingam K, Kumar R. Evaluating the role of oxidative stress in acute ischemic stroke. *J Neurosci Rural Pract*. 2020;11:156-159. [Crossref]
16. Karaaslan F, Demir F, Yılmaz R, Akıl E. Total oxidant/antioxidant status, copper and zinc levels in acute ischemic stroke patients after mechanical thrombectomy. *Clin Neurol Neurosurg*. 2023;229:107718. [Crossref]
17. Heyland DK, Dhaliwal R. Role of glutamine supplementation in critical illness given the results of the REDOXS study. *JPEN J Parenter Enteral Nutr*. 2013;37:442-443. [Crossref]

18. van der Hulst RR, van Kreel BK, von Meyenfeldt MF, et al. Glutamine and the preservation of gut integrity. *Lancet*. 1993;341:1363-1365. **[Crossref]**

19. Wu G. Intestinal mucosal amino acid catabolism. *J Nutr*. 1998;128:1249-1252. **[Crossref]**

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Sarcopenia screening: cultural adaptation and validation of the mini sarcopenia risk assessment questionnaire for Turkish older adults

Ayşe Dikmeer[1], Zeynep Şahiner[1], Merve Hafızoğlu[1], Didem Karaduman[1], Cansu Atbaş[1], İbrahim İleri[1], Burcu Balam Doğu[1], Mustafa Cankurtaran[1], Meltem Gülhan Halil[1]

[1]Division of Geriatrics, Department of Internal Medicine, Faculty of Medicine, Hacettepe University, Ankara, Türkiye

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ABSTRACT

Objective: Early detection of sarcopenia using accessible screening tools is essential but challenging due to the limitations of current instruments. The purpose of this study was to validate the Mini Sarcopenia Risk Assessment (MSRA-7 and MSRA-5) questionnaires in Turkish.

Methods: A total of 157 community-dwelling older adults were consecutively recruited from an outpatient geriatric clinic. Muscle strength and mass were measured using handgrip strength, chair stand test, and bioelectrical impedance analysis. Since only one participant met the criteria for confirmed sarcopenia, analyses focused on probable sarcopenia as defined by the European Working Group on Sarcopenia in Older People (EWGSOP2). Reliability was assessed with Cronbach's alpha and intraclass correlation coefficients (ICCs). Construct validity was evaluated via Spearman correlation with the SARC-F questionnaire. Diagnostic performance was analyzed using ROC curves.

Results: The Turkish MSRA-7 and MSRA-5 demonstrated acceptable internal consistency (Cronbach's alpha: 0.650 and 0.705, respectively) and excellent reliability (ICC range: 0.971–0.992). Both versions showed strong negative correlations with SARC-F ($r = -0.767$ for MSRA-7; $r = -0.781$ for MSRA-5, $p < 0.001$), confirming construct validity. ROC analysis yielded AUC values of 0.688 for MSRA-7 and 0.721 for MSRA-5. The MSRA-5 showed slightly superior diagnostic accuracy.

Conclusion: The Turkish adaptations of the MSRA-7 and MSRA-5 demonstrate validity and reliability as instruments for screening probable sarcopenia. Given its stronger internal consistency and diagnostic performance, in clinical practice, the MSRA-5 could be the preferred tool for early identification and intervention in older adults in Türkiye.

Keywords: older adults, sarcopenia, screening tool

Introduction

Sarcopenia, defined as the progressive loss of muscle mass and function with aging, is a serious public health issue associated to higher risks of falls, frailty, functional decline, and mortality.[1] Despite its clinical significance, no universal consensus exists on its diagnostic criteria or cut-off points. Several international organizations, including the European Working Group on Sarcopenia in Older People (EWGSOP2)[2], have proposed criteria emphasizing muscle strength along with assessment of skeletal muscle mass (SMM).

Corresponding author: Ayşe Dikmeer
Email: adikmeer@yahoo.com

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However, these diagnostic methods are often inaccessible in routine clinical practice, contributing to the underdiagnosis of sarcopenia. To address this, simple screening tools have been developed, such as the Strength, Assistance with walking, Rise from a chair, Climb stairs, and Falls (SARC-F) questionnaire.[3] Despite its widespread use, the SARC-F questionnaire has been shown to have low sensitivity, which may result in a substantial number of sarcopenia cases being overlooked. In the Turkish validation study by Bahat et al., SARC-F demonstrated sensitivity values ranging between 25% and 50 %, depending on the diagnostic criteria applied, further highlighting its limitations in reliably identifying individuals at risk.[4]

Rossi et al. developed the Mini Sarcopenia Risk Assessment (MSRA) questionnaire to enhance screening accuracy, achieving a sensitivity of 80.4% and a specificity of 60.4%.[5] The MSRA questionnaire is available in two formats: MSRA-7 and MSRA-5. The original MSRA-7 version consists of seven items assessing key risk factors for sarcopenia, including age, weight loss, level of physical activity, mobility limitations, recent hospitalization and protein intake (via questions on dairy and meat consumption). Each item is scored with weighted values, yielding a total score ranging from 0 to 40, where lower scores indicate higher risk for sarcopenia. The shortened MSRA-5 version omits the two nutrition-related items (dairy and meat intake), resulting in a 5-question tool with a total score range from 0 to 60. In both versions, cut-off values have been established to differentiate individuals at risk, allowing for rapid, non-invasive screening in clinical and community settings.

Main Points

- The Turkish versions of the Mini Sarcopenia Risk Assessment (MSRA-7 and MSRA-5) questionnaires demonstrated acceptable validity and excellent reliability for screening sarcopenia among older adults.
- The MSRA-5 version showed slightly better internal consistency and diagnostic performance compared to MSRA-7, suggesting it may be the preferred tool for clinical practice in Türkiye.
- Strong negative correlations with the SARC-F questionnaire support the construct validity of the Turkish MSRA versions, and newly identified cut-off points enhance their applicability in the Turkish older population.

The MSRA questionnaire has been validated in multiple languages, including Thai, Polish, Spanish, Greek, Brazilian Portuguese, and Chinese, underscoring its cross-cultural applicability.[6-11] Given Türkiye's aging population and the increasing prevalence of sarcopenia, a validated Turkish version is essential. The objective of this study is to translate, culturally adapt, and validate the MSRA questionnaire for Turkish-speaking older adults, ensuring its effectiveness in clinical and research settings. Establishing a reliable screening tool will aid early intervention and improve health outcomes for older individuals in Türkiye.

Materials and Methods

Subjects

The study participants were community-dwelling older individuals aged 65 and above, recruited from an outpatient Geriatrics clinic. Demographic information, including participants' age, sex, and level of education was recorded. Furthermore, all participants had a comprehensive geriatric assessment, which encompassed evaluations of functional status with the Katz Index of Independence in Activities of Daily Living[12,13], Lawton Brody Instrumental Activities of Daily Living scale[14,15], Clinical Frailty Scale (CFS)[16], depressive symptoms via the Yesavage Geriatric Depression Scale (YDS)[17,18], nutritional status with the Mini Nutritional Assessment–Short Form (MNA-SF)[19,20], cognitive function measured by Standardised Mini-Mental State Examination (SMMSE)[21], and sarcopenia screening with SARC-F[3,4] and Turkish versions of MSRA.

Exclusion criteria included the existence of severe cognitive impairment, acute illnesses or exacerbations of chronic diseases requiring hospitalization, severe hearing or visual impairments preventing accurate questionnaire completion, and refusal to participate. All participants provided informed consent prior to enrollment. The study protocol was approved by the local ethics committee of Hacettepe University Health Sciences Research Ethics Committee (Reference number GO 21/644) and conducted in accordance with the Declaration of Helsinki.

Translation and adaptation process

Permission for the use of the MSRA has been obtained from Dr. Andrea P. Rossi, corresponding author of the original study.[5] The translation and cultural adaptation

of the MSRA-7 and MSRA-5 questionnaires into Turkish were performed following standardized international guidelines for cross-cultural adaptation of health-related measures. Initially, the MSRA questionnaires were independently translated into Turkish by two bilingual experts. The two translations were compared, and discrepancies were resolved by consensus, resulting in a single forward-translated Turkish version. Subsequently, this version underwent backward translation into English by two independent translators unfamiliar with the original questionnaire. The backward-translated versions were compared with the original questionnaires to ensure consistency and equivalency. A panel of experts, reviewed the translations for cultural appropriateness and relevance. After minor modifications, including changing the term 'milk coffee' to 'tea or coffee' to align with Turkish cultural preferences and removing the term 'ragout' due to the absence of an equivalent Turkish word, the Turkish versions were pretested with a sample of older adults (n=16) for clarity and comprehensibility, resulting in the final Turkish MSRA questionnaires (Appendix).

Reliability

Internal consistency reliability was assessed using Cronbach's alpha. Inter-rater reliability was evaluated by comparing questionnaire results from two independent raters who assessed the same participants (n=16) on the same day. Intra-rater reliability (test-retest reliability) was measured by having the same rater administer the questionnaire to the same participants with an interval of approximately two weeks. Both inter-rater and intra-rater reliabilities were analyzed using ICCs, with values ≥0.75 indicating excellent reliability.

Measurement of muscle strength and muscle mass

Handgrip strength was assessed using a calibrated handheld dynamometer (T.K.K.5401; Takei Scientific Instruments). Participants performed the measurement three times for the dominant hand, and the highest recorded value (kg) was used. Muscle strength was additionally assessed through the chair stand test, measuring the time (seconds) taken to rise from a chair five consecutive times without arm support. Skeletal muscle mass was evaluated by bioelectrical impedance analysis (BIA) using a validated device (Bodystat QuadScan 4000). Skeletal muscle mass index (SMMI) was calculated by dividing appendicular skeletal muscle mass by height squared (kg/m²).

According to the Revised European Working Group on Sarcopenia in Older People (EWGSOP2) criteria, sarcopenia is defined as the presence of reduced muscle strength (HS <27 kg in men, <16 kg in women or chair stand test >15 s) combined with low muscle mass (<7 kg/m² for men and <5.5 kg/m² for women). Probable sarcopenia is identified when low muscle strength is detected.[2] Since only one participant met the EWGSOP2 criteria for confirmed sarcopenia, all analyses in this study were conducted based on the presence or absence of probable sarcopenia, which reflects reduced muscle strength without confirmed low muscle mass.

Statistical analyses

Descriptive statistics were presented as median (interquartile range [IQR]) for non-normally distributed continuous variables, mean ± standard deviation (SD) for normally distributed continuous variables, and frequencies and percentages (%) for categorical variables. Comparisons between groups were performed using t-test or Mann-Whitney U tests for continuous variables, where appropriate and Chi-square tests for categorical variables. Construct validity was evaluated using Spearman correlation coefficients between the Turkish MSRA versions and SARC-F questionnaire. Receiver operating characteristic (ROC) curve analysis was performed to determine optimal cut-off points, sensitivity, and specificity for predicting probable sarcopenia. All statistical analyses were performed using SPSS version SPSS 25.0 (IBM Corp., Armonk, NY) with statistical significance set at $p<0.05$.

Results

A total of 157 participants (64.3% women) with a median age of 72 (68-78) were included in the study. Significant sex differences were observed in several demographic and clinical characteristics (Table 1). Women had notably lower education levels (87.1% ≤5 years vs. 48.2% in men, $p<0.001$), higher prevalence of hypertension (80.2% vs. 64.3%, $p=0.028$), lower prevalence of cardiovascular diseases (16.8% vs. 39.3%, $p=0.002$), and higher body mass index (BMI) (median BMI: 29.70 vs. 27.40 kg/m², $p<0.001$). Regarding components of comprehensive geriatric assessment, women showed slightly lower independence in activities of daily living as measured by the Katz and Lawton-Brody scales. Additionally, women had significantly higher YDS and CFS scores, and lower MNA-SF and SMMSE scores, and physical performance parameters such as handgrip strength and

Table 1. Demographic and clinical characteristics of the study population

	Women (n=101)	Men (n=56)	p
Age	72.0 (67.5-78.5)	72.5 (68.2-77.0)	0.65
Education time			
≤ 5 years	88 (87.1%)	27 (48.2%)	**<0.001**
> 5 years	13 (12.9%)	29 (51.8%)	
Hypertension	81 (80.2%)	36 (64.3%)	**0.028**
Diabetes mellitus	57 (56.4%)	28 (50.0%)	0.50
Cardiovascular Disease	17 (16.8%)	22 (39.3%)	**0.002**
Cerebrovascular Disease	7 (6.9%)	2 (3.6%)	0.38
BMI (kg/m^2)	29.70 (27.35-34.10)	27.40 (24.65-29.90)	**<0.001**
Katz	6 (5-6)	6 (6-6)	**0.004**
Lawton Brody	8 (6-8)	8 (8-8)	**0.024**
YDS	4 (1-6)	1 (0-3)	**<0.001**
MNA-SF	13 (11-14)	14 (13-14)	**<0.001**
CFS	3 (3-5)	3 (2-3)	**<0.001**
SMMSE	26 (22.5-28)	29 (26.25-30)	**<0.001**
Handgrip strength (kg)	18.70 (14.70-22.85)	28.45 (21.75-32.85)	**<0.001**
Chair stand test (s)	15.06 (13.0-18.11)	14.55 (10.78-16.96)	**0.036**
SARC-F	3 (1-5)	1 (0-4)	**0.008**
MSRA-7	25 (15-30)	30 (20-35)	**0.003**
MSRA-5	40 (15-52.5)	55 (35-55)	**<0.001**
SMMI (kg/m^2)	9.52 ± 1.19	11.01 ± 1.46	**<0.001**
Probable Sarcopenia	54 (53.5%)	35 (62.5%)	0.31

BMI: Body mass index, CFS: Clinical Frailty Scale, MNA-SF: Mini Nutritional Assessment Short Form, MSRA-5: Mini Sarcopenia Risk Assessment 5 items, MSRA-7: Mini Sarcopenia Risk Assessment 7 items, SARC-F: Strength, assistance with walking, rise from a chair, climb stairs and falls, SMMI: Skeletal Muscle Mass Index, SMMSE: Standardised Mini-Mental State Examination, YDS: Yesavage Geriatric Depression scale. Results were shown as mean ± 2SD for parametric variable (SMMI), median (IQR) for non-parametric variables (Age, BMI, Katz, Lawton-Brody, YDS and MNA-SF, CFS, SMMSE, handgrip strength, chair stand test, SARC-F and MSRA scores), and as numbers (n) and percentiles (%) for categorical variables.

chair stand test scores. Women also scored higher in sarcopenia screening tools (SARC-F, MSRA-7, MSRA-5) and had lower skeletal muscle mass index (SMMI) values compared to men. However, no significant difference was found between sexes in the prevalence of probable sarcopenia.

Reliability

Cronbach's alpha was used to evaluate the internal consistency of the Turkish MSRA questionnaires, which demonstrated acceptable reliability with values of 0.650 for MSRA-7 and 0.705 for MSRA-5. Additionally, both inter-rater and intra-rater (test-retest) reliability were evaluated using ICCs. For MSRA-7, ICC was 0.983 (95% CI: 0.953–0.994) for inter-rater reliability and 0.992 (95% CI: 0.977–0.997) for intra-rater reliability. Similarly, MSRA-5 showed high reliability with ICC values of 0.971 (95% CI: 0.921–0.990) for inter-rater reliability and 0.988 (95% CI: 0.967–0.996) for intra-rater reliability. These findings indicate excellent reliability of the Turkish versions of the MSRA questionnaires.

Construct validity

To evaluate the construct validity of the Turkish versions of MSRA-7 and MSRA-5, Spearman correlation analyses were conducted using the SARC-F questionnaire as a comparator. Strong negative correlations were found between SARC-F and both MSRA-7 ($r = -0.767$, $p < 0.001$) and MSRA-5 ($r = -0.781$, $p < 0.001$), indicating excellent construct validity of the Turkish MSRA questionnaires.

Cut-off values

ROC curve analyses were conducted to determine the diagnostic performance of MSRA-7, MSRA-5, and SARC-F questionnaires in predicting probable sarcopenia. The areas under the ROC curve (AUC) were 0.688 (95% CI: 0.609–0.759, $p<0.001$) for MSRA-7 (Figure 1), 0.721 (95% CI: 0.644–0.790, $p<0.001$) for MSRA-5 (Figure 2), and 0.723 (95% CI: 0.646–0.791, $p<0.001$) for SARC-F (Figure 3).

The optimal cut-off points identified using the Youden index were ≤20 for MSRA-7 (sensitivity: 53.93%, specificity: 77.94%), ≤35 for MSRA-5 (sensitivity: 55.06%, specificity: 80.88%), and ≥3 for SARC-F (sensitivity: 64.04%, specificity: 72.06%).

Pairwise comparisons of ROC curves revealed no statistically significant differences between MSRA-5, MSRA-7, and SARC-F (MSRA-5 vs MSRA-7, MSRA-5 vs SARC-F, and MSRA-7 vs SARC-F; p=0.08, p=0.95, p=0.28, respectively.) (Figure 4). These findings suggest that all three tools have comparable diagnostic performance for screening probable sarcopenia, with MSRA-5 and SARC-F demonstrating slightly higher overall accuracy compared to MSRA-7.

Discussion

The objective of this study was to translate, culturally adapt, and validate the Turkish versions of the MSRA-7 and MSRA-5 questionnaires for the screening of sarcopenia in community-dwelling older adults in Türkiye. Our findings exhibited acceptable validity and excellent reliability of both Turkish MSRA versions, consistent with previous validation studies in other populations and languages.

In the original validation by Rossi et al., MSRA displayed a sensitivity of 80.4% and specificity of 60.4% for detecting sarcopenia risk among older Italian adults.[5] In our study, MSRA-5 exhibited a sensitivity of 55.06% and specificity

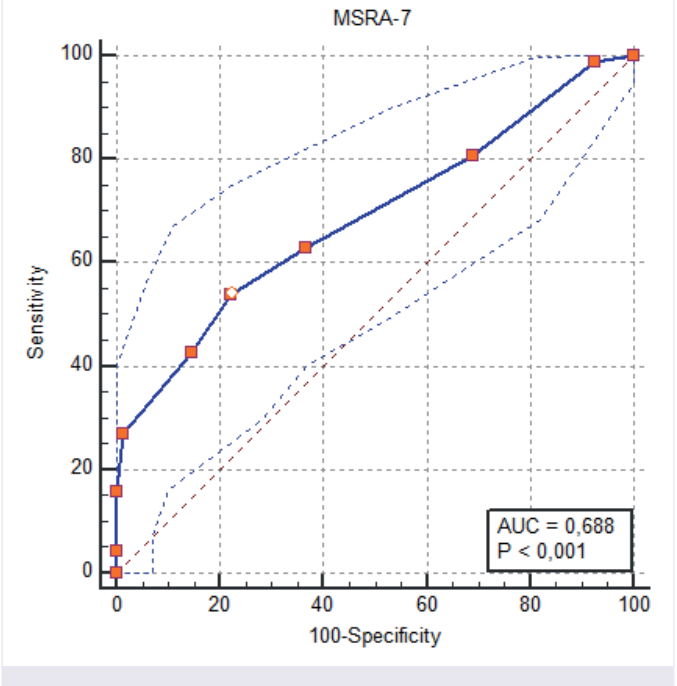

Figure 1. ROC curve illustrating the diagnostic performance of the Mini Sarcopenia Risk Assessment (MSRA-7) questionnaire in predicting probable sarcopenia

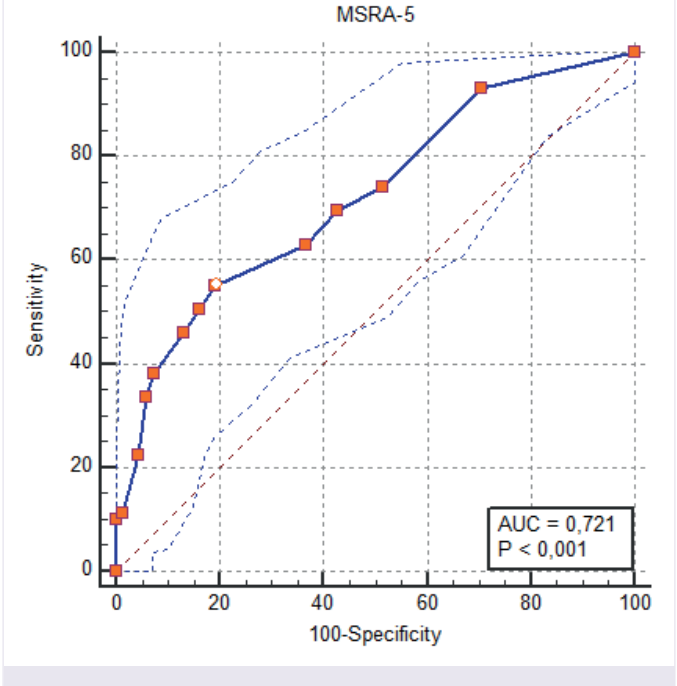

Figure 2. ROC curve illustrating the diagnostic performance of the Mini Sarcopenia Risk Assessment (MSRA-5) questionnaire in predicting probable sarcopenia

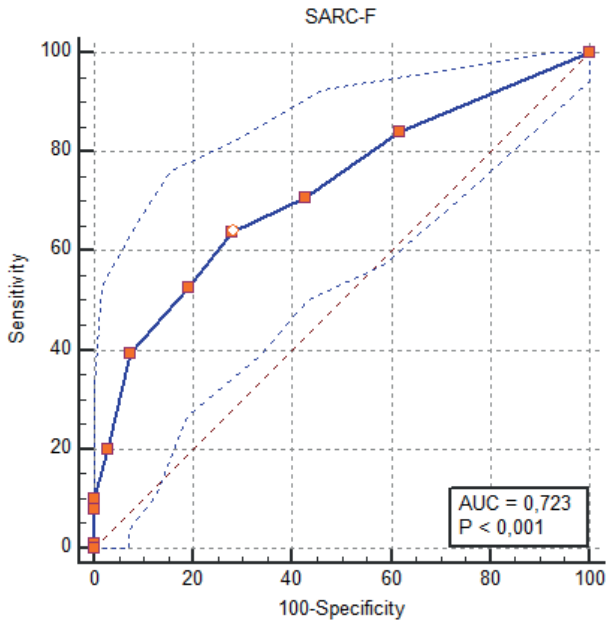

Figure 3. ROC curve illustrating the diagnostic performance of the Strength, Assistance with walking, Rise from a chair, Climb stairs, and Falls (SARC-F) questionnaire in predicting probable sarcopenia

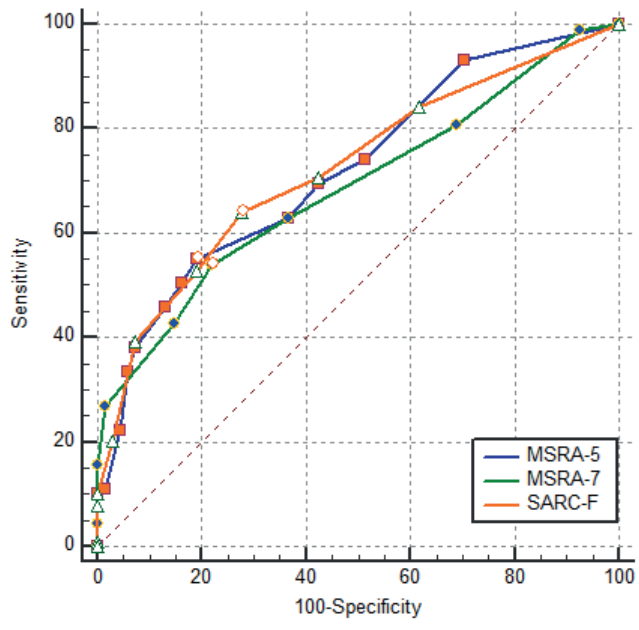

Figure 4. Comparison of ROC curves for MSRA-7, MSRA-5, and SARC-F questionnaires in predicting probable sarcopenia

of 80.88%, whereas MSRA-7 had slightly lower sensitivity (53.93%) and specificity (77.94%). Also, the MSRA-7 version demonstrated a relatively lower Cronbach's alpha (0.650) compared to MSRA-5 (0.705), suggesting moderate internal consistency. This discrepancy may be partly attributed to the question regarding dairy product consumption in the MSRA-7, which may have introduced variability in participant responses. In the Turkish context, cultural dietary habits, such as variability in types and frequency of dairy intake may lead to inconsistencies in how older adults interpret and respond to this item. The MSRA-5 version notably omits this question, concentrating instead on fundamental risk factors including age, weight loss, physical activity, and hospitalizations. This more streamlined structure appears to contribute to its stronger internal consistency and better overall diagnostic performance in our study, as reflected by both higher Cronbach's alpha and superior ROC curve characteristics (AUC: 0.721 vs. 0.688 for MSRA-7).

Comparing our results with other cross-cultural validation studies, consistent trends emerge in favor of the MSRA-5 questionnaire over MSRA-7 in terms of diagnostic accuracy. In the Chinese validation conducted by Yang et al., MSRA-5 was shown to be more effective than MSRA-7 for sarcopenia screening in community-dwelling older adults, aligning with our own findings.[11] Similarly, the Polish validation reported high sensitivity for both MSRA-7 and MSRA-5, however, MSRA-5 demonstrated better specificity compared to MSRA-7.[7] In the Spanish validation study, MSRA-5 again showed superior diagnostic performance compared to MSRA-7.[8] Taken together, these validation studies support the notion that MSRA-5's more concise structure—focusing on core sarcopenia risk factors such as age, mobility, weight loss, comorbidities, and recent hospitalization—may contribute to its superior diagnostic utility across diverse populations. Our study confirms this pattern in Turkish older adults, further reinforcing the MSRA-5 as a culturally adaptable and clinically effective tool for sarcopenia screening.

Despite the known limitations of the SARC-F questionnaire, particularly its low sensitivity for detecting sarcopenia[22], it was selected as the reference tool for evaluating construct validity in this study due to its widespread clinical use and endorsement by international guidelines.

Specifically, the EWGSOP2 recommends SARC-F as a first-line screening tool in clinical practice.[2] Its use across diverse healthcare settings and populations provides a practical benchmark for comparison with newly validated instruments like the MSRA. Therefore, the strong negative correlations observed between SARC-F and both MSRA-7 and MSRA-5 further support the construct validity of the Turkish versions of MSRA within a real-world clinical screening context. The results align with those observed in the earlier cross-cultural validation study by Pantouvaki et al., where strong inverse correlations were found between MSRA-7 and MSRA-5 scores and the SARC-F ($r = -0.741$ and $r = -0.724$, respectively; $p < 0.001$).[9]

The optimal cut-off points identified in our study (≤20 for MSRA-7 and ≤35 for MSRA-5) differ slightly from those reported in the original Italian validation and other language adaptations. For example, Rossi et al. proposed ≤30 for MSRA-7 and ≤45 for MSRA-5, reflecting differences in population characteristics and sarcopenia prevalence.[5] The lower thresholds observed in the Turkish population may be attributed to cultural and dietary habits, differing healthcare access, or variations in the interpretation of specific questionnaire items, such as those related to mobility and protein intake. These findings underscore the significance of validation tailored to specific contexts and emphasize the need to establish culturally appropriate cut-off points to optimize the diagnostic accuracy of sarcopenia screening tools across diverse settings.

However, several limitations should be noted. Firstly, our study utilized BIA for muscle mass measurement, which, although practical, is less precise than imaging techniques like dual-energy X-ray absorptiometry (DXA). This limitation may influence the accuracy of sarcopenia diagnosis. Secondly, our analyses were conducted solely on patients with probable sarcopenia, as only one participant was identified with confirmed sarcopenia based on EWGSOP2 criteria. This limitation could restrict the applicability of the findings to confirmed sarcopenia cases and highlights the need for future studies to include a larger number of individuals diagnosed with confirmed sarcopenia. Additionally, our study was conducted in a single outpatient setting, potentially limiting the generalizability of findings to broader community or institutional populations. Finally, although our sample size was statistically adequate, larger multi-center studies could further validate these results and explore subgroup differences more comprehensively.

Conclusion

In conclusion, the Turkish versions of the MSRA-7 and MSRA-5 questionnaires exhibit strong psychometric properties for screening sarcopenia among older adults. The MSRA-5, with its slightly better diagnostic performance, could be recommended as the preferred screening tool in clinical practice. Their use can facilitate early identification and intervention strategies in clinical and research settings within Türkiye, ultimately contributing to better geriatric care outcomes.

Ethical approval

This study has been approved by the Hacettepe University Health Sciences Research Ethics Committee (approval date 26.05.2021, number GO:21/644). Written informed consent was obtained from the participants.

Author contribution

The authors declare contribution to the paper as follows: Study conception and design: AD, MGH; data collection: AD, ZS, MH, DK, CA, IE; analysis and interpretation of results: AD, ZS, MH; draft manuscript preparation: AD, MC, BBD, MGH. All authors reviewed the results and approved the final version of the article.

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Conflict of interest

The authors declare that there is no conflict of interest.

References

1. Sayer AA, Cooper R, Arai H, et al. Sarcopenia. *Nat Rev Dis Primers*. 2024;10:68. **[Crossref]**
2. Cruz-Jentoft AJ, Bahat G, Bauer J, et al. Sarcopenia: revised European consensus on definition and diagnosis. *Age Ageing*. 2019;48:16-31. **[Crossref]**

3. Malmstrom TK, Morley JE. SARC-F: a simple questionnaire to rapidly diagnose sarcopenia. *J Am Med Dir Assoc*. 2013;14:531-532. **[Crossref]**
4. Bahat G, Yilmaz O, Kılıç C, Oren MM, Karan MA. Performance of SARC-F in regard to sarcopenia definitions, muscle mass and functional measures. *J Nutr Health Aging*. 2018;22:898-903. **[Crossref]**
5. Rossi AP, Micciolo R, Rubele S, et al. Assessing the risk of sarcopenia in the elderly: the Mini Sarcopenia Risk Assessment (MSRA) questionnaire. *J Nutr Health Aging*. 2017;21:743-749. **[Crossref]**
6. Akarapornkrailert P, Muangpaisan W, Boonpeng A, Daengdee D. Validation of the Thai version of SARC-F, MSRA-7, and MSRA-5 questionnaires compared to AWGS 2019 and sarcopenia risks in older patients at a medical outpatient clinic. *Osteoporos Sarcopenia*. 2020;6:205-211. **[Crossref]**
7. Krzymińska-Siemaszko R, Deskur-Śmielecka E, Styszyński A, Wieczorowska-Tobis K. Polish translation and validation of the Mini Sarcopenia Risk Assessment (MSRA) questionnaire to assess nutritional and non-nutritional risk factors of sarcopenia in older adults. *Nutrients*. 2021;13:1061. **[Crossref]**
8. Moreno-Sánchez I, Aibar-Almazán A, Carcelén-Fraile MD, et al. Cross-cultural adaptation and clinical validation of the mini sarcopenia risk assessment questionnaire in community-dwelling spanish older adults. *Diagnostics (Basel)*. 2024;14:2123. **[Crossref]**
9. Pantouvaki A, Kastanis G, Patelarou E, Alpantaki K, Kleisiaris C, Zografakis-Sfakianakis M. Greek translation, cultural adaptation and validation of the mini sarcopenia risk assessment questionnaire, to evaluate sarcopenia in Greek elderly at a hospital setting. *Nurs Rep*. 2023;13:404-411. **[Crossref]**
10. Ribeiro LS, Souza BG, de Lima JB, Pimentel GD. Cross-cultural adaptation of the Brazilian Portuguese-translated version of the Mini Sarcopenia Risk Assessment (MSRA) questionnaire in cancer patients. *Clin Pract*. 2021;11:395-403. **[Crossref]**
11. Yang M, Hu X, Xie L, et al. Validation of the Chinese version of the mini sarcopenia risk assessment questionnaire in community-dwelling older adults. *Medicine (Baltimore)*. 2018;97:e12426. **[Crossref]**
12. Katz S, Ford AB, Moskowitz RW, Jackson BA, Jaffe MW. Studies of illness in the aged. The index of ADL: a standardized measure of biological and psychosocial function. *JAMA*. 1963;185:914-919. **[Crossref]**
13. Arik G, Varan HD, Yavuz BB, et al. Validation of Katz index of independence in activities of daily living in Turkish older adults. *Arch Gerontol Geriatr*. 2015;61:344-350. **[Crossref]**
14. Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. *Gerontologist*. 1969;9:179-186.
15. Işık EI, Yılmaz S, Uysal I, Basar S. Adaptation of the lawton instrumental activities of daily living scale to Turkish: validity and reliability study. *Ann Geriatr Med Res*. 2020;24:35-40. **[Crossref]**
16. Özsürekci C, Balcı C, Kızılarslanoğlu MC, et al. An important problem in an aging country: identifying the frailty via 9 Point Clinical Frailty Scale. *Acta Clin Belg*. 2020;75:200-204. **[Crossref]**
17. Yesavage JA, Brink TL, Rose TL, et al. Development and validation of a geriatric depression screening scale: a preliminary report. *J Psychiatr Res*. 1982;17:37-49. **[Crossref]**
18. Durmaz B, Soysal P, Ellidokuz H, Işık AT. Validity and reliability of geriatric depression scale-15 (short form) in Turkish older adults. *North Clin Istanb*. 2018;5:216-220. **[Crossref]**
19. Guigoz Y, Lauque S, Vellas BJ. Identifying the elderly at risk for malnutrition. The Mini Nutritional Assessment. *Clin Geriatr Med*. 2002;18:737-757. **[Crossref]**
20. Sarikaya D, Halil M, Kuyumcu ME, et al. Mini nutritional assessment test long and short form are valid screening tools in Turkish older adults. *Arch Gerontol Geriatr*. 2015;61:56-60. **[Crossref]**
21. Molloy DW, Alemayehu E, Roberts R. Reliability of a standardized mini-mental state examination compared with the traditional mini-mental state examination. *Am J Psychiatry*. 1991;148:102-105. **[Crossref]**
22. Kera T, Kawai H, Hirano H, et al. Limitations of SARC-F in the diagnosis of sarcopenia in community-dwelling older adults. *Arch Gerontol Geriatr*. 2020;87:103959. **[Crossref]**

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Investigating preoperative nutritional status and determining the predictors of nutritional status in pediatric surgery patients

Nazife Gamze Özer Özlü[1], Eda Ayten Kankaya[1], Fatma Vural[1]

[1]Faculty of Nursing, Dokuz Eylül University, İzmir, Türkiye

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ABSTRACT

Objective: This study aimed to evaluate the preoperative nutritional status of pediatric surgery patients and identify predictive factors influencing malnutrition.

Methods: A descriptive, cross-sectional study was conducted at a tertiary university hospital. Data were collected through structured interviews with mothers of children aged three months to 16 years scheduled for elective surgery. Nutritional status was evaluated using STRONGkids tool, Gomez, Waterlow, and WHO classification. Logistic regression identified nutritional risk predictors.

Results: Among 162 participants, Gomez and Waterlow classifications show that 66.0% and 76.5% of children are normal, respectively, while WHO classification (z-scores) show that 50.0% of children are in the normal range, while 4.9% are severely undernutrition when calculated without distinction of age. It also shows that 52.5% of children under 5 years of age are normal, 4.9% are severely undernutrition according to WHO classification, and 50.0% of children over 5 years of age are normal, 4.2% are severely undernutrition. Significant differences in nutritional risk were observed based on gender ($p=0.03$), chronic disease presence ($p<0.01$), and type of surgery ($p<0.01$). The analysis revealed that children undergoing thoracic surgery had a 3.16-fold higher nutritional risk compared to those undergoing abdominal or genitourinary surgeries. The length of hospital stays increased nutritional risk by 1.11 times per day. Maternal feeding attitudes were significantly associated with nutritional risk ($p<0.01$). Preoperative laboratory values indicated lower hemoglobin, hematocrit, and albumin levels in high-risk groups.

Conclusions: Preoperative nutritional assessment is crucial in pediatric surgery. Surgery type, hospitalization length, and maternal attitudes significantly impact nutritional risk. Early identification and targeted interventions can improve postoperative outcomes and reduce complications. Further research should explore the effects of age and chronic disease on nutrition.

Keywords: pediatric surgery, nutritional status, STRONGkids tool, Gomez classification, Waterlow classification, z score, predictive factors

Introduction

Preoperative nutritional status plays a crucial role in pediatric surgery, significantly impacting surgical outcomes, recovery time, and overall health.[1] Malnutrition before surgery is associated with increased postoperative complications, prolonged hospital stays, and delayed wound healing.[2,3] Research indicates that 45% to 62% of hospitalized children experience malnutrition, with longer hospital stays exacerbating the nutritional decline.[4,5] Thoracic surgeries pose the highest risk due to their effects on respiratory function and metabolism,

Corresponding author: Eda Ayten Kankaya
Email: edaayten.kankaya@deu.edu.tr

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highlighting the need for thorough nutritional assessment and intervention.[6]

Several factors contribute to preoperative malnutrition in pediatric surgery patients. Surgical stress, metabolic demands, chronic conditions, and extended hospitalization increase the risk of nutritional deterioration.[6] Maternal feeding attitudes and parental stress significantly affect children's preoperative nutrition.[7] Studies show that negative feeding behaviors and heightened parental anxiety correlate with child malnutrition[8], whereas educational interventions for parents can improve children's nutritional status and overall well-being.[9]

Despite the known effects of malnutrition on surgical outcomes, research on preoperative nutritional risk remains limited. Most existing studies focus on specific surgical subgroups rather than comprehensively analyzing pediatric surgery patients.[10,11] To address this gap, this study evaluates preoperative nutritional status using validated assessment tools such as the STRONGkids Nutrition Screening Tool, Gomez classification, Waterlow classification, and WHO classification criteria.[12-16] Furthermore, the study investigates the influence of demographic, clinical, and maternal factors on pediatric patients' nutritional risk.

By determining key predictors, this study aims to develop targeted nutritional interventions for pediatric surgery patients. Early identification and appropriate dietary strategies can enhance postoperative recovery and long-term health outcomes.

Main Points

- The preoperative nutritional status of pediatric surgical patients varies significantly depending on the assessment method used. WHO z-scores detect more cases of malnutrition than the Gomez or Waterlow classifications.
- Thoracic surgery, a prolonged preoperative hospital stay, and older age are independent predictors of a higher preoperative nutritional risk.
- Negative maternal feeding attitudes increase nutritional risk in children before surgery, and early screening with targeted interventions can help reduce complications.

Aim

This study aimed to evaluate the preoperative nutritional status of pediatric surgery patients and identify the factors that predict it.

Methods

Study design and patients

This study was designed as a descriptive, cross-sectional, and predictive. Data was collected through face-to-face interviews between April 2022 and October 2023 at a tertiary university hospital's pediatric surgery inpatient clinic. Informed consent was obtained from the mothers before data collection.

Inclusion criteria:

- The child was planned for elective surgery.
- The child was between 3 months and 16 years old.
- The child had been hospitalized for at least one day.
- The mother was 18 years old or older.
- The mother could read, write, and speak the local language fluently.

Exclusion criteria:

- The child was admitted to the intensive care unit.
- The child was undergoing emergency surgery.
- The child had used steroids or appetite stimulants in the last three months.
- The child was receiving enteral or parenteral nutrition therapy.
- The mother had sensory disabilities such as hearing or vision impairments.

Outcomes

The primary outcome of this study was to evaluate pediatric surgery patients' preoperative nutritional status using the STRONGkids tool, Gomez classification, Waterlow classification, and WHO classification.

The secondary outcomes included:

- Investigating the impact of children's demographic characteristics, such as gender, age, breastfeeding

status, duration of breastfeeding, duration of complementary feeding, use of oral supplements, use of supplementary vitamins, and presence of chronic disease, on their nutritional status.

- Examining how children's clinical characteristics, including the type of surgery, length of hospital stays, weight, height, arm circumference, abdominal circumference, hemoglobin, hematocrit, albumin, and CRP levels, influence their nutritional status.
- Assessing the effect of maternal characteristics, such as maternal age, education level, working status, and attitudes toward feeding, on the child's nutritional status.
- Determining the predictive value of children's demographic and clinical characteristics and maternal characteristics in the preoperative nutritional assessment of pediatric surgery patients.

Sample size estimation

The sample size was determined using the G*Power 3.1.9.2 software.[17] Based on a medium effect size (0.05), a theoretical power of 0.80, and a 95% confidence interval[18], the minimum required sample size was calculated as 98. However, 162 children and their mothers voluntarily participated in the data collection. A post-hoc power analysis was performed to verify the sample size's adequacy. Using the mean scores of the Mothers' Attitudes Towards the Feeding Process Scale (MATFPS) according to the STRONGkids tool, the effect size was determined as 1.17, yielding a post-hoc power of 1.000, with an alpha value of 0.05.

Assessment of nutritional status

Demographic and Clinical Characteristics: A structured form, developed based on the relevant literature[19-23], was used to collect data on:

- **Child-related variables:** age, height, weight, abdominal and arm circumference, sex, preoperative diagnosis, planned surgical procedure, type of surgery, presence of chronic diseases, use of oral appliances, breast milk intake, supplementary food, and vitamin intake, length of hospital stay, and preoperative hemoglobin, hematocrit, albumin, and CRP levels.
- **Maternal variables:** age, educational level, number of children in the household and maternal feeding attitude. The Mothers' Attitudes Towards the Feeding Process Scale (MATFPS) was used to determine maternal nutritional attitudes. This 27-item scale, developed by Dilsiz and Dağ[24], is a 5-point Likert scale used to evaluate maternal attitudes toward feeding. Total scores range from 27 to 135, with higher scores indicating greater feeding-related issues. In this study, the MATFPS demonstrated high reliability (Cronbach's alpha = 0.90).
- **Nutritional Status Assessment Tools:** In 1956, Gomez introduced a classification of malnutrition based on weight below a certain percentile of the median weight for age (WFA)[13] In the 1970s, Waterlow introduced a classification based on weight for height (WFH) and also suggested the use of standard deviation scores (SD scores)[14], which have been used by the World Health Organization (WHO) since 1995.[16] Therefore, the Gomez, Waterlow and WHO classification were used in the assessment of nutritional status.

For consistency and comparative clarity, nutritional status was categorized as normal, mild, moderate, and severe across all systems: The Gomez classification for weight-for-age is as follows: normal is greater than 90%, mild malnutrition is between 75-90%, moderate malnutrition is between 60-74%, and severe malnutrition is less than 60%. The Waterlow classification for height-for-age (stunting) includes normal as greater than 95%, mild stunting as between 90-95%, moderate stunting as between 85-89%, and severe stunting as less than 85%. For weight-for-height (wasting), normal is greater than 90%, mild wasting is between 81-90%, moderate wasting is between 70-80%, and severe wasting is less than 70%. Although the WHO does not formally define "mild" wasting, for this study, z-scores between -1 and -2 standard deviations are labeled as "mild" to enable comparison across classification systems.

- **Gomez and Waterlow Malnutrition Classification:** It is based on body weight measurement and is widely used to determine the degree of malnutrition. Gomez published the first classification based on weight for age. The measured weight is evaluated by comparing it with the 50th percentile value of healthy children of the same age and gender with good nutrition (weight for age). It is widely used to determine the degree of malnutrition. The Gomez classification evaluates protein-energy malnutrition based on weight-for-age: values ≥90% are considered normal, 76–89% indicate mild malnutrition (1st degree), 61–75% indicate moderate malnutrition (2nd degree), and <60% indicate severe malnutrition (3rd degree).[13]

The Waterlow classification was developed after it was seen that weight-for-age alone was not sufficient to define the etiology of malnutrition in societies. It is used more frequently because it includes height measurement and indicates chronic malnutrition. In this classification, it distinguishes between acute malnutrition (underweight) based on weight-for-height and chronic malnutrition (stunting) based on height-for-age. The Waterlow classification distinguishes between acute and chronic malnutrition. It evaluates wasting using weight-for-height (WFH) for children under 5 years or BMI-for-age for children aged 5 years and older—not directly BMI values, and stunting using height-for-age (HFA).[14]

- **World Health Organization (WHO) Growth Standards:** This classification undernutrition is assessed using weight-for-length/height z-scores in children under 5 years of age and BMI-for-age z-scores in children aged 5 years and older. In this study, children with a z-score below -2 SD were classified as undernutrition, and those with a z-score below -3 SD were defined as severely undernourished, in accordance with WHO criteria (WHO, 1995). Although WHO does not define "mild" wasting, for the purpose of this study, values between -1 and -2 SD were categorized as mild malnutrition to allow consistent comparisons with the Gomez and Waterlow classifications.[16] According to the WHO criteria:
  - Wasting is defined as a weight-for-height (for children under 5) or BMI-for-age (for children aged 5 and older) z-score below -2 SD, with severe wasting defined as below -3 SD.
  - Stunting is defined as a height-for-age z-score (HFA) below -2 SD.
  - The WHO classification does not formally define mild wasting; however, z-scores between -1 and -2 SD may indicate a nutritional risk.

Additionally, based on the 2022 ESPGHAN definition, undernutrition is considered a condition resulting from imbalanced nutrition or abnormal nutrient utilization, leading to negative effects on tissue function or body composition. This definition includes both static z-score thresholds and dynamic changes such as a decline of more than 1 SD in weight-for-age (WFA), weight-for-height (WFH), or BMI-for-age over time, as well as growth faltering and the broader clinical context.[25]

- **STRONGkids Tool:** This screening tool was developed by Hulst et al.[12] to assess the risk of malnutrition in hospitalized children aged 1 month to 18 years who have been admitted for at least one day. The validity and reliability of the STRONGkids tool have been assessed in various populations, including Turkish children, as demonstrated in the study by Oruçoğlu and İnanç.[26] This tool evaluates four key components: subjective clinical assessment, high-risk disease condition, reduction in food intake, and weight loss, which generate a final score. A score of 4 to 5 indicates a high risk of malnutrition, while a score of 1 to 3 points suggests a moderate risk. A score of 0 points signifies a low risk of malnutrition.[27-29] This classification helps in the early identification of malnutrition risk, allowing for timely interventions and appropriate nutritional support.

Procedure

The study was conducted in a pediatric surgery inpatient clinic following the American Society of Anesthesiologists (ASA) preoperative nutrition guidelines. Clear liquids were allowed for up to two hours before surgery for all ages, while breast milk was permitted up to four hours before surgery for infants. Formula and cow's milk were allowed up to six hours before surgery, and carbohydrate loading was performed two to three hours preoperatively. Routine preoperative laboratory samples were collected from electronic patient files to minimize additional blood drawings. Data on hemoglobin, hematocrit, CRP, and albumin levels and preoperative diagnosis, surgical plan, and hospitalization details were retrieved electronically. The same investigator took anthropometric measurements within the first 48 hours of hospitalization. Depending on the child's age, weight was measured using digital baby scales or adult weight scales. Height was measured supine for infants under two years old, with the head and feet fixed, while children over two years were measured standing using a wall-mounted stadiometer. Arm and abdominal circumferences were measured between 7:00 and 8:00 AM using standardized Baxter height and weight devices. Additionally, mothers were given the MATFPS questionnaire, which they completed within 10 minutes.

Statistical analysis

IBM SPSS Version 24.0 (IBM Corp.) was used for data analysis. Normality tests included Kolmogorov-Smirnov, Shapiro-Wilk, Kurtosis-Skewness tests, kurtosis-skewed coefficient values, Q-Q plots, and box plots.[30] Non-

parametric tests were applied to data that did not comply with normal distribution. Statistical significance was set at p-values less than 0.05 within a 95% confidence interval. Descriptive statistics were applied to analyze the data. Analytical statistics included Kruskal-Wallis and Mann-Whitney U tests. Given the broad age range of the study population (6 months to 16 years), raw anthropometric measurements such as weight, height, and mid-arm circumference were not used directly in statistical analyses. This adjustment ensures age-standardized comparisons, reducing bias due to natural growth variations. Additionally, multiple linear regression analysis was performed to predict the factors influencing the nutritional status of children.

Logistic regression analysis evaluated the significant variables according to the primary analysis.[31] p-values of 0.05 were considered statistically significant. The Hosmer-Lemeshow test was conducted to assess the model's fit. If the P value is above 0.05, the model's predictive value can be considered high. In this study, the Hosmer-Lemeshow test's value was 0.89, indicating the model's high predictive value.

Ethics

Ethical permission was obtained (Decision no:2022/06-13; Date:16.02.2022) from the non-interventional ethics committee of the university to which the institution is affiliated, and written permission (Number: E-59537164-799-233459, Date: 22.04.2022) from the hospital where the study was conducted. Written informed consent was obtained from each subject or relative following a detailed explanation of the objectives and protocol of the study, which was conducted by the ethical principles stated in the "Declaration of Helsinki".

Results

Table 1 evaluates preoperative nutritional status in pediatric surgery patients using three different classification methods: Gomez (weight-for-age), Waterlow (height-for-age), and WHO classification (z-score). According to the Gomez classification, 66.0% of children were classified as usual, while 6.2% were severely malnourished. The Waterlow classification showed that 76.5% of children had normal height-for-age, with 3.1% classified as severely stunted. In contrast, WHO classification (z-scores) indicated that only 50.0% of children were in the normal range, while 4.9% were severely malnourished. In contrast, according to WHO classification (z-scores), 50.0% of children were in the normal range, while 4.9% were severely malnourished when calculated without distinction of age.

In calculations made independently of the table, 52.5% of children under 5 years of age were in the normal range, while 4.9% were severely undernutrition. Among children over 5 years of age, 50.0% were in the normal range, while 4.2% were severely undernutrition. In addition, analyses according to WHO classification showed that 3.1% were stunting (Height-for-age (HFA)), 24.1% were wasting (Weight-for-height (WFH) <5 years, BMI-for-age ≥5 years), and 3.1% were undernutrition (Weight-for-age (WFA)). These differences highlight the varying sensitivity of different assessment methods in assessing nutritional risk.

Table 2 analyzes child-related demographic variables based on STRONGkid's nutrition risk groups. Gender distribution showed a statistically significant difference among risk groups (p=0.03), with boys and girls distributed differently across the low, medium, and high-risk categories. Age group classification did not significantly correlate with nutrition risk (p=0.15). Additional vitamins

Table 1. Evaluation of preoperative nutritional status in pediatric surgery patients using different assessment methods (n=162)

	Weight by age (Gomez Classification)	Height for age (Waterlow Classification)	WHO classification (WFA/BMI)
	n (%)	n (%)	n (%)
Normal	107 (66.0)	124 (76.5)	81 (50.0)
Mild	27 (16.7)	23 (14.2)	58 .835.8)
Moderate	18 (11.1)	10 (6.2)	15 (9.3)
Severe	10 (6.2)	5 (3.1)	8 (4.9)

*z-scores are calculated according to WHO references

Table 2. Analysis of child-related demographic variables according to STRONGkids nutrition screening tool risk groups (n=162)

Child-related variables	STRONGkids Nutrition Screening Tool Risk Grouping			Test statistics	p-value
	Low risk (I)	Medium risk (II)	High risk (III)		
Gender n, (%)				X^{2***}= 6.56 Cramer's V=0.20	**p=0.03**
Girl	6, (9.4)	41, (64.1)	17, (17.3)		
Boy	24, (58.2)	57, (58.2)	17, (17.3)		
Child's age group n, (%)				X^{2****}=11.67 Cramer's V=0.18	p= 0.15
Infant	3, (13.6)	11, (50.0)	8, (36.4)		
Toddler	6, (27.3)	10, (45.5)	6, (27.3)		
Preschooler	6, (16.7)	21, (58.3)	9, (25.0)		
School-age child	10, (22.2)	27, (60.0)	8, (17.8)		
Teenager	5, (13.5)	29, (78.4)	3, (8.1)		
Breast milk intake n, (%)	30, (19.2)	92, (59.0)	34, (21.8)	X^2=2.72 Cramer's V=00.15	p=0.222
Use of additional vitamins n, (%)	6, (9.7)	37, (59.7)	19, (30.6)	X^2=8.71 Cramer's V=0.23	**p=0.01**
Taking oral supplements n, (%)	7 (11.1)	37, (58.7)	19, (30.2)	X^2=7.23 Cramer's V=0.21	**p=0.02**
Chronic disease n, (%)	2 (3.2)	43, (69.4)	17, (27.4)	X^2=18.23 Cramer's V=0.31	**p<0.01**
Type of surgery n, (%)				X^2=23.40 Cramer's V=0.27	**p<0.01**
Abdominal surgery	7, (10.0)	48, (68.6)	15, (21.4)		
Thorax surgery	5, (11.6)	22, (51.2)	16, (37.2)		
Genitourinary surgery	18, (36.7)	28, (57.1)	3, (6.1)		
Child's age (years)*	6.29±4.62	7.80±4.03	4.71±4.01	F^{****}=5.58 II<III	**p<0.01**
Duration of breastfeeding (months)*	15.23±10.21	9.31±8.05	7.23±1.11	F=8.376 I<II	**p<0.01**
Time to start supplementary food (months)*	5.38±1.76	5.47±2.86	5.17±3.77	F=0.132	p=0.87
Preoperative length of hospital stays (days)*	1.60±1.06	3.95±4.15	9.20±11.84	F=12.93 I<III	**p<0.01**
Child's weight (z score) *	0.11±0.60	0.07±0.87	0.05±0.92	F=0.04	p=0.95
Child's height (z score) *	-0.10±0.72	0.05±0.84	0.12±0.82	F=0.66	p=0.51
Child's arm circumference (z score) *	0.09±0.80	-0.14±0.79	0.04±0.82	F=1.40	p=0.24
Child's abdominal circumference (z score) *	-0.04±0.85	-0.00±0.86	0.15±0.72	F=0.600	p=0.55
Preoperative hemoglobin (g/dL) *	12.18±0.91	12.06±2.09	10.81±1.67	F=6.54 I<III	**p<0.01**
Preoperative hematocrit (%) *	36.50±2.85	36.66±5.25	33.43±4.50	F=6.06 I<III	**p<0.01**
Preoperative albumin (g/dL) *	44.88±2.73	43.25±5.88	40.90±6.45	F=4.18 I<III	**p=0.01**
Preoperative C-Reactive Protein (mg/dL) *	2.18±2.90	15.81±30.44	23.24±43.41	F=3.80 I<III	**p=0.02**

*= data is given as mean± SD

X^{2***}= Pearson's chi-squared test

X^{2****}= Fisher's exact test, Cramér's V= effect size measurement for the chi-square test of independence

F^{*****}= ANOVA test

Row percentages were taken from chi-square tables.

and oral supplements were significantly higher in the medium and high-risk groups (p=0.01 and p=0.02, respectively). Children with chronic diseases were predominantly in the medium and high-risk categories (p<0.01), and the type of surgery was also significantly associated with nutrition risk (p<0.01). Furthermore, the length of hospital stay was significantly longer in the high-risk group (p<0.01). Preoperative laboratory values, including hemoglobin, hematocrit, and albumin levels, were significantly lower in the high-risk group (p<0.01, p<0.01, and p=0.01, respectively), indicating a potential link between nutritional risk and preoperative health status. Additionally, C-reactive protein levels were significantly higher in the high-risk group (p=0.02), suggesting a possible inflammatory response associated with higher nutritional risk.

Table 3 examines maternal demographic variables about STRONGkids nutrition risk groups. Although maternal education level and employment status varied across risk groups, the differences were insignificant (p=0.13 and p=0.18, respectively). However, maternal feeding attitude was significantly associated with nutrition risk, with mothers of children in higher-risk groups showing a more negative feeding attitude (p<0.01). Similarly, the high-risk group's negative mood during meals and reactions to

Table 3. Analysis of maternal demographic variables according to STRONGkids nutrition screening tool risk groups (n=162)

Mother-related variables	STRONGkids Nutrition Screening Tool Risk Grouping			Test statistics	p-value
	Low risk (I)	Medium risk (II)	High risk (III)		
Mother's education level n, (%)				X^{2**}=7.00 Cramer's V=0.14	p=0.13
Primary education	5, (15.2)	45, (68.2)	11, (16.7)		
Secondary education	9, (15.8)	31, (54.4)	17, (29.4)		
High education	11, (28.2)	22, (56.4)	6, (15.4)		
Mother's working status n, (%)				X^2=3.37-8 Cramer's V=0.14	p=0.18
Working	9, (22.0)	20, (48.8)	12, (29.3)		
Not working	21, (17.4)	78, (64.5)	22, (18.2)		
Maternal age*	35.63±5.76	36.50±7.39	32.82±6.35	F***=3.56	p=0.10
Maternal feeding process attitude*	52.20±18.21	61.11±2.12	68.17±19.78	F=4.93 I<II I<III	**p<0.01**
Negative mood during meals*	9.60±6.00	13.81±7.41	16.14±7.90	F=6.64 I<II I<III	**p=0.02**
Attitude towards inadequate/unbalanced nutrition*	22.23±10.03	23.87±8.67	25.94±7.62	F=12.46	p=0.23
Negative nutritional strategies*	9.30±4.25	9.42±4.56	10.85±4.73	F=1.27	p=0.28
Force feeding*	4.80±1.58	5.61±3.19	6.11±3.11	F=1.62	p=0.20
Reacting to others' opinions*	6.26±3.19	8.37±4.59	9.11±4.61	F=3.74 I<II I<III	**p=0.02**

*= data is given as mean± SD
X^{2**}= Pearson's chi-squared test, Cramér's V= effect size measurement for the chi-square test of independence
F***= ANOVA test
Row percentages were taken from chi-square tables.

others' opinions about feeding were significantly higher (p=0.02).

Table 4 presents a binary logistic regression analysis examining factors predicting pediatric surgery patients' preoperative nutritional risk. The model, which included significant variables from Tables 1 and 2, correctly predicted nutritional risk status with an accuracy of 79.0% (Nagelkerke R^2 = 0.39, p<0.001). According to the regression analysis results, thoracic surgery patients had a 3.16-fold higher nutritional risk than abdominal surgery and genitourinary surgery patients. A one-unit increase in the child's age increased the nutritional risk by 0.86 times. Increasing the day of hospitalization by one day increased the risk of high nutritional risk by 1.11 times. Gender, vitamin use, chronic diseases, and other parameters did not make a difference regarding high risk (Table 4).

Discussion

The results of this study provide critical insight into the factors that influence preoperative nutritional risk in pediatric surgical patients. Using the STRONGkids Nutrition Screening Tool, several pediatric and maternal factors were analyzed to determine their impact on nutritional status.

This study highlights the variability in nutritional assessment depending on the classification method used. The Gomez and Waterlow classifications identified a higher proportion of children as normal. In contrast, the WHO (z-score) classification identified more cases of malnutrition. Moreover, since the WHO classification is independent of age, it demonstrated higher sensitivity, detecting more malnutrition cases, with approximately a quarter of the children classified as wasted. These

Table 4. Investigation of factors predictive of nutritional status in children before surgery (n=162).

	RR	95% C.I. for EXP(B)		Sig. – p
		Lower	Upper	
Gender	0.40	0.14	0.07	0.07
Use of additional vitamins	0.58	0.19	0.32	0.32
Taking oral supplements	0.85	0.31	0.76	0.76
Chronic disease	0.81	0.31	0.67	0.67
Type of surgery	3.16	1.14	**0.02**	**0.02**
Child's age (years)	0.86	0.76	**0.001**	**0.001**
Duration of breastfeeding (months)	0.97	0.91	0.51	0.51
Preoperative length of hospital stay (days)	1.11	1.01	**0.02**	**0.02**
Preoperative hemoglobin (g/dL)	0.78	0.49	0.29	0.29
Preoperative hematocrit (%)	0.98	0.80	0.86	0.86
Preoperative albumin (g/dL)	1.004	0.91	0.93	0.93
Preoperative C-Reactive Protein (mg/dL)	1.008	0.99	0.26	0.26
Maternal feeding process attitude	1.01	0.97	0.38	0.38
Negative mood during meals	0.99	0.89	0.85	0.85
Reacting to others' opinions	0.97	0.85	0.76	0.76
Constant	5.74		0.41	0.41

Nagelkerke R2: 0.39, p<0.001
The rate at which the model correctly predicts psychological distress: 79.0%
RR= Relative Ratio

differences suggest that reliance on a single method may lead to misclassification. In a study examining the malnutrition status of hospitalized children, 25% of children had a z-score index of less than -2 during hospitalization, and based on the measurements taken, 17.5% (10% moderate malnutrition; 7.5% of children were malnourished during hospitalization according to the Gomez malnutrition classification system. According to the Waterlow classification system, 20% of children were acutely malnourished during hospitalization.[32] A combined approach using multiple assessments may provide a more accurate nutritional risk assessment in pediatric surgical patients and help guide appropriate preoperative interventions.

This study found that gender, use of vitamin supplements, oral supplements, chronic diseases, type of surgery, child's age, duration of breastfeeding, preoperative hospital stay, and laboratory findings significantly affected the nutritional levels measured with STRONGKids in pediatric surgical patients. Similar to our study, these factors have been shown in the literature to affect nutritional levels in children negatively.[11,33,34] The lack of effect of maternal education and work status on nutritional risk was surprising. Maternal nutritional attitudes, such as unpleasant moods during meals and reactions to others' nutritional suggestions, were significantly associated with higher-risk groups. According to one study, family type and children's age-appropriate BMI influenced parental attitudes. Mothers with prominent families had higher negative attitude scores and age-related BMI. Mothers of children with eating problems were more negative.[8] In another study, nutrition education increased children's average weight by 331.42 grams.[9] It is thought that mothers' psychological and behavioral characteristics influence children's nutrition. Learning about healthy eating and reducing stress during meals may improve mothers' nutrition.

When the study examined the factors that predicted the risk of malnutrition, the notable finding was that the type of surgery significantly affected the nutritional risk. Children who underwent thoracic surgery had a 3.16 times higher risk than those who underwent abdominal or genitourinary surgery. Thoracic surgery requiring significant respiratory care has increased metabolic demand and nutritional sensitivity. Recent studies have shown that nutrition affects outcomes in pediatric thoracic surgery. Stunting increases postoperative complications in children undergoing abdominal or thoracic surgery.[2] Acute malnutrition was present in 42% of Russian children admitted to thoracic surgery units, and 70% of them were at high risk.6 Anton-Martin et al. (2018) reported that underweight children supported by ECMO had a higher in-hospital mortality rate than normal-weight children using multiple logistic regression.[3] According to our research, malnutrition affects postoperative outcomes, and the type of surgery affects nutritional risk. Children undergoing high-risk surgery, such as thoracic surgery, require preoperative nutritional screening and special treatment. Child age was another predictor of malnutrition. A one-unit increase in the child's age increased the nutritional risk by 0.86 times. This result differs from the literature[10,11,35] although older children may be at higher risk due to longer exposure to chronic diseases, more difficult surgical treatments, or inadequate preoperative nutrition. Preoperative length of hospital stay was another significant predictor of malnutrition. Hospitalization increased the risk of malnutrition by 1.11 times per day, and the risk of malnutrition increased with increasing preoperative hospital stay. Inadequate oral intake and preoperative surgical stress in the hospital may have contributed to this situation. Studies have reported that malnourished patients have longer hospital stays.[4,5] These parameters are considered necessary in the preoperative nutritional evaluation of pediatric surgical patients.

Limitation

The children's wide age range may have influenced nutritional evaluation. As children age, their metabolic needs and responses to catabolic stressors may vary, potentially affecting their nutritional status differently. To address this variability, nutritional assessments were stratified according to age groups. The study was conducted in a pediatric surgery inpatient clinic of a tertiary university hospital by the ASA preoperative nutrition guidelines, and therefore, nutritional deficiencies may have been lower. In this respect, it may not reflect the Turkish sample.

Conclusion

This study highlights the critical role of preoperative nutritional status in pediatric surgery. It also highlights the changing sensitivity of nutritional assessment methods; the WHO (z-score) classification detects more cases of malnutrition than Gomez and Waterlow. Malnutrition significantly affects surgical outcomes, recovery times, and overall health, and a significant proportion of hospitalized children are at risk, particularly

those undergoing thoracic surgery. Key determinants of nutritional risk include prolonged hospital stay, age, and maternal attitudes towards nutrition. Negative maternal attitudes towards feeding have been associated with poorer feeding outcomes. This study highlights the need for early nutritional assessments and interventions to reduce malnutrition risks, especially in high-risk surgical populations, to improve postoperative recovery and long-term health outcomes. Future research should focus on expanding the understanding of nutritional risk factors in diverse pediatric populations to further improve preoperative care protocols.

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Ethical approval

This study has been approved by the Non-Interventional Ethics Committee of Dokuz Eylul University (approval date 16.02.2022, number 2022/06-13). Written informed consent was obtained from the participants.

Author contribution

The authors declare contribution to the paper as follows: Study conception and design: NGÖÖ, EAK, FV; data collection: NGÖÖ, EAK; analysis and interpretation of results: NGÖÖ, EAK; draft manuscript preparation: NGÖÖ, EAK, FV. All authors reviewed the results and approved the final version of the article.

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The authors declare that there is no conflict of interest.

References

1. Canada NL, Mullins L, Pearo B, Spoede E. Optimizing perioperative nutrition in pediatric populations. *Nutr Clin Pract*. 2016;31:49-58. **[Crossref]**
2. Alshehri A, Afshar K, Bedford J, Hintz G, Skarsgard ED. The relationship between preoperative nutritional state and adverse outcome following abdominal and thoracic surgery in children: results from the NSQIP database. *J Pediatr Surg*. 2018;53:1046-1051. **[Crossref]**
3. Anton-Martin P, Papacostas M, Lee E, Nakonezny PA, Green ML. Underweight status is an independent predictor of in-hospital mortality in pediatric patients on extracorporeal membrane oxygenation. *JPEN J Parenter Enteral Nutr*. 2018;42:104-111. **[Crossref]**
4. Allard JP, Keller H, Jeejeebhoy KN, et al. Malnutrition at hospital admission-contributors and effect on Length of Stay: a Prospective Cohort Study From the Canadian malnutrition task force. *JPEN J Parenter Enteral Nutr*. 2016;40:487-497. **[Crossref]**
5. Nigatu YD, Gebreyesus SH, Allard JP, Endris BS. The effect of malnutrition at admission on length of hospital stay among adult patients in developing country: a prospective cohort study. *Clin Nutr ESPEN*. 2021;41:217-224. **[Crossref]**
6. Fomina MV, Borovik TE, Yatsyk SP, et al. Assessment of the nutritional status of children admitted to the thoracic surgical department. *Pediatrics (Consilium Medicum)*. 2023;1:86-94. **[Crossref]**
7. Fışkın G, Ölçer Z. The relationship between mothers' feeding behaviors and their children's attitudes towards the feeding process. *Online Turkish Journal of Health Sciences*. 2022;7:53-61. **[Crossref]**
8. Bayindir-Gümüş A, Yardimci H, Koç N, Sezer E, Kara-Uzun A. Relationships between maternal feeding attitudes and child nutritional problems. *Nurs Health Sci*. 2024;26:e70015. **[Crossref]**
9. Nafista UF, Nurhaeni N, Waluyanti FT. Improvement in maternal knowledge, attitudes, and children's weight with education on World Health Organization feeding recommendations. *Pediatr Med Chir*. 2023;45:10.4081/pmc.2023.314. **[Crossref]**
10. Koofy NE, Eldin HMN, Mohamed W, et al. Impact of preoperative nutritional status on surgical outcomes in patients with pediatric gastrointestinal surgery. *Clin Exp Pediatr*. 2021;64:473-479. **[Crossref]**
11. Ross F, Latham G, Joffe D, et al. Preoperative malnutrition is associated with increased mortality and adverse outcomes after paediatric cardiac surgery. *Cardiol Young*. 2017;27:1716-1725. **[Crossref]**

12. Hulst JM, Zwart H, Hop WC, Joosten KF. Dutch national survey to test the STRONGkids nutritional risk screening tool in hospitalized children. *Clin Nutr*. 2010;29:106-111. **[Crossref]**

13. Gómez F, Ramos Galvan R, Frenk S, et al. Mortality in second and third degree malnutrition. 1956. *Bull World Health Organ*. 2000;78:1275-1280.

14. Waterlow JC. Classification and definition of protein-calorie malnutrition. *Br Med J*. 1972;3:566-569. **[Crossref]**

15. World Health Organization (WHO). Child growth standards. Available at: https://www.who.int/tools/child-growth-standards (Accessed on Feb 20, 2025).

16. World Health Organization (WHO). Physical status: the use and interpretation of anthropometry. Report of the WHO Expert Committee. *World Health Organ Tech Rep Ser*. 1995;854:1-452.

17. Kang H. Sample size determination and power analysis using the G*Power software. *J Educ Eval Health Prof*. 2021;18:17. **[Crossref]**

18. Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed. New York, NY: Routledge; 1988.

19. Durakbaşa ÇU, Fettahoğlu S, Bayar A, Mutus M, Okur H. The Prevalence of malnutrition and effectiveness of STRONGkids Tool in the identification of malnutrition risks among pediatric surgical patients. *Balkan Med J*. 2014;31:313-321. **[Crossref]**

20. Pars H, Açıkgöz A, Erdoğan BD. Validity and reliability of the Turkish version of three screening tools (PYMS, STAMP, and STRONG-kids) in hospitalized children. *Clin Nutr ESPEN*. 2020;39:96-103. **[Crossref]**

21. Menzies J, Hughes J, Leach S, Belessis Y, Krishnan U. Prevalence of malnutrition and feeding difficulties in children with Esophageal Atresia. *J Pediatr gastroenterol nutr*. 2017;64:e100-e105. **[Crossref]**

22. Park JE, Chung KS, Song JH, et al. The C-reactive protein/albumin ratio as a predictor of mortality in critically ill patients. *J Clin Med*. 2018;7:333. **[Crossref]**

23. Pan L, Liu Y, Feng Y, et al. Nutrition risk profile of 62 408 inpatients based on electronic health records in a tertiary children's hospital. *Nutrition*. 2021;85:111137. **[Crossref]**

24. Dilsiz H, Dağ İ. Mother's attitudes towards the feeding process scale: development, validity, and reliability study. *Turkish Journal of Pediatric Disease*. 2020;14:7-15. **[Crossref]**

25. Hulst JM, Huysentruyt K, Gerasimidis K, et al. A practical approach to identifying pediatric disease-associated undernutrition: a position statement from the ESPGHAN special interest group on clinical malnutrition. *J Pediatr Gastroenterol Nutr*. 2022;74:693-705. **[Crossref]**

26. Oruçoğlu B, İnanç N. Assessment of the STRONGkids screening tool: a cross-sectional study in Turkish children. *Clinical Science of Nutrition*. 2020;2:35-42. **[Crossref]**

27. Santos CA, Rosa CD, Franceschini SD, Firmino HH, Ribeiro AQ. Usefulness of the strongKids screening tool in detecting anemia and inflammation in hospitalized pediatric patients. *J Am Coll Nutr*. 2021;40:155-163. **[Crossref]**

28. Carter LE, Shoyele G, Southon S, et al. Screening for pediatric malnutrition at hospital admission: which screening tool is best? *Nutr Clin Pract*. 2020;35:951-958. **[Crossref]**

29. Galera-Martínez R, Moráis-López A, Rivero de la Rosa MD, et al. Reproducibility and inter-rater reliability of 2 paediatric nutritional screening tools. *J Pediatr Gastroenterol Nutr*. 2017;64:e65-e70. **[Crossref]**

30. Mishra P, Pandey CM, Singh U, et al. Descriptive statistics and normality tests for statistical data. *Ann Card Anaesth*. 2019;22:67-72. **[Crossref]**

31. Hayran M, Hayran M, editors. Basic Statistics for Health Research. Ankara, Türkiye: Pelikan Publishing;2021.

32. Pars H, Kazancı H, Söylemez Bayram G. Evaluation of malnutrition development in hospitalized children. *Journal of Hacettepe University Faculty of Nursing*. 2020;7:15-22. **[Crossref]**

33. Katoch OR. Determinants of malnutrition among children: a systematic review. *Nutrition*. 2022;96:111565. **[Crossref]**

34. Amoadu M, Abraham SA, Adams AK, et al. Risk factors of malnutrition among in-school children and adolescents in developing countries: a scoping review. *Children (Basel)*. 2024;11:476. **[Crossref]**

35. Wondemagegnehu BD, Aklilu WK, Beyene MD, Nonyane BAS. Impact of malnutrition on the outcome and length of hospital stay in elective pediatric surgical patients: prospective cohort study at tertiary hospitals in Ethiopia. *BMC Nutr*. 2023;9:127. **[Crossref]**

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Evaluation of malnutrition risk among adult patients admitted to the emergency department: a cross-sectional study

Emre Duman[1], Alev Keser[2], İlknur Kepenekçi Bayram[3], Onur Polat[4], Nurcan Yabanci Ayhan[2], Pınar Sonyürek Arı[5]

[1]Department of Nutrition and Dietetics, Faculty of Health Sciences, Siirt University, Siirt, Türkiye
[2]Department of Nutrition and Dietetics, Faculty of Health Sciences, Ankara University, Ankara, Türkiye
[3]Department of General Surgery, Faculty of Medicine, Ankara University, Ankara, Türkiye
[4]Department of Emergency Medicine, Faculty of Medicine, Ankara University, Ankara, Türkiye
[5]Department of Clinical Nutrition, Faculty of Medicine, Ankara University, Ankara, Türkiye

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ABSTRACT

Objective: This study aimed to identify demographic characteristics associated with nutritional risk and evaluate the prevalence and severity of malnutrition among adult patients admitted to the emergency department.

Methods: This cross-sectional study included 187 adult emergency department patients with stable vital signs and a Glasgow Coma Scale score greater than 13. Malnutrition risk and status were assessed using the Nutritional Risk Screening-2002 (NRS-2002) and Subjective Global Assessment (SGA) within the first 24 hours of hospital admission. Data were collected through structured bedside interviews.

Results: According to NRS-2002, 24.6% of patients were at risk for malnutrition, while SGA identified moderate malnutrition in 41.3% (SGA-B) and severe malnutrition in 39.1% (SGA-C) of cases. Binary logistic regression analysis showed that increasing age was significantly associated with nutritional risk (OR=1.032; 95% CI: 1.008–1.056; p=.008). Gender and reason for emergency admission did not reach statistical significance.

Conclusion: This study highlights that malnutrition risk is substantial among emergency department patients and significantly associated with increasing age. These findings emphasize the importance of incorporating systematic nutritional screening protocols at emergency admission, particularly in older adults, to ensure timely dietetic assessment and optimize clinical outcomes.

Keywords: clinical nutrition, emergency department, malnutrition, nutritional risk screening

Introduction

Malnutrition is a universal public health problem that can be seen all over the world at all ages and is also an impediment to global poverty eradication, productivity, and economic growth.[1] This perspective is further supported by the World Health Organization, which emphasizes the serious and enduring consequences of the global malnutrition problem on individuals, families, communities, and nations, including developmental, economic, social, and medical impacts.[2]

Corresponding author: Alev Keser
Email: akeser@ankara.edu.tr

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The term "malnutrition" includes a range of conditions characterized by a lack, excess, or imbalance of various essential nutrients, which can result in negative impacts on the body's composition, functioning, and clinical outcomes.[3] While it is possible for malnourished individuals to experience either undernutrition or overnutrition, the term "malnutrition" is frequently used interchangeably with "undernutrition".

Malnutrition is an under-recognized and undertreated condition that affects 30–50% of hospitalized patients.[3,4] A research investigation was conducted in Türkiye involving a total of 34 hospitals located in 19 cities, with a sample size of 29,139 patients. The study revealed that 15% of the patients exhibited signs of nutritional risk. The prevalence of nutritional risk was found to be highest among patients in the intensive care unit, with a rate of 52%. Additionally, a notable proportion of patients in the internal medicine department, specifically 16.4%, were identified as malnourished. The study results showed that a mere 51.8% of patients identified as having nutritional risk were provided with appropriate nutritional support.[5] More than one-third (36%) of patients experience malnutrition before hospital discharge, a condition that can be prevented, and the prevalence of malnutrition increases with the length of hospital stay.[6] This situation may occur as a result of diminished dietary consumption for a variety of reasons, including impaired absorption of macronutrients and/or micronutrients, heightened nutrient excretion, or modified metabolic requirements.[3] When a patient admitted to the hospital for any reason is malnourished or in a state of disease, extensive changes occur in physiological function, which negatively affects the success of the treatment, prolongs the recovery period, catabolic metabolism, chronic low-grade inflammation, hospital stay, increases the risk of developing nosocomial infections, and causes increased rates of morbidity and mortality.[3,7]

Main Points

- Approximately one in four adult patients presenting to our tertiary emergency department (ED) were at nutritional risk according to NRS-2002 (≥3).
- Logistic regression analysis identified increasing age as a statistically significant independent predictor of nutritional risk.
- Emergency admissions due to respiratory, neurological, gastrointestinal, or infectious diseases were not significantly associated with increased nutritional risk in this cohort.
- The model demonstrated good fit and modest predictive strength.
- These findings support routine use of nutritional screening tools like NRS-2002 in emergency departments, particularly for elderly patients, to enable early dietetic intervention and potentially improve patient outcomes.

In the malnutrition screenings performed on hospitalized patients in the world and in Türkiye, it has been shown that the frequency of malnutrition is higher in some clinics such as oncology, pulmonology, geriatrics, surgery, and intensive care units, and these clinics are evaluated as risky clinics in terms of malnutrition.[5,8,9] Although emergency services are not included in these malnutrition screening studies, there are some studies in the literature in recent years emphasizing the frequency of malnutrition and its negative effects, especially in elderly patients who applied to the emergency department.[10–12] In a limited number of studies examining the prevalence of malnutrition among adults presenting to emergency services, the prevalence ranged from 15 to 29%, particularly among elderly patients.[12–14] Malnutrition screening is generally not performed on individuals who apply to the emergency department. However, screening for malnutrition in the emergency department can capture a vulnerable population that may be overlooked.[10]

The prevention and potential reversal of malnutrition can be achieved through the timely and sufficient implementation of nutritional therapy. Nevertheless, it is imperative to enhance the awareness and knowledge of healthcare providers, while also establishing clinical protocols, to effectively identify and address this issue.[15] The identification of malnutrition has been proposed by the European Society for Clinical Nutrition and Metabolism (ESPEN) through a two-step methodology. The initial step entails utilizing a validated screening instrument, such as the Nutritional Risk Screening 2002 (NRS-2002), to evaluate the probability of malnutrition in individuals. Following that, a thorough assessment is performed utilizing the Subjective Global Assessment (SGA) in order to validate the diagnosis of malnutrition. Given that these tests do not necessitate any form of analysis, it can be inferred that there are no supplementary expenses involved.[16] Following the assessment of an individual's nutritional status, the provision of nutritional support should be administered by the dedicated nutritional support team, if deemed necessary. Nevertheless, there is a dearth of hospitals equipped with nutritional support teams, and their ability to offer emergency services is typically lacking.[17]

The aim of the research is to determine the prevalence of malnutrition among adult patients who are admitted to the emergency department. Additionally, the study aims to identify the specific patient population that is particularly susceptible to malnutrition as well as evaluate the severity of malnutrition in patients who are diagnosed with this condition. The research results suggest that there is a need for increasing awareness about the evaluation of nutritional status among patients admitted to the emergency department.

Methods

Study design and setting

This descriptive, cross-sectional study aimed to evaluate malnutrition status among adult patients admitted to the Ankara University Ibn-i Sina Hospital Emergency Department. The study included all adult patients (aged ≥18 years) presenting to the emergency department over one week. Patients were recruited consecutively throughout the week (24 hours/day) to ensure comprehensive inclusion.

Selection of participants

Detailed patient information was obtained from hospital patient files and interviews conducted with patients or their relatives. Patients with unstable vital functions, those who were uncooperative, disoriented, or had a Glasgow Coma Scale ≤13 were excluded due to potential unreliability in obtaining accurate information and difficulties in performing nutritional assessments. Eligible patients were informed about the research, and written informed consent was obtained from those agreeing to participate. A total of 187 adult patients who met these inclusion criteria and agreed to participate constituted the study sample. The study was conducted in March 2016. The flowchart illustrating the patient selection process is presented in Figure 1.

Sample size estimation

The sample size was evaluated retrospectively with G*Power version 3.1.9.7, indicating that with an effect size of 0.3 (medium), an alpha level of 0.05, and a statistical power of 0.80, the required minimum sample size was 143 patients. Therefore, the recruited sample of 187 patients is considered adequate for statistical reliability.

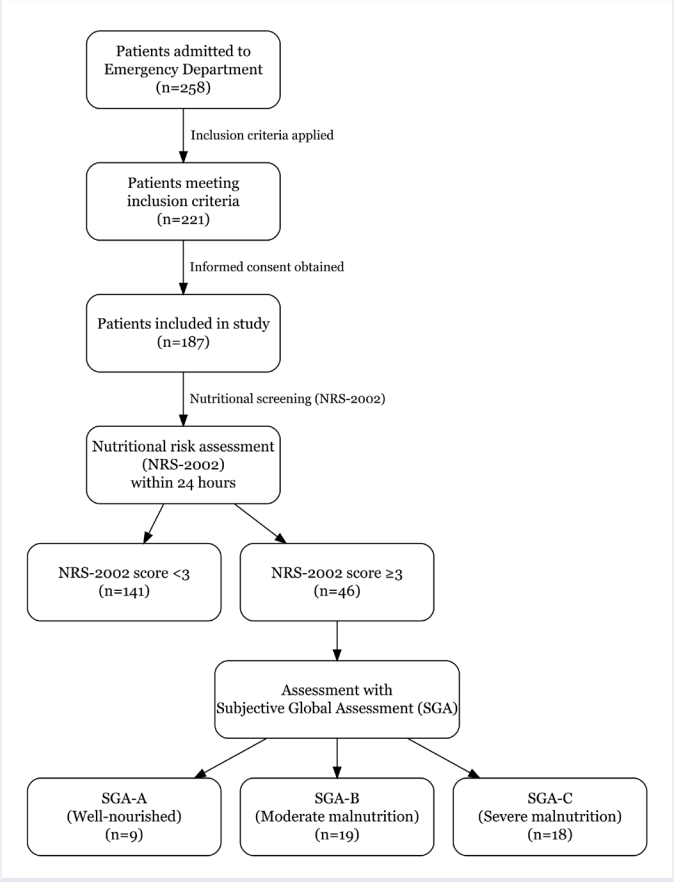

Figure 1. Flowchart illustrating patient selection, NRS-2002, and SGA procedures

Methods and measurements

Data related to patient demographics (age, gender), reasons for emergency department visits, and comorbid conditions were collected through structured bedside interviews. Interviews were performed either directly with patients or, if necessary, their relatives. Weight change during the preceding three months was recorded as (a) documented weight in electronic medical records when available or (b) patient/relative self-report; only unintentional loss >5% body weight was accepted as clinically significant. Patients' nutritional status data were collected using validated nutritional assessment tools (NRS-2002 and SGA).

The NRS-2002 and SGA questionnaires were used to assess each patient's nutritional status and nutritional risk within the first 24 hours after admission. An ad hoc working group developed the NRS-2002 for the purpose of determining a person's nutritional status, and the ESPEN was in charge of the group.[18] This nutritional tool

has been proven to have the capacity to correctly identify patient populations that stand to gain the greatest advantages from receiving nutritional support. It is necessary to begin by adding the "Nutritional Score" (0–3) to the "Severity of Disease Score" (0–3) before moving on to the next step of the calculation for the nutritional risk score. Patients who are 70 or older receive a score of 1, regardless of their gender. The highest possible score is seven. Per ESPEN guidance, an NRS-2002 total score ≥3 denotes nutritional risk warranting further assessment and intervention. Accordingly, patients who scored ≥3 proceeded to SGA for malnutrition grading, whereas those with a score <3 were considered low risk and did not undergo further nutritional assessment.

The Subjective Global Assessment (SGA) is a tool for nutritional assessment that was first introduced in 1982[19], and it has since been validated by controlled clinical trials.[20,21] SGA is defined by the presence of five clinically significant characteristics related to nutritional status. These characteristics include decreased nutrient intake, inadvertent weight loss, oral intake-related symptoms, functional capacity, and metabolic demand. A physical examination is also part of the SGA, and during this examination, particular attention is paid to fluid accumulation, muscle atrophy, and subcutaneous fat loss. Individuals are either considered to be severely malnourished (SGA-C), mildly or moderately malnourished (SGA-B), or well-nourished (SGA-A).

Statistical analysis

IBM SPSS Statistics 22 (IBM Corp., Armonk, NY, USA) was used to analyze the study data. The Kolmogorov-Smirnov test was utilized to check the normal distribution of the variables. Categorical variables were examined using the Chi-squared (χ^2) test and presented as frequency distributions. Binary logistic regression analysis was conducted to identify factors independently associated with nutritional risk (NRS-2002 ≥3 as the dependent categorical variable). The confidence interval was set at 95%, with a significance level of $p<.05$ in all statistical tests.

Ethical approval

Ethical approval for the study was obtained from the Ankara University Faculty of Medicine Clinical Research Ethics Committee (approval date May 11, 2015, number 08-344-15). At the beginning of the study, all participants provided informed consent by signing a consent form before participating in the study. The study was conducted following the principles outlined in the Declaration of Helsinki.

Results

The study comprised 187 patients in total, of which 52.4% were female and 47.6% were male. Of the patients, most (50.8%) were older than 65. In the previous three months, 25.1% of the patients had experienced weight loss. The majority (31.6%) of applications to the emergency room were for respiratory disorders. According to data obtained with the NRS-2002, 24.6% (n=46) of individuals were at risk of malnutrition. Among these 46 high-risk patients who underwent further assessment using the SGA tool, 41.3% were classified as moderately malnourished (SGA-B) and 39.1% as severely malnourished (SGA-C) (Table 1).

Table 2 shows the relationship between nutritional assessment scores (NRS-2002 and SGA) and demographic characteristics of the patients admitted to the emergency department. Patients aged ≥65 years were significantly more likely to have higher nutritional risk scores (NRS-2002 ≥3: 67.4%; p=.01) and severe malnutrition (SGA-C: 61.1%; p=.005). Similarly, recent weight loss within the last three months was strongly associated with increased nutritional risk (NRS-2002 ≥3: 72.3%; p<.001) and severe malnutrition (SGA-C: 72.2%; p<.001). However, no statistically significant association was found between nutritional assessment scores (NRS-2002 or SGA) and gender or reasons for emergency department admission (p>.05).

Binary logistic regression analysis revealed that increasing age was significantly associated with nutritional risk (NRS-2002 ≥3) (OR=1.032; 95% CI: 1.008–1.056, p=.008). Gender and reasons for admission to the emergency department did not demonstrate statistically significant associations (p>.05). The overall regression model was statistically significant (χ^2=17.879, df=6, p=.007), demonstrated good fit (Hosmer–Lemeshow χ^2=11.795, p=.161), and explained 13.6% of the variance in nutritional risk (Nagelkerke R^2=.136) (Table 3).

Discussion

The results of this study highlight a significant prevalence of nutritional risk among adult patients admitted to the emergency department, with notable implications for clinical practice and healthcare management. Using

Table 1. Demographic characteristics of patients (n=187)

Characteristics	n	%
Gender		
Male	89	47.6
Female	98	52.4
Age (year)		
19-64	92	49.2
≥65	95	50.8
Weight loss in the last 3 months		
Yes	47	25.1
No	140	74.9
Reasons for application to emergency department		
Respiratory diseases	59	31.6
Neurological diseases	28	15.0
Gastrointestinal diseases	27	14.4
Infections	10	5.3
Other medical conditions*	63	33.7
NRS-2002 Score		
Score ≥3	46	24.6
Score <3	141	75.4
SGA Score *(applied only to NRS-2002 ≥3 patients; n=46)*		
SGA-A	9	19.6
SGA-B	19	41.3
SGA-C	18	39.1

SGA evaluated only in NRS-2002 ≥3 group. Due to low frequencies, cardiovascular, endocrine, hematological, cancer, bone diseases, liver diseases, urinary system diseases, suicide, swelling, lassitude, and ear, nose, and throat diseases were merged under the category of "other medical conditions".

the NRS-2002, 24.6% of all patients were classified as nutritionally at risk. Among the 46 patients with an NRS-2002 score ≥3 who subsequently underwent SGA, 19 (41.3%) were classified as moderate malnutrition (SGA-B) and 18 (39.1%) as severe malnutrition (SGA-C) (Table 1). These figures correspond to 10.2% and 9.6% of the entire study population, respectively. Thus, the apparently higher SGA percentages merely reflect the distribution within the high-risk subgroup rather than the whole cohort. Although the absolute prevalence estimates differ because the two tools were applied to different denominators, both instruments consistently identify a sizeable malnourished population, underscoring the need for standardized and sequential screening approaches in emergency-care settings.[22]

The prevalence of nutritional risk identified in this study aligns closely with findings from international studies, emphasizing a universal healthcare concern. Previous research conducted in emergency department populations has consistently demonstrated significant malnutrition risks, especially among elderly cohorts. For instance, a study conducted in Ireland reported malnutrition in 7.6% of elderly patients, with an additional 28% identified as being at nutritional risk.[10] Similarly, evidence from the United States indicated a rising trend in the prevalence of malnutrition among older emergency department visitors, emphasizing the increasing importance of addressing malnutrition as a public health priority.[23]

Advanced age was significantly associated with increased nutritional risk (OR=1.032; 95% CI: 1.008–1.056; p=.008) (Table 3). This result is consistent with extensive literature documenting the vulnerability of elderly populations to nutritional deficiencies due to physiological changes, polypharmacy, chronic illnesses, and socioeconomic factors such as social isolation and economic instability.[24] Therefore, routine nutritional screening and targeted interventions for elderly patients in emergency departments are crucial for improving clinical outcomes and reducing healthcare costs associated with malnutrition.

Interestingly, neither gender nor reasons for emergency admission demonstrated a significant association with nutritional risk in our cohort (p>.05) (Table 3). In contrast to our findings, the study by Ratsavong et al.[25] suggests that gender differences and specific admission reasons are influential determinants of nutritional status. The absence of significant associations in our study may reflect the heterogeneity in clinical presentations and demographic compositions of emergency populations, highlighting the necessity for further context-specific research to clarify these relationships.

In our cohort, respiratory disorders were the most common reason for emergency department visits (31.6%), consistent with prior literature highlighting the high acute care burden of pulmonary conditions. Although respiratory diseases did not emerge as statistically significant predictors of nutritional risk in the multivariate model, their clinical relevance remains noteworthy. Chronic respiratory illnesses such as chronic obstructive

Table 2. The relationship between nutritional assessment scores (NRS-2002 and SGA) and demographic characteristics

Characteristics	NRS-2002 Score (n=187)				p	SGA Score (n=46)						p
	Score ≥3		Score <3			SGA-A		SGA-B		SGA-C		
	n	%	n	%		n	%	n	%	n	%	
Gender												
Male	19 (21.9)	41.3	70 (67.1)	49.6	.396[α]	4 (4.3)	44.4	8 (9.0)	42.1	7 (8.6)	38.9	.789[α]
Female	27 (24.1)	58.7	71 (73.9)	50.4		5 (4.7)	55.6	11 (10.0)	57.9	11 (9.4)	61.1	
Age (year)												
19-64	15 (22.6)	32.6	77 (69.4)	54.6	**.010[α]**	2 (4.4)	22.2	3 (9.3)	15.8	10 (8.9)	55.6	**.005[α]**
≥65	31 (23.4)	67.4	64 (71.6)	45.4		7 (4.6)	77.8	16 (9.7)	84.2	8 (9.1)	44.4	
Weight loss in the last 3 months												
Yes	34 (11.6)	73.9	13 (35.4)	9.2	**<.001[β]**	7 (2.3)	77.8	14 (4.8)	73.7	13 (4.5)	72.2	**<.001[α]**
No	12 (34.4)	26.1	128 (105.6)	90.8		2 (6.7)	22.2	5 (14.2)	26.3	5 (13.5)	27.8	
Reasons for application to emergency department												
Respiratory diseases	14 (14.5)	30.5	45 (44.5)	31.9	.088[α]	3 (2.8)	33.4	7 (6.0)	36.8	4 (5.7)	22.2	.343[α]
Neurological diseases	3 (6.9)	6.5	25 (21.1)	17.7		- (1.3)	-	- (2.8)	-	3 (2.7)	16.7	
Gastrointestinal diseases	4 (6.6)	8.7	23 (20.4)	16.3		2 (1.3)	22.2	1 (2.7)	5.3	1 (2.6)	5.6	
Infections	3 (2.5)	6.5	7 (7.5)	5.0		1 (0.5)	11.1	1 (1.0)	5.3	1 (1.0)	5.6	
Other medical conditions[*]	22 (15.5)	47.8	41 (47.5)	29.1		3 (3.0)	33.3	10 (6.4)	52.6	9 (6.1)	50.0	
TOTAL	**46**	**100**	**141**	**100**		**9**	**100**	**19**	**100**	**18**	**100**	

Data are presented as observed counts (O), with expected counts (E) in parentheses: O (E). [*]Due to low frequencies, cardiovascular, endocrine, hematological, cancer, bone diseases, liver diseases, urinary system diseases, suicide, swelling, lassitude, and ear, nose, and throat diseases were merged under the category of "other medical conditions". [α]Pearson's Chi-squared (χ^2) test. [β]Fisher's exact test. $p<.05$.

pulmonary disease (COPD) are frequently associated with increased metabolic demands, systemic inflammation, and symptoms such as dyspnoea and anorexia, all of which contribute to nutritional depletion and muscle wasting. Additionally, COPD-related malnutrition has been linked to impaired respiratory muscle function, reduced fat-free mass, and diminished quality of life, reinforcing the importance of nutritional vigilance even in the absence of statistical associations.[26,27]

The clinical and economic consequences of malnutrition emphasize its importance as a healthcare priority. Malnutrition significantly increases morbidity and mortality, delays wound healing, and raises susceptibility to infections.[28,29] Additionally, malnutrition profoundly impacts healthcare systems by increasing hospital stays, higher readmission rates, and escalating healthcare costs. Previous systematic reviews and meta-analyses have consistently reported extended hospital stays and increased mortality among malnourished patients, further

Table 3. Factors associated with nutritional risk (NRS-2002 ≥3) in patients admitted to the emergency department

Variables	B	SE	Wald	p	Exp(B)	95% CI Exp(B)
Age	.032	.012	7.113	**.008**	1.032	1.008 – 1.056
Gender	.360	.360	.998	.318	1.433	.707 – 2.905
Reasons for application to emergency department	–	–	7.003	0.136	–	–
Respiratory diseases	-.712	.418	2.897	.089	.491	.216 – 1.114
Neurological diseases	-1.303	.682	3.653	.056	.272	.071 – 1.034
Gastrointestinal diseases	-1.026	.618	2.759	.097	.358	.107 – 1.203
Infections	.132	.786	.028	.867	1.141	.244 – 5.327
Other medical conditions	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.

Binary logistic regression analysis was performed. Dependent variable: Nutritional risk assessed by NRS-2002 (score ≥3 vs. <3). Nagelkerke R^2=.136; Overall model: χ^2=17.879, df=6, p<.007. Hosmer-Lemeshow test (χ^2=11.795, p=.161). p<.05 statistically significant. The "reasons for application to emergency department" row reflects the omnibus test of the categorical variable as a whole. "Other medical conditions" was used as the reference category.
B: regression coefficient; SE: standard error; OR (Exp(B)): odds ratio; CI: confidence interval.

reinforcing the need for robust nutritional management protocols in acute care settings.[30,31]

In light of these findings, the substantial prevalence of nutritional risk identified in this study calls for the systematic implementation of standardized nutritional screening protocols in emergency departments. Special attention should be directed toward elderly patients, particularly those who report recent unintentional weight loss during triage, even though weight loss did not remain an independent predictor in multivariate analysis. Comprehensive nutritional assessment strategies and timely, individualized nutritional interventions should become standard practices to enhance patient outcomes, optimize resource utilization, and ultimately improve the quality of emergency medical care.

Limitations

The study's cross-sectional design and relatively small sample size constitute key limitations; therefore, causal relationships between malnutrition and adverse clinical outcomes cannot be established. Although a post-hoc power calculation confirmed that the total sample (n=187) provided >80% power to detect the predefined medium effect for the primary outcome, the available numbers were insufficient for robust subgroup analyses (e.g., by specific admission diagnosis, gender, or weight-loss status). Consequently, estimates within these subgroups should be interpreted with caution and cannot be generalized beyond this cohort. In addition, being a single-center investigation limits the generalizability of the findings to other settings or broader patient populations. Reliance on self-reported data may also have introduced recall bias for certain variables. Data were collected in 2016; however, the absence of substantive changes in screening protocols since then limits the risk of temporal bias.

Nutritional assessment was restricted to two widely used tools (NRS-2002 and SGA); inclusion of additional instruments or biochemical markers might have yielded deeper insights into nutritional status. Although the NRS-2002 was originally developed for hospitalized patients, its application in emergency settings has been endorsed by ESPEN, particularly due to its ease of use and rapid applicability. However, the subjective nature of disease severity assessment within the NRS-2002 may introduce variability depending on clinical judgment and individual clinician experience, especially under emergency conditions.

Moreover, patients with severe cognitive impairment or life-threatening trauma were excluded for pragmatic reasons; this underrepresentation of the sickest cohort may have led to an underestimation of true malnutrition prevalence.

Finally, downstream clinical outcomes such as length of stay, readmission, or in-hospital mortality were not collected, preventing correlation of nutritional risk with hard endpoints; future prospective work should address this gap.

Despite these limitations, our results underscore the critical importance of systematic malnutrition screening in emergency departments, particularly for elderly patients, because early recognition and timely nutritional interventions can enhance outcomes and reduce complications.

Conclusion

Our findings corroborate prior ED studies by confirming a high malnutrition risk, particularly among older adults, in a Turkish tertiary centre. These findings highlight the importance of early nutritional screening and timely interventions in emergency department settings. As one of the few studies exploring nutritional risk in Turkish emergency departments, our results emphasize the need for increased awareness and widespread implementation of systematic nutritional assessments to mitigate adverse clinical outcomes associated with malnutrition. Future research should focus on developing effective interventions, including tailored nutritional counseling and support, to address malnutrition risks in emergency patients.

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Ethical approval

This study has been approved by the Ankara University Faculty of Medicine Clinical Research Ethics Committee (approval date May 11, 2015, number 08-344-15). Written informed consent was obtained from the participants.

Author contribution

The authors declare contribution to the paper as follows: Study conception and design: AK, İKB, OP, NYA, PSA; data collection: AK, OP, PSA; analysis and interpretation of results: ED, AK; draft manuscript preparation: ED, AK. All authors reviewed the results and approved the final version of the article.

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Conflict of interest

The authors declare that there is no conflict of interest.

References

1. Dukhi N. Global prevalence of malnutrition: evidence from literature. In: Imran M, Imran A, editors. Malnutrition. London: IntechOpen; 2020:1-16. [Crossref]
2. World Health Organization (WHO). Malnutrition. 2024. Available at: https://www.who.int/news-room/questions-and-answers/item/malnutrition(Accessed on Sep 28, 2024).
3. Saunders J, Smith T. Malnutrition: causes and consequences. *Clin Med (Lond)*. 2010;10:624-627. [Crossref]
4. Sauer AC, Goates S, Malone A, et al. Prevalence of malnutrition risk and the impact of nutrition risk on hospital outcomes: results from nutritionDay in the U.S. *JPEN J Parenter Enteral Nutr*. 2019;43:918-926. [Crossref]
5. Korfali G, Gündoğdu H, Aydintuğ S, et al. Nutritional risk of hospitalized patients in Turkey. *Clin Nutr*. 2009;28:533-537. [Crossref]
6. van Vliet IM, Gomes-Neto AW, de Jong MF, Jager-Wittenaar H, Navis GJ. High prevalence of malnutrition both on hospital admission and predischarge. *Nutrition*. 2020;77:110814. [Crossref]
7. Tang Z, Cai H, Cui Y. Influence of early postoperative feeding in gastrointestinal anastomotic fistula formation and healing time in rabbits. *Biomed Res Int*. 2018;2018:8258096. [Crossref]
8. Tangvik RJ, Tell GS, Guttormsen AB, et al. Nutritional risk profile in a university hospital population. *Clin Nutr*. 2015;34:705-711. [Crossref]
9. Güzel S, Keser A, Bayram İK. Risk of malnutrition in general surgical patients. *J Health Sci Med*. 2021;4:55-62. [Crossref]
10. Griffin A, O'Neill A, O'Connor M, et al. The prevalence of malnutrition and impact on patient outcomes among older adults presenting at an Irish emergency department: a secondary analysis of the OPTI-MEND trial. *BMC Geriatr*. 2020;20:455. [Crossref]
11. Vivanti A, Isenring E, Baumann S, et al. Emergency department malnutrition screening and support model improves outcomes in a pilot randomised controlled trial. *Emerg Med J*. 2015;32:180-183. [Crossref]
12. Gentile S, Lacroix O, Durand AC, et al. Malnutrition: a highly predictive risk factor of short-term mortality in elderly presenting to the emergency department. *J Nutr Health Aging*. 2013;17:290-294. [Crossref]

13. Pereira GF, Bulik CM, Weaver MA, Holland WC, Platts-Mills TF. Malnutrition among cognitively intact, noncritically ill older adults in the emergency department. *Ann Emerg Med*. 2015;65:85-91. **[Crossref]**

14. Andersen AL, Nielsen RL, Houlind MB, et al. Risk of malnutrition upon admission and after discharge in acutely admitted older medical patients: a prospective observational study. *Nutrients*. 2021;13:2757. **[Crossref]**

15. Reber E, Gomes F, Vasiloglou MF, Schuetz P, Stanga Z. Nutritional risk screening and assessment. *J Clin Med*. 2019;8:1065. **[Crossref]**

16. Cederholm T, Bosaeus I, Barazzoni R, et al. Diagnostic criteria for malnutrition - an ESPEN consensus statement. *Clin Nutr*. 2015;34:335-340. **[Crossref]**

17. A.S.P.E.N. Practice Management Task Force , Delegge M, Wooley JA, et al. The state of nutrition support teams and update on current models for providing nutrition support therapy to patients. *Nutr Clin Pract*. 2010;25:76-84. **[Crossref]**

18. Kondrup J, Allison SP, Elia M, Vellas B, Plauth M; Educational and Clinical Practice Committee; European Society of Parenteral and Enteral Nutrition (ESPEN). ESPEN guidelines for nutrition screening 2002. *Clin Nutr*. 2003;22:415-421. **[Crossref]**

19. Baker JP, Detsky AS, Wesson DE, et al. Nutritional assessment: a comparison of clinical judgement and objective measurements. *N Engl J Med*. 1982;306:969-972. **[Crossref]**

20. Norman K, Pirlich M, Smoliner C, et al. Cost-effectiveness of a 3-month intervention with oral nutritional supplements in disease-related malnutrition: a randomised controlled pilot study. *Eur J Clin Nutr*. 2011;65:735-742. **[Crossref]**

21. Norman K, Kirchner H, Freudenreich M, et al. Three month intervention with protein and energy rich supplements improve muscle function and quality of life in malnourished patients with non-neoplastic gastrointestinal disease-a randomized controlled trial. *Clin Nutr*. 2008;27:48-56. **[Crossref]**

22. Ferguson M, Capra S, Bauer J, Banks M. Development of a valid and reliable malnutrition screening tool for adult acute hospital patients. *Nutrition*. 1999;15:458-464. **[Crossref]**

23. Lanctin DP, Merced-Nieves F, Mallett RM, et al. Prevalence and economic burden of malnutrition diagnosis among patients presenting to United States emergency departments. *Acad Emerg Med*. 2021;28:325-335. **[Crossref]**

24. Kaur D, Rasane P, Singh J, et al. Nutritional interventions for elderly and considerations for the development of geriatric foods. *Curr Aging Sci*. 2019;12:15-27. **[Crossref]**

25. Ratsavong K, van Elsacker T, Doungvichit D, et al. Are dietary intake and nutritional status influenced by gender? The pattern of dietary intake in Lao PDR: a developing country. *Nutr J*. 2020;19:31. **[Crossref]**

26. Keogh E, Mark Williams E. Managing malnutrition in COPD: a review. *Respir Med*. 2021;176:106248. **[Crossref]**

27. Collins PF, Yang IA, Chang YC, Vaughan A. Nutritional support in chronic obstructive pulmonary disease (COPD): an evidence update. *J Thorac Dis*. 2019;11:S2230-S2237. **[Crossref]**

28. Martín-Sánchez FJ, Cuesta Triana F, Rossello X, et al. Effect of risk of malnutrition on 30-day mortality among older patients with acute heart failure in emergency departments. *Eur J Intern Med*. 2019;65:69-77. **[Crossref]**

29. Munoz N, Litchford M, Cereda E. Nutrition and wound care. *Phys Med Rehabil Clin N Am*. 2022;33:811-822. **[Crossref]**

30. Uhl S, Siddique SM, McKeever L, et al. Malnutrition in hospitalized adults: a systematic review. Rockville, MD: Agency for Healthcare Research and Quality; 2021.

31. Kaegi-Braun N, Faessli M, Kilchoer F, et al. Nutritional trials using high-protein strategies and long duration of support show strongest clinical effects on mortality: results of an updated systematic review and meta-analysis. *Clin Nutr ESPEN*. 2021;45:45-54.

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Comparison of SARC-F and SARC-CalF in predicting low muscle strength measurement according to different diagnostic criteria in hospitalized older patients

Melda Kangalgil[1], Hülya Ulusoy[2,3], Uğur Bayramoğlu[3], Sündüz Yüksel[3]

[1]Department of Nutrition and Dietetics, Faculty of Health Sciences, Sivas Cumhuriyet University, Sivas, Türkiye
[2]Department of Anesthesiology and Reanimation, Faculty of Medicine, Karadeniz Technical University, Trabzon, Türkiye
[3]Nutrition Support Team, Faculty of Medicine, Karadeniz Technical University, Trabzon, Türkiye

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ABSTRACT

Objective: Sarcopenia is a highly prevalent syndrome in hospitalized older patients and is associated with adverse clinical outcomes. The management of sarcopenia depends on the use of appropriate screening and diagnostic tools. The aim of this study was to evaluate the performance of sarcopenia risk screening methods for predicting low muscle strength based on different diagnostic criteria.

Methods: This retrospective study included hospitalized patients over 65 years of age. Three commonly used diagnostic criteria European Working Group on Sarcopenia in the Elderly, Asian Working Group on Sarcopenia, Sarcopenia Definition and Outcomes Consortium and population-based criteria were applied as reference standards. The sensitivity and specificity of the SARC-F and SARC-CalF tools were evaluated based on low handgrip strength as defined by the different reference criteria.

Results: A total of 364 patients with a median age of 74 (12) years and the main reasons for hospitalization were surgery (37.1%) and oncological diseases (20.6%) were included in the study. According to different reference criteria, the SARC-F tool has a sensitivity of 80.2-85.8% and a specificity of 53.7-70.6%. The sensitivity and specificity of the SARC-CalF tool was 70.7-76.2% and 46.1-58.8%, respectively. The sensitivity of both tools was lower among surgical patients and those who were well-nourished.

Conclusions: The SARC-F tool demonstrates higher sensitivity in assessing low muscle strength in hospitalized older patients. However, further research is needed to identify the most appropriate sarcopenia risk assessment method, particularly according to the patient's characteristics.

Keywords: sarcopenia, older adults, muscle strength

Introduction

Sarcopenia is a complex nutritional disorder[1] which is associated with poor health outcomes such as functional dependency, falls, fractures and mortality.[2-4] Although the pathophysiological mechanisms have not been fully elucidated, the pathogenesis of sarcopenia is multifactorial and includes age, hormonal imbalance,

Corresponding author: Melda Kangalgil
Email: meldakangalgil@cumhuriyet.edu.tr

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chronic inflammation, redox imbalance, and mitochondrial disfunction.[5] The prevalence of sarcopenia among older adults' ranges from 18% to 66% in different patient groups.[6]

Early detection and diagnosis of sarcopenia is important, but sarcopenia is often underdiagnosed in clinical practice.[7] Several working groups have proposed current definitions of sarcopenia, including the Asian Working Group for Sarcopenia (AWGS), the European Working Group for Sarcopenia in Older Persons (EWGSOP2); and the Sarcopenia Definitions and Outcomes Consortium (SDOC).[8-10] Previous studies have reported poor agreement between different criteria used in the diagnosis of sarcopenia.[11,12]

Screening methods are the first step in the nutritional care process, which is of great importance in the diagnosis of sarcopenia. The detection of sarcopenia requires reliable measurement of muscle strength and muscle mass using valid, reproducible, cost-effective and highly sensitive tools.[13] The SARC-F (Simple Questionnaire for Rapid Diagnosis of Sarcopenia) has been developed as a possible rapid diagnostic test for sarcopenia.[14] The SARC-F questionnaire is a practical self-report tool that can be easily used in health care settings to identify potential cases of sarcopenia and determine whether individuals require further assessment.[15] Previous studies on the clinical validity and cultural adaptation of the SARC-F tool in different countries have reported that it is a valid tool with low sensitivity and high specificity in determining the risk of sarcopenia.[16-18] Anthropometric measurements are important assessment methods that can be used to determine nutritional status, diagnose nutritional disorders and monitor medical nutrition therapy in older patients.[19] Some studies have suggested including calf circumference in diagnostic algorithms for sarcopenia and SARC-CalF was developed to improve the sarcopenia screening performance of SARC-F by including calf circumference measurement.[20-22] Previous studies reported that SARC-CalF significantly enhances the sensitivity and overall diagnostic accuracy of SARC-F for screening sarcopenia in various older populations.[23,24]

Main Points

- Screening methods play a crucial role in the diagnosis of sarcopenia.
- The diagnostic accuracy of sarcopenia risk screening tools is strongly influenced by the characteristics of the patient population.
- The SARC-F tool demonstrates higher sensitivity for sarcopenia risk screening in hospitalized older patients.

The second step in the sarcopenia diagnostic algorithm, following screening for sarcopenia risk, is the assessment of muscle strength, which typically requires a chair stand test or hand dynamometer.[9] The measurement of handgrip strength, a singular indicator of overall muscle strength, has been widely adopted as a useful and prognostically significant parameter, especially for older adults.[25] However, the cut-off values for handgrip strength used in the diagnosis of sarcopenia vary across different consensus groups and handgrip strength measurement may not always be feasible in clinical practice.[26] These variations in protocols may lead to discrepancies in handgrip strength measurements, potentially impacting the accuracy of sarcopenia screening.[27]

Interestingly, to date, no specific study has been conducted to evaluate the performance of SARC-F and SARC-CalF in identifying a low handgrip strength in hospitalized patients with different characteristics. The aim of this study was to assess the performance of the SARC-F and SARC-CalF tools in predicting low handgrip strength according to various diagnostic criteria for sarcopenia in hospitalized older patients.

Method

Study population

This retrospective study was conducted between June 2022 and 2024 with older patients referred to the nutritional support team from inpatient clinics of a university hospital. Patients were excluded from advanced dementia, presence of delirium or confusion, multiorgan failure and comatose state based on medical record documentation, patients treated in the intensive care unit and palliative care unit and a disease/condition that prevented reliable anthropometric and handgrip strength measurements (primary neuromuscular disease, limb amputation, etc.). The Strengthening the Reporting of Observational Studies in Epidemiology statement was used to organize and report the results.[28] The study protocol was approved by the local ethics committee (approval number: 2024/83).

Demographics and clinical characteristics

Demographics and clinical data, including age, sex, primary admission categories and comorbidity status were recorded. The age-adjusted burden of chronic diseases of the patients was determined with the Charlson Comorbidity Index (CCI).[29]

Nutritional assessment and anthropometric measurements

Anthropometric measurements and nutritional assessment were performed by a dietitian. Nutritional status was assessed using the Mini Nutritional Assessment (MNA). An MNA score <17 was classified as malnutrition, a score between 17 and 23.5 as at risk of malnutrition, and a score > 24 as indicating normal nutritional status.[30] The MNA is a comprehensive assessment method recommended for the diagnosis of malnutrition in older patients.[31]

Body weight and height were measured with light clothes and without shoes using a scale and stadiometer available at the hospital, and body mass index (BMI, kg/m^2) was calculated. Mid-arm circumference (MAC, cm) was measured on a fully relaxed upper arm, using inelastic tape, marking the midpoint between the acromion and olecranon protrusion. Calf circumference (CC, cm) was measured in the largest circumference of the leg.

Sarcopenia risk assessment

SARC-F and SARC-CalF tools were used for sarcopenia risk assessment, respectively. SARC-F questionnaire includes five components: strength, assistance walking, rise from a chair, climb stairs, and falls. Each component of SARC-F scores 0-2 points, with a total score ranging from 0 to 10.[32] The SARC-CalF consists of the five components of the SARC-F in addition to measuring calf circumference. The first five items are scored in the same as the SARC-F. Calf circumference component is scored as 0 point if the calf circumference measurement is >34 cm for males and >33 cm for females and as 10 points if the calf circumference measurement is ≤34 cm for males and ≤33 cm for females.[22]A total score of SARC-F ≥ 4 and a total score of SARC-CalF ≥11 indicate risk for sarcopenia, respectively.[14,22]

Muscle strength

Muscle strength was assessed using handgrip strength with a hand dynamometer. Patients were positioned as recommended by the American Society of Hand Therapists, in a sitting position with the arms bent 90 degrees at the elbow and shoulder joints.[33] The dominant hand was measured three times, however, if a condition affected the reliability of the measurement such as vascular access in the dominant hand, the non-dominant hand was preferred. To ensure measurement reliability, the hand was allowed to rest for one minute between measurements and the average value of the measurements was recorded.

The EWGSOP2 and AWGS cut-off points for low hand grip strength were <27 kg and <28 kg in men and <16 kg and <18 kg in women, respectively.[8,9] SDOC criteria for low hand grip strength was <35.5 kg in men and <20 kg in women.[10] The country-specific handgrip strength cut-off points were determined as <32 kg for men and <22 kg for women (Table 1).[34]

Statistical analysis

Data were analyzed using SPSS software (version 23, IBM). The normality of the data was evaluated using the Kolmogorov-Smirnov test and histogram graphs. Descriptive data is reported as means ± standard deviations, median and interquartile range, or percentages, as appropriate. Differences between categorical variables were determined by Chi-square test. Continuous variables were analyzed using independent samples t-test or Mann–Whitney U test, as appropriate. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) of each criterion was calculated with a contingency table. Sensitivity and specificity were classified as poor if <50%, fair if >50% and <80%, good if ≥80%. All statistical tests were considered statistically significant at p value <0.05.

Table 1. Cut-off values to define low handgrip strength

	EWGSOP2	AWGS	SDOC	Specific
Low handgrip strength				
Male	<27 kg	<28 kg	<35.5 kg	<32 kg
Female	<16 kg	<18 kg	<20 kg	<22 kg

Results

A total of 483 patients who underwent sarcopenia risk assessment and handgrip strength measurements were initially screened for eligibility during the study period. Of these, 97 patients did not have a nutritional assessment, 16 patients did not have anthropometric measurements, and 6 patients were excluded from the treated with intensive care unit, and the remaining 364 patients were included in the study, and the characteristics of the study population are shown in Table 2. Participants were predominately male (65.1%) with a median (IQR) age of 74 (12) years. The most common primary hospitalization diagnoses were surgery (37.1%) and oncological diseases (20.6%).

Table 2. Demographic and clinical parameters

	Total
Age, years, median (IQR)	74 (12)
Sex, n (%)	
Male	237 (65.1)
Female	127 (34.9)
Hospital clinic, n (%)	
Surgery	163 (44.8)
Medical	201 (55.2)
CCI, median (IQR)	6 (2)
Admission diagnoses, n (%)	
Neurologic	61 (16.8)
Surgery	135 (37.1)
Oncology	75 (20.6)
Respiratory	30 (8.2)
Other	63 (17.3)
Nutritional status, n (%)	
Normal nutritional status	92 (25.3)
Malnutrition risk	97 (26.6)
Malnutrition	175 (48.1)
Anthropometric measurements	
BMI, kg/m^2, median (IQR)	24.1 (6.8)
Handgrip strength (kg), median (IQR)	13.9 (13.7)
Calf circumference, cm, median (IQR)	31.5 (5.8)
Mid-arm circumference, cm, mean±SD	26.1±4.7

* Metabolic, endocrine, gastrointestinal, cardiac, renal, and infectious disease.

The prevalence of low muscle strength according to EWGSOP2, AWGS, SDOC and community-based criteria is 81.6-95.9%. The sensitivity and specificity of SARC-F was 85.8% and 53.7% for EWGSOP2, 84.7% and 54.4% for AWGS, 80.2% and 60% for SDOC, and 80.9% and 70.6% for population-based criteria (Table 3). The sensitivity and specificity of SARC-CalF was 76.2% and 58.8% for EWGSOP2, 75% and 56.5% for AWGS, 70.7% and 46.1% for SDOC, and 70.9% and 50% for population-based criteria (Table 4).

Discussion

As sarcopenia is a predictor of adverse clinical outcomes in hospitalized older patients, early detection through appropriate screening and early intervention is of critical importance. The variability of cut-off values for handgrip strength used in sarcopenia screening may be attributed to cultural, social and lifestyle differences among individuals. The lack of a consensus on the assessment of handgrip strength in epidemiological studies also contributes significantly to the variability.[27] Therefore, data are needed to determine the most appropriate cut-off points for handgrip strength measurement and the most appropriate screening tool in the sarcopenia diagnostic algorithm in hospitalized patients.

Several sarcopenia screening tools are available, but the most widely used tool in clinical practice is the SARC-F. Studies investigating the usefulness of SARC-F in the detection of sarcopenia have reported conflicting results. In a meta-analysis of older patients living in the community, in hospitals, and in nursing homes, SARC-F was found to have a low-moderate sensitivity of 36% and a high specificity of 87%.[35] Similarly, in a recent meta-analysis of community-dwelling, nursing home, and hospitalized older adults, the SARC-F score was reported to have low sensitivity and high specificity.[36] Otherwise, there are very few studies to determine the usefulness of SARC-F in the detection of sarcopenia in hospitalized patients. In 115 patients with hip fracture, the sensitivity and specificity of SARC-F tool as a screening method for sarcopenia ranged from 86% to 95% and 40% to 56%, respectively, depending on the reference criteria.[37] Dedeyne et al.[38] reported that the SARC-F showed good sensitivity (83-84%) and poor specificity (19-20%) to identify geriatric rehabilitation inpatients at risk for sarcopenia according to EWGSOP2 and AWGS definitions. Consistent with previous studies, the present study according to different reference standards, the sensitivity of SARC-F ranged from 80.2-

Table 3. Sensitivity and specificity of SARC-F score according to handgrip strength in different sarcopenia consensus definitions

	Low muscle strength-EWGSOP2			
SARC-F ≥ 4	**Sensitivity (%)**	**Specificity (%)**	**PPV (%)**	**NPV (%)**
Total population	85.8%	53.7%	89.2%	46.1%
Nutritional status				
Normal nutritional status	75.4%	74.2%	85.2%	60.5%
Malnutrition risk/malnutrition	88.5%	36.1%	90.1%	32.5%
Hospital clinic				
Surgery	79.6%	53.3%	88.3%	37.2%
Medical	90.8%	54.0%	89.7%	57.1%
	Low muscle strength -AWGS			
Total population	84.7%	54.4%	90.1%	39.7%
Nutritional status				
Normal nutritional status	72.3%	74.0%	87.0%	52.6%
Malnutrition risk/malnutrition	88.0%	36.7%	91.8%	27.5%
Hospital clinic				
Surgery	78.9%	56%	90.8%	32.5%
Medical	89.3%	53.1%	90.9%	48.6%
	Low muscle strength -SDOC			
Total population	80.2%	60%	97.9%	11.5%
Nutritional status				
Normal nutritional status	60.5%	66.7%	96.3%	10.5%
Malnutrition risk/malnutrition	86.7%	55.5%	98.3%	12.5%
Hospital clinic				
Surgery	75.6%	71.4%	98.3%	11.6%
Medical	83.9%	50%	97.6%	11.4%
	Low muscle strength -Population based			
Total population	80.9%	70.6%	98.2%	15.3%
Nutritional status				
Normal nutritional status	62.9%	72.7%	94.4%	21.0%
Malnutrition risk/malnutrition	86.5%	66.7%	99.1%	10.0%
Hospital clinic				
Surgery	76.5%	70%	97.5%	16.3%
Medical	84.5%	71.4%	98.8%	14.3%

85.8% and the specificity ranged from 53.7-70.6% for the low muscle strength, whereas the sensitivity of SARC-F was lower in surgical and well-nourished patients. One of the most important reasons for the differences between studies may be that diagnostic accuracy depends on patient characteristics such as disease severity, stage and comorbidity.[39] Moreover, given the heterogeneity of hospitalized patients and the varied in the causes of sarcopenia development, it is obvious that a significant gap in this field.

Table 4. Sensitivity and specificity of SARC-CalF score according to handgrip strength in different sarcopenia consensus definitions

	Low muscle strength -EWGSOP2			
SARC-CALF ≥ 11	**Sensitivity (%)**	**Specificity (%)**	**PPV (%)**	**NPV (%)**
Total population	76.2%	58.8%	89.5%	34.9%
Nutritional status				
Normal nutritional status	70.6%	71.4%	80%	60%
Malnutrition risk/malnutrition	77.1%	50%	91.2%	24.6%
Hospital clinic				
Surgery	74.5%	54.5%	87.5%	33.3%
Medical	77.3%	62.1%	90.8%	36%
	Low muscle strength -AWGS			
Total population	75%	56.5%	90%	30.2%
Nutritional status				
Normal nutritional status	70.6%	71.4%	80%	60%
Malnutrition risk/malnutrition	75.7%	44%	91.8%	18%
Hospital clinic				
Surgery	73.9%	55%	88.7%	30.5%
Medical	75.7%	57.7%	90.8%	30%
	Low muscle strength -SDOC			
Total population	70.7%	46.1%	96.5%	7%
Nutritional status				
Normal nutritional status	56%	60%	93.3%	12%
Malnutrition risk/malnutrition	74%	37.5%	97%	4.9%
Hospital clinic				
Surgery	70%	50%	96.2%	8.3%
Medical	71.2%	42.8%	96.7%	6%
	Low muscle strength -Population based			
Total population	70.9%	50%	96.5%	8.1%
Nutritional status				
Normal nutritional status	56.5%	55.5%	86.7%	20%
Malnutrition risk/malnutrition	73.9%	40%	98.2%	3.3%
Hospital clinic				
Surgery	70.1%	44.4%	93.7%	11.1%
Medical	71.5%	60%	98.3%	6%

SARC-CalF, as an updated version of SARC-F, includes the inclusion of calf circumference measurement in SARC-F. In this study, the sensitivity and specificity of SARC-CalF were found to be 70.9-76.2% and 46.1-58.8%, respectively. Previous studies have shown that the diagnostic accuracy of CARC-CalF is higher than SARC-F in different hospitalized patient population.[40,41] In contrast to, in a study with hospitalized older patients with reported that SARC-F tool is more appropriate for use in a sarcopenia screening algorithm.[42] Likewise, in the community-dwelling older adult population, SARC-CalF did not show superiority over SARC-F for sensitivity analyses.[43] However, the different results of the studies are closely related to the obesity status of the included older patients, as SARC-CalF may make it difficult to detect sarcopenic obesity and edema. Moreover, the original cut-off points for calf circumference in SARC-CalF are 34 and 33 cm for men and women respectively.[22] However, these cut-off points differ from the sarcopenia risk levels recommended for use in different patient populations.[34,44] Therefore, future studies are needed to evaluate the diagnostic accuracy of the cut-off points in the SARC-CalF tool by revising them for different patient populations. Some studies have reported that the diagnostic capacity of sarcopenia improved when the cut-off point of SARC-F and SARC-CalF were used differently from the original study.[45,46] However, differences in references for diagnosis of sarcopenia, the use of different cut-offs for SARC-F and SARC-CalF scores and the heterogeneity of the population should be considered.

The study has several limitations. First, a causal association could not be established due to the retrospective observational design. Also, the study patients were referred to the nutrition support team, and approximately 75% of the study population consisted of patients with nutritional risk or malnutrition. Considering that nutritional risk and malnutrition are risk factors for sarcopenia[47,48] this may have led to overestimation of sarcopenia the prevalence of sarcopenia and limit the generalizability of our findings. Finally, our study included geriatric patients with a wide range of disease types and severities, and an acute illness may cause a temporary decline in handgrip strength in an older adult.

Based on the results of our study, it can be concluded that the SARC-F tool predicts the occurrence of low muscle strength with greater accuracy in hospitalized older patients. However, further research is needed to determine the most appropriate sarcopenia risk assessment method, especially according to the patient's characteristics. Considering the impact of sarcopenia on clinical outcomes, its tendency to increase with age and disease burden, and its high prevalence, research in different countries should be focused on developing effective screening strategies and establishing reliable criteria.

Ethical approval

This study has been approved by the Scientific Research Ethics Committee of Karadeniz Technical University Health Sciences (approval number: 2024/83 and date: 03.06.2024).

Author contribution

The authors declare contribution to the paper as follows: Study conception and design: MK, HU; data collection: MK, UB, SY; analysis and interpretation of results: MK, UB, SY; draft manuscript preparation: MK, HU. All authors reviewed the results and approved the final version of the article.

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The authors declare that there is no conflict of interest.

References

1. Cederholm T, Barazzoni R, Austin P, et al. ESPEN guidelines on definitions and terminology of clinical nutrition. *Clin Nutr*. 2017;36:49-64. [Crossref]
2. Yeung SS, Reijnierse EM, Pham VK, et al. Sarcopenia and its association with falls and fractures in older adults: a systematic review and meta-analysis. *J Cachexia Sarcopenia Muscle*. 2019;10:485-500. [Crossref]
3. Xu J, Wan CS, Ktoris K, Reijnierse EM, Maier AB. Sarcopenia is associated with mortality in adults: a systematic review and meta-analysis. *Gerontology*. 2022;68:361-376. [Crossref]
4. Zhou H, Ding X, Luo M. The association between sarcopenia and functional disability in older adults. *J Nutr Health Aging*. 2024;28:100016. [Crossref]

5. Picca A, Calvani R. Molecular mechanism and pathogenesis of sarcopenia: an overview. *Int J Mol Sci*. 2021;22:3032. [Crossref]
6. Yuan S, Larsson SC. Epidemiology of sarcopenia: prevalence, risk factors, and consequences. *Metabolism*. 2023;144:155533. [Crossref]
7. Ooi H, Welch C. Obstacles to the early diagnosis and management of sarcopenia: current perspectives. *Clin Interv Aging*. 2024;19:323-332. [Crossref]
8. Chen LK, Woo J, Assantachai P, et al. Asian working group for sarcopenia: 2019 consensus update on sarcopenia diagnosis and treatment. *J Am Med Dir Assoc*. 2020;21:300-307.e2. [Crossref]
9. Cruz-Jentoft AJ, Bahat G, Bauer J, et al. Sarcopenia: revised European consensus on definition and diagnosis. *Age Ageing*. 2019;48:16-31. [Crossref]
10. Bhasin S, Travison TG, Manini TM, et al. Sarcopenia definition: the position statements of the sarcopenia definition and outcomes consortium. *J Am Geriatr Soc*. 2020;68:1410-1418. [Crossref]
11. Pagotto V, Silveira EA. Applicability and agreement of different diagnostic criteria for sarcopenia estimation in the elderly. *Arch Gerontol Geriatr*. 2014;59:288-294. [Crossref]
12. Mayhew AJ, Amog K, Phillips S, et al. The prevalence of sarcopenia in community-dwelling older adults, an exploration of differences between studies and within definitions: a systematic review and meta-analyses. *Age Ageing*. 2019;48:48-56. [Crossref]
13. Ackermans LL, Rabou J, Basrai M, et al. Screening, diagnosis and monitoring of sarcopenia: when to use which tool? *Clin Nutr ESPEN*. 2022;48:36-44. [Crossref]
14. Malmstrom TK, Miller DK, Simonsick EM, Ferrucci L, Morley JE. SARC-F: a symptom score to predict persons with sarcopenia at risk for poor functional outcomes. *J Cachexia Sarcopenia Muscle*. 2016;7:28-36. [Crossref]
15. Roberts S, Collins P, Rattray M. Identifying and managing malnutrition, frailty and sarcopenia in the community: a narrative review. *Nutrients*. 2021;13:2316. [Crossref]
16. Bahat G, Yilmaz O, Kılıç C, Oren MM, Karan MA. Performance of SARC-F in regard to sarcopenia definitions, muscle mass and functional measures. *J Nutr Health Aging*. 2018;22:898-903. [Crossref]
17. Drey M, Ferrari U, Schraml M, et al. German version of SARC-F: translation, adaption, and validation. *J Am Med Dir Assoc*. 2020;21:747-751.e1. [Crossref]
18. Piotrowicz K, Głuszewska A, Czesak J, et al. SARC-F as a case-finding tool for sarcopenia according to the EWGSOP2. National validation and comparison with other diagnostic standards. *Aging Clin Exp Res*. 2021;33:1821-1829. [Crossref]
19. Portero-McLellan KC, Staudt C, Silva FR, et al. The use of calf circumference measurement as an anthropometric tool to monitor nutritional status in elderly inpatients. *J Nutr Health Aging*. 2010;14:266-270. [Crossref]
20. Kim S, Kim M, Lee Y, et al. Calf circumference as a simple screening marker for diagnosing sarcopenia in older Korean adults: the Korean frailty and aging cohort study (KFACS). *J Korean Med Sci*. 2018;33:e151. [Crossref]
21. Wu SE, Chen WL. Calf circumference refines sarcopenia in correlating with mortality risk. *Age Ageing*. 2022;51:afab239. [Crossref]
22. Barbosa-Silva TG, Menezes AM, Bielemann RM, Malmstrom TK, Gonzalez MC; Grupo de Estudos em Composição Corporal e Nutrição (COCONUT). Enhancing SARC-F: improving sarcopenia screening in the clinical practice. *J Am Med Dir Assoc*. 2016;17:1136-1141. [Crossref]
23. da Luz MC, Pinho CP, Bezerra GK, et al. SARC-F and SARC-CalF in screening for sarcopenia in older adults with Parkinson's disease. *Exp Gerontol*. 2021;144:111183. [Crossref]
24. Fu X, Tian Z, Thapa S, et al. Comparing SARC-F with SARC-CalF for screening sarcopenia in advanced cancer patients. *Clin Nutr*. 2020;39:3337-3345. [Crossref]
25. Bohannon RW. Grip strength: an indispensable biomarker for older adults. *Clin Interv Aging*. 2019;14:1681-1691. [Crossref]
26. Coletta G, Phillips SM. An elusive consensus definition of sarcopenia impedes research and clinical treatment: a narrative review. *Ageing Res Rev*. 2023;86:101883. [Crossref]
27. Fernandes S, Rodrigues da Silva E, New York B, et al. Cutoff points for grip strength in screening for sarcopenia in community-dwelling older-adults: a systematic review. *J Nutr Health Aging*. 2022;26:452-460. [Crossref]
28. von Elm E, Altman DG, Egger M, et al. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *Int J Surg*. 2014;12:1495-1499. [Crossref]
29. Charlson M, Szatrowski TP, Peterson J, Gold J. Validation of a combined comorbidity index. *J Clin Epidemiol*. 1994;47:1245-1251. [Crossref]
30. Vellas B, Guigoz Y, Garry PJ, et al. The mini nutritional assessment (MNA) and its use in grading the nutritional state of elderly patients. *Nutrition*. 1999;15:116-122. [Crossref]
31. Guigoz Y, Vellas B. Nutritional assessment in older adults : MNA® 25 years of a screening tool and a reference standard for care and research; what next? *J Nutr Health Aging*. 2021;25:528-583. [Crossref]
32. Malmstrom TK, Morley JE. SARC-F: a simple questionnaire to rapidly diagnose sarcopenia. *J Am Med Dir Assoc*. 2013;14:531-532. [Crossref]
33. Fess EE, Moran AC. Grip strength: clinical assessment recommendations. New York: American Society of Hand Therapists; 1992.
34. Bahat G, Tufan A, Tufan F, et al. Cut-off points to identify sarcopenia according to European Working Group on Sarcopenia in Older People (EWGSOP) definition. *Clin Nutr*. 2016;35:1557-1563. [Crossref]

35. Huang L, Shu X, Ge N, et al. The accuracy of screening instruments for sarcopenia: a diagnostic systematic review and meta-analysis. *Age Ageing*. 2023;52:afad152. **[Crossref]**

36. Qian S, Zhang S, Lu M, et al. The accuracy of screening tools for sarcopenia in older Chinese adults: a systematic review and meta-analysis. *Front Public Health*. 2024;12:1310383. **[Crossref]**

37. Ha YC, Won Won C, Kim M, Chun KJ, Yoo JI. SARC-F as a useful tool for screening sarcopenia in elderly patients with hip fractures. *J Nutr Health Aging*. 2020;24:78-82. **[Crossref]**

38. Dedeyne L, Reijnierse EM, Pacifico J, et al. SARC-F is inaccurate to identify geriatric rehabilitation inpatients at risk for sarcopenia: RESORT. *Gerontology*. 2022;68:252-260. **[Crossref]**

39. Knottnerus JA, Muris JW. Assessment of the accuracy of diagnostic tests: the cross-sectional study. *J Clin Epidemiol*. 2003;56:1118-1128. **[Crossref]**

40. Ishihara Y, Kusakabe T, Yasoda A, et al. Comparison of the utility of SARC-F, SARC-CalF, and calf circumference as screening tools for sarcopenia in patients with osteoporosis. *PLoS One*. 2024;19:e0310401. **[Crossref]**

41. Yalcin A, Gokce B, Turhan G, et al. Comparison of diagnostic accuracy of the SARC-F, SARC-CalF, and Ishii tests for diagnosis of sarcopenia in hospitalized older patients: a cross-sectional study. *Nutr Clin Pract*. 2024;39:1396-1405. **[Crossref]**

42. Mainardi LG, Borges TC, Gomes TL, et al. Association of SARC-F and dissociation of SARC-F + calf circumference with comorbidities in older hospitalized cancer patients. *Exp Gerontol*. 2021;148:111315. **[Crossref]**

43. Bahat G, Oren MM, Yilmaz O, et al. Comparing SARC-F with SARC-CalF to screen sarcopenia in community living older adults. *J Nutr Health Aging*. 2018;22:1034-1038. **[Crossref]**

44. Özcan B, Güner M, Ceylan S, et al. Calf circumference predicts sarcopenia in maintenance hemodialysis. *Nutr Clin Pract*. 2024;39:193-201. **[Crossref]**

45. Zhu L, Li J, Li M, et al. Accuracy of SARC-F, SARC-CalF, and Ishii test in assessing severe sarcopenia in older adults in nursing homes. *J Nutr Health Aging*. 2022;26:576-580. **[Crossref]**

46. Guo JY, Yu K, Li CW, et al. The application of Chinese version of SARC-F and SARC-CalF in sarcopenia screening against five definitions: a diagnostic test accuracy study. *BMC Geriatr*. 2024;24:883. **[Crossref]**

47. Beaudart C, Sanchez-Rodriguez D, Locquet M, et al. Malnutrition as a strong predictor of the onset of sarcopenia. *Nutrients*. 2019;11:2883. **[Crossref]**

48. Sato PH, Ferreira AA, Rosado EL. The prevalence and risk factors for sarcopenia in older adults and long-living older adults. *Arch Gerontol Geriatr*. 2020;89:104089. **[Crossref]**

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Individualized nutritional management for cancer patients: a key component of treatment

Derya Hopancı Bıçaklı[1]

[1]Department of Nutrition and Dietetics, Faculty of Health Sciences, Muğla Sıtkı Koçman University, Muğla, Türkiye

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ABSTRACT

The type of cancer, size and location of the tumor, stage of the disease, and treatments provided may lead to different degrees of malnutrition in patients. Symptoms that develop due to the tumor itself or the treatment process may cause a decrease in oral food intake. Therefore, for patients undergoing cancer treatment, personalized nutrition therapy is of great importance. Patients should be regularly screened and evaluated for early detection of malnutrition. All oncology patients should be provided with nutritional counseling, and individuals in the high-risk group should be closely monitored. The nutrition plan should be created based on the type of the disease, treatment process, symptoms, individual needs and living conditions. The primary preference in nutritional treatment is to ensure that the patient is naturally fed orally. However, in cases of inadequate nutritional intake, oral nutritional suplements (ONS), enteral nutrition (EN) or parenteral nutrition (PN) methods can be utilized. EN and PN can be used as complementary to each other when necessary and can increase the effectiveness of nutritional therapy. Regular follow-ups during this process are critical for the maintenance of the patient's nutritional status and prevention of possible complications. The nutritional education process should be reinforced with supportive educational materials whose language is understandable and plain in an environment suitable for the patient's needs.

Keywords: cancer, malnutrition, nutritional support

Introduction

Cancer is not only a disease of abnormal cell growth, but also a condition that profoundly affects the body's metabolic processes and nutritional balance. Throughout the course of the disease, from diagnosis to treatment and beyond, patients often face challenges that compromise their ability to maintain adequate nutritional intake. Addressing these challenges is essential for improving treatment outcomes, quality of life, and overall prognosis.

Malnutrition in patients with cancer

The type of cancer, size and location of the tumor, stage of the disease, and treatments provided may lead to varying degrees of malnutrition in patients with cancer. Gastrointestinal dysfunction and anorexia that develop due to the disease or the treatment process may cause malnutrition. Malnutrition, a common problem in patients with cancer, is detected in 15-40% of the cases at the time of diagnosis. This rate increases during the treatment process and reaches a high rate of 40-80% in patients with advanced-stage cancer. Therefore, nutritional status should be evaluated early, and patient-specific nutritional therapy should be planned.[1]

Corresponding author: Derya Hopancı Bıçaklı
Email: deryahopanci@hotmail.com

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Symptoms that may affect the patient's nutrition may occur during radiotherapy (RT), chemotherapy (CT), and surgical procedures. Symptoms that vary according to the application dose and the area where RT is performed prevent the patient from taking in nutrients. For instance, RT performed on the head and neck region may cause changes or loss in taste, mucositis, dry mouth, fatigue, nausea, trismus, and tooth and gum problems. If the patient undergoes RT together with CT, these symptoms may be accompanied by loss of appetite, nausea, lack of hunger, feeling full quickly, and fatigue. RT performed on the abdominal region may cause diarrhea, abdominal pain, or cramps. If RT is performed on the thoracic region, it may cause stenosis or strictures in the esophagus, esophagitis, and difficulty swallowing.[2] The location, complexity, and extent of resection of surgical procedures performed on the patient may have a direct impact on the patient's nutritional status.[3] Surgeries targeting the digestive system increase the risk of malnutrition and thus may affect absorption of nutrients and gastrointestinal functions. In addition, combinations of CT performed before or after surgery, and long-term treatment protocols may lead to numerous negative effects on nutrition. Side effects such as nausea, vomiting, mucositis, loss of appetite, and changes in taste due to treatment make it difficult for the patient to have adequate and balanced nutrition, and thus increase the risk of malnutrition further.[4]

Main Points

- Malnutrition is common in cancer patients and requires early assessment.
- The patient's nutritional status should be evaluated early, and an individualized nutritional treatment plan should be developed and continuously monitored.
- Symptoms affecting food intake due to treatment should be kept under control.
- Nutritional therapy should primarily focus on natural oral feeding; however, when necessary, oral nutritional supplements (ONS), enteral nutrition (EN), or parenteral nutrition (PN) may be used. EN and PN can also be combined when needed.
- Nutrition education should be simple and understandable, supported by clear educational materials in appropriate setting.

Consequences of malnutrition on treatment outcomes

Malnutrition is a common problem at every stage of cancer, regardless of the stage, and has intense effects on patients' general health status. In patients receiving curative, adjuvant, or palliative treatment, nutritional deficiencies can bring about serious consequences such as muscle loss, decreased functional capacity, increased risk of infection, and poor response to treatment. Malnutrition is also known to increase surgical complications and is an independent risk factor that negatively affects survival.[5,6] Malnutrition that occurs during cancer treatment increases the risk of toxicity, worsens the quality of life, and reduces patients' functionality. It is also closely related to sarcopenia, since it worsens muscle function and causes a decrease in lean body mass and muscle performance.[7] Low skeletal muscle mass and weight loss are independent prognostic factors that negatively affect survival in cancer patients. These factors are also key features of cancer cachexia, a progressive and often irreversible syndrome commonly observed in advanced-stage disease.[7,8] Sarcopenia is not only caused by cancer or old age, but can also be triggered by CT. Iatrogenic sarcopenia is characterized by poor muscle quality, which leads to changes in the volume of distribution of medications, pharmacokinetics, and consequently increases CT toxicity. Sarcopenia is associated not only with reduced CT response but also with worse outcomes in a vicious cycle. Muscle loss deteriorates the patient's general health status further and thus can adversely affect the response to treatment.[9] Negative effects of sarcopenia on outcome also occur in surgical patients, since it is a risk factor for perioperative and postoperative complications.[10] Although more than 50% of hospitalized patients with cancer and up to 30% of outpatients develop sarcopenia, unfortunately, in clinical practice, nutritional assessment is performed in only 30–60% of malnourished patients.[11,12] Muscle mass and adipose tissue are among the important factors affecting oncological outcomes. Therefore, adequate nutrition is the most important strategy to optimize body composition, since it is an essential part of successful cancer treatment. The main goal in performing nutritional intervention is to affect body composition positively in order to improve outcomes of the cancer treatment and prognosis, and to reduce morbidity.[1]

Guidelines and evidence-based nutritional interventions

In international guidelines, it is recommended that intensive nutritional counseling should be given and oral nutritional supplements (ONS) should be provided to increase nutritional intake, reduce treatment-related weight loss, and prevent treatment interruptions in patients undergoing cancer treatment.[13-15] Oral nutritional intervention is a critical step in the prevention and treatment of malnutrition by closing the gap between recommended and actual nutritional intake during treatment to meet the patient's needs.[15] It has been demonstrated that nutritional counseling provided by oncology dietitians provide significant benefits in improving nutritional status, body weight, and quality of life.[3,16]

The key factor in successful cancer treatment is appropriate nutrition. The type of nutritional therapy varies according to the patient's history, the type and stage of the tumor, and the patient's response to treatment. The type of the cancer or the location of the tumor requires personalized nutritional models. Since nutrition affects the development of the disease, natural symptoms of the tumor, response to anti-neoplastic therapies and recovery, and thus has a strong effect on the quality of life and prognosis of the disease, it is a central factor in oncology.[1] The idea that patients should take adequate nutrients to maintain daily activity, functional capacity, and to have more successful treatments is accepted by both patients and their families and caregivers.[17]

In 2021, the European Society for Clinical Nutrition and Metabolism (ESPEN) recommended the following:

1. Malnutrition risk should be screened regardless of body mass index (BMI) or history of weight loss,
2. Nutrient intake, body composition, inflammation, energy expenditure, and physical function should be assessed,
3. Individualized multimodal therapy should be provided to improve oral nutrient intake, reduce inflammation and metabolic stress, and increase physical activity.[18]

On the other hand, in 2020, the American Society of Clinical Oncology (ASCO) recommended that only dietary counseling should be given and corticosteroids and progesterone analogs should be appropriately administered.[19] Both ESPEN and ASCO emphasize that enteral and parenteral nutrition should only be administered to patients with inadequate oral intake or impaired intestinal function. In 2021, the European Society for Medical Oncology (ESMO) recommended that screening should be performed for malnutrition, and that the patient's clinical, psychological and social status, nutrition, social support and exercise needs, requirements for corticosteroids, olanzapine, and progestin to improve his or her appetite should be comprehensively assessed.[20]

Nutritional screening and assessment

The patient's nutritional status should be assessed periodically at different stages of the cancer journey, because nutritional status is not steady; it varies. The type and stage of the tumor, the treatment method and comorbidities affect the patient's nutritional needs. The patient's inflammatory and metabolic processes should be continuously assessed. Nutritional interventions can be adapted according to the current risk.[7] Patients' nutritional problems should be assessed continuously from the initial signs and symptoms of anorexia to pre-cachexia, cachexia and advanced cachexia. If this is compared to a pyramid, while advanced cachexia represents the peak of the pyramid, pre-cachexia caused by initial malnutrition is the broad base of the pyramid.[21] The effectiveness of any nutritional intervention depends on the timing of support. The best results from nutritional intervention are achieved when it is performed early, adequately and continuously.[18] Proactive assessment of nutritional status is essential for the selection of the intervention needed, which makes it possible to identify and follow up patients who would benefit from nutritional intervention. Although there are many screening and assessment tools, none of them is complete and flawless. In adult oncology patients, screening and assessment tools proved as valid and reliable can be used to determine the malnutrition risk. One of these tools is the Patient-Generated Subjective Global Assessment (PG-SGA), which was developed specifically for patients with cancer, is administered to rate the symptoms.[22] The PG-SGA is considered as a valid and reliable tool that can be used to assess nutritional needs of adult oncology patients receiving outpatient and inpatient treatment comprehensively, and to determine nutritional triage.[23-26] In addition to the PG-SGA, the NRS 2002[26,27], a nutritional risk screening tool recommended by ESPEN for inpatients, and the Subjective Global Assessment (SGA)[28], which is mandatory to be recorded in the reimbursement system in Turkey, are also used. The Global Leadership Initiative on Malnutrition (GLIM) proposed a definition of malnutrition that takes into account both phenotypic (unintentional weight loss, low body mass index [BMI], and reduced

muscle mass) and etiological criteria (reduced nutrient intake or absorption, inflammation, or disease burden) for the diagnosis of malnutrition to guide nutritional intervention and expected prognosis.[29] The primary goal of all these nutritional screening tools is to assess the nutritional status of patients and, accordingly, to predict the risk of improved or worsened clinical outcomes.[30]

The nutritional treatment process should be evaluated in five stages:

1. Nutritional Screening and Assessment: determining the risk of malnutrition.
2. Medical and Nutritional History: Acute and chronic diseases and nutritional habits.
3. Anthropometric Measurements: BMI, calf circumference, mid-upper arm circumference, hand dynamometer.
4. Biochemical Data: Albumin, prealbumin, transferrin, micronutrients, CRP, etc.
5. Physical Examination Findings: Muscle loss, adipose tissue changes, ascites, edema, functional capacity.[31]

To ensure the effectiveness of individualized nutrition therapy, in addition to nutritional and clinical parameters, patients' oral food consumption, daily eating habits, food choices, psychological status, autonomy in eating and cooperation should be examined in detail. In addition, whether patients need help or support in the nutrition process should be determined and a personalized approach should be developed. When the patient's nutritional history is taken, not only his or her energy and protein intake but also changes in solid and liquid food intake (type, texture, temperature), the suitability and adequacy of ONS, EN or PN application if previously recommended, the actual daily macro and micronutrient intake level from artificial nutrition and other nutritional sources, ONS use, food avoidance and intolerances, medications used, herbal products and complementary or alternative products, ability to shop, prepare food, people who the patient lives with, and economic factors affecting his or her access to food should also be questioned and recorded.[31] After the use of herbal and supplementary products in patients receiving CT is questioned, the patient should be informed about potential drug-non-drug interactions regarding nutritional support. Before a nutritional plan is made for adult oncology patients, some laboratory findings such as fasting blood sugar, neutrophil and platelet levels, nutritional anemia profile (hemoglobin, hematocrit, folate, vitamin B12 and iron); electrolyte and kidney (urea creatinine) and liver functions; albumin and prealbumin values to be evaluated together with C-reactive protein value, and the results of gastrointestinal function tests (swallowing tests, abdominal films, gastric emptying and transit time, etc. tests).should also be taken into account.[31]

The patient's intellectual level should be taken into consideration when nutritional counseling and education is provided to him or her. Factors such as the presence of fatigue or depression, the severity and location of pain if present, whether or not the patient lives alone, whether or not the patient receives social support, and whether or not the patient has a chronic disease that requires him or her to go on a diet may affect both the nutritional plan and the way the patient implements these. In addition, especially in patients over the age of 65, loss of muscle mass, loss of subcutaneous fat, presence of pressure ulcers or wounds, appetite, structure and health of the mouth and teeth, and presence of edema or ascites should also be taken into account.[31]

To assess muscle loss, which is a defining characteristic of sarcopenia and cachexia of sarcopenia and cachexia, a bioelectrical impedance analyzer can be used or, more practically, calf circumference is measured. Other anthropometric measurements such as weight, height, BMI, weight loss, mid-arm circumference, and skinfold thickness are also indispensable criteria for follow-up and evaluation. The process of muscle loss in a cancer patient is similar to a forest fire and subsequent afforestation. Just as fire destroys a forest rapidly, muscle loss also occurs in a short time. However, like reforestation, recovery of muscle mass can also be possible over time, with proper nutrition and appropriate support. Early intervention is important because preserving existing muscle is easier than rebuilding it.[32]

Nutrition education and counseling in oncology

From a nutritional perspective, interventions include oral nutrition and diet education, ONS, or EN or PN as appropriate, and combinations of these.[32] In the clinical practice of individualized nutrition counseling, oral nutrition always ranks in priority. Oral nutrition is the preferred way of feeding, as it is an important part of the patient's daily routine and contributes to the patient's autonomy significantly. The patient should be encouraged to sit at the dinner table with the family and friends, and to avoid isolating himself or herself. Diet is the only factor that the patient can control during all treatments

and interventions. Accepting that the prescribed diet is suitable and adapted to individual needs is also a very effective approach in terms of supporting the patient's psychology, as it gives the patient a sense of control. Individualized diet counseling should be performed and monitored by a dietician who is an expert in this field. Adequate nutritional intake is also accepted by both the patient, and the family and caregivers to maintain activities of daily living, energy, functional capacity, and to have more successful treatments.[1] Patients' spouses and relatives are more concerned about patients' weight loss than are the patients. Patients feel more pressurized when they are forced to eat, which affects their relationships negatively.[33] Individualized nutritional counseling is the most effective nutritional intervention, and ensuring consistent and adequate nutrition is one of the most important factors that can overcome predictable post-treatment deterioration.[24,34,35]

In multidisciplinary teams providing cancer treatment, an oncology dietitian should always be included. Patients receiving active treatment should be evaluated by an oncology dietitian and provided with medical nutrition therapy if necessary.[31] The main goal of nutrition therapy is to protect oral nutrition while food-related discomfort is minimized with strategies such as individualized diet counseling, food fortification and ONS.[36] Dietary recommendations should be provided considering factors such as food quality, portion size, meal timing and consistency compliance to optimize energy and protein intake. The dietitian can provide personalized recommendations based on the patient's energy expenditure, disease status and food preferences. In nutritional counseling, symptoms such as anorexia, nausea, dysphagia, abdominal bloating, diarrhea and constipation should be addressed, and compliance should be encouraged by explaining the reasons and goals of the nutritional recommendations to the patient.[37]

After all assessments are performed, a dietitian should inform the patient about the personalized nutrition plan in a relaxed and calm environment, where the patient's relatives are present if possible and allow them to ask questions. A significant obstacle to behavioral change is that patients generally do not consider nutrition as therapy. Animated videos, easily understandable illustrated educational materials, brochures, and other patient-focused resources can be effective in educating patients about nutrition-based treatments.[11,32]

It is recommended that dietetic counseling should be held face to face within the first 4 days after treatment is started, once a week during the first half of treatment, and then once every 2 weeks for the remaining period. Between the nutritional counseling sessions held face to face, additional counseling can be given on the telephone if necessary.

Use of supplements and complementary practices

The prevalence of complementary and alternative medicine use among adult patients with cancer in the United States is approximately 36%.[38] Interactions between medicinal plants and foods and oral antineoplastic agents are an issue that should be taken into consideration, because the complementary medicine combinations used may interact with cancer medication taken by patients and lead to negative results. Although there are a limited number of studies conducted on the pharmacokinetic interactions of dietary supplements and cancer drugs, there is evidence of several possible interactions and adverse reactions. Certain components of foods and dietary supplements (e.g., St. John's wort, grapefruit juice, and epigallocatechin gallate obtained from green tea") may alter the pharmacokinetics of certain types of drugs.[39]

Inappropriate or excessive use of dietary supplements during and after treatment may also lead to serious problems. In a study in which the use of antioxidant dietary supplements (selenium, multivitamins, zinc, and vitamins A, C, and E) before and after diagnosis in postmenopausal breast cancer survivors was investigated, it was demonstrated that the risk of total death increased and recurrence-free survival worsened with the use of antioxidant dietary supplements during CT or RT.[40]

Oral nutrition support and dietary strategies

A nutrition education program including nutritional change lists, quick, easy and nutritious snack ideas appropriate for the patient's needs, nutritional measures that can be taken against symptoms should be arranged, and plans for personalized meals and recipes should be made.[11] In the literature, studies in which dietary counseling has been demonstrated to help prevent discontinuation of treatment in patients receiving adjuvant RT or CT, to increase oral protein and energy intake, body weight and quality of life, and to reduce the frequency and severity of toxicity are available.[14,34,41,42] In several studies, it has been reported that regular dietary counseling is superior

to interventions that provide ONS alone in maintaining quality of life, and the positive effect continues even three months after RT in the outcomes of patients in the group receiving counseling.[34,41,43] It has been reported that providing additional ONS results in better weight gain, increases protein-calorie intake, improves quality of life, and is associated with better anticancer treatment tolerance.[44] Dietary counselling and use of ONS should be the first step towards increasing oral energy and protein intake to improve clinical outcomes.[45,46] In the Oncology Evidence-Based Nutrition Practice Guidelines, it is indicated that early and intensive nutritional intervention improves weight management and treatment outcomes in a variety of cancers (e.g. breast, ovarian, lung, leukemia, head and neck, colorectal, upper gastrointestinal).

Nutritional intervention increases lean tissue mass, perceived health, patient satisfaction, appetite and treatment tolerance, and shortens length of hospital stay and admissions.[31]

Because of the strong association between nutritional status and quality of life, it has been emphasized that all adult oncology patients should be provided with a nutritional plan after diagnosis.[47] In their systematic review and meta-analysis, Baldwin et al. investigated the effect of dietary intervention in 1414 patients with cancer who were malnourished or at risk of malnutrition, and who received both CT and RT as adjuvant, neoadjuvant, or primary treatment. Oral nutritional intervention by a dietitian improved global quality of life, emotional functioning, dyspnea, and anorexia, but did not affect mortality.[48]

In a randomized controlled trial conducted to compare nutritional outcomes of patients undergoing RT applied to the gastrointestinal or head and neck region according to the radiation oncology medical nutrition protocol of the American Dietetic Association and patients undergoing standard practice, less deterioration was reported in body weight, nutritional status, and quality of life in the protocol group at the end of 12 weeks.

In addition, there were clinically significant differences between the protocol group and standard practice group in terms of lean mass, which suggested that nutritional intervention performed according to the protocols would be more beneficial in patients undergoing RT.[49]

When the patient's diet is planned, it should be taken into consideration that tumors and treatments may affect nutritional status and nutrient absorption. Malnutrition is common in patients with head, neck, and gastrointestinal system cancers, while symptoms such as mucositis, taste changes, dysphagia, nausea, and diarrhea may be observed in patients receiving RT.[14] Fiber and lactose intake has been analyzed in the treatment of diarrhea in patients receiving RT applied to the abdominal and pelvic region.[50-52] In a study, reduced lactose and fiber intake were determined to have no effect on GI toxicity after 12-24 months.[34] In another study, a diet rich in soluble fiber significantly improved GI toxicity.[53]

It is reported that high-fiber and low-fat diets, together with probiotics, have a protective effect against GI toxicity in patients receiving RT.[54] Improvement in RT-related diarrhea results from non-starch polysaccharides. During this period, fluid intake should be increased, and fatty and gas-producing foods should be avoided. In addition, foods rich in potassium and sodium should be recommended.

In case xerostomia and mucositis occurs after RT applied to the head and neck region, patients should be given stews and soft foods, oral nutrition products should be used, and a nutrition plan with sufficient content in terms of vitamin C, beta carotene and vitamin E should be prepared.[55] During this period, oral care should be performed very well, and hard and dry foods, acidic drinks and salty foods should be avoided.

One of the frequently asked questions is the use of antioxidants during RT. Although antioxidant use reduces RT toxicity in patients with head and neck cancer, it may increase overall recurrence and mortality, especially in those who smoke during RT. In studies on the antioxidant use, conflicting effects on treatment toxicity have been revealed.[56] In the ESPEN oncology guideline, it is stated that vitamin and mineral intake should be provided according to recommended dietary allowance and that high-dose micronutrient use should not be recommended unless there are significant deficiencies.[13]

A working group including the members of the Italian Association of Medical Oncology (AIOM), the Italian Society for Clinical Nutrition and Metabolism (SINPE) and the Federation of Voluntary-Based Cancer Organizations (FAVO) published a consensus document in the joint project called "Integration of Nutritional Therapy in Oncology" (INTO)[57] in which appropriate nutritional support for patients with cancer was given in detail.[46] According to this document, the main practical recommendations can be summarized as follows:

a. Nutritional screening should be performed at diagnosis and at regular intervals in patients at risk of malnutrition by using validated tools.

b. Patients at risk of malnutrition should be referred to an oncology dietitian to make a comprehensive nutritional assessment.

c. Nutritional support should include ONS and/or EN, total or supplemental PN, depending on spontaneous food intake, tolerance to and efficacy of food intake, and especially dietary counselling.

d. Alternative hypocaloric anticancer diets (e.g. macrobiotic, ketogenic or vegan diets) are not recommended.

e. Nutritional support can be integrated into palliative care programs based on individual assessments, quality of life impacts, life expectancy and patient awareness.

f. Home artificial feeding should be prescribed and regularly monitored using protocols defined by oncologists and oncology dietitians.

Enteral and Parenteral Nutrition in Oncology

If the patient is able to eat and has a functional gastrointestinal system, nutritional counseling with or without ONS should be the intervention of choice to address changing nutritional demands due to treatment or disease. If oral feeding is inadequate, artificial feeding should be considered. Criteria for increased nutritional measures include the following:

1. if there is inadequate nutritional intake for more than 10 days due to surgery, CT or RT and if it is expected to be less than 50% of requirements
2. if nutrient intake is less than 50% of requirements for more than 1-2 weeks
3. if it is thought that malnourished patients will not be able to take in and/or absorb sufficient amounts of nutrients for a long period of time due to antineoplastic treatments
4. if the tumor mass itself obstructs oral intake and nutrient progression through the upper GI tract, artificial feeding should be considered

The decision whether EN or PN is performed should be made by considering the location and extent of the tumor, complications, treatment plan and purpose, prognosis, general physical condition of the patients, and duration of nutritional support.[45,58] EN should be preferred in artificial nutrition to preserve the function and integrity of intestines and to reduce bacterial translocation and infectious complications. A standard polymeric nutritional formula may be preferred. EN is recommended during CT/RT in malnourished or at-risk patients, if malnutrition or inadequate nutritional intake is present or expected. Routine systematic artificial nutrition is not recommended during RT. PEG or nasogastric tube is recommended in case radiation-induced mucositis is severe or the tumors of the head, neck, or thorax are obstructive.[27] EN is contraindicated in cases of intestinal obstruction or ileus, severe shock, intestinal ischemia, high-output fistula, severe intestinal bleeding, intestinal failure due to radiation enteritis, short bowel syndrome, peritoneal carcinomatosis, and chylothorax.[31]

In these cases, or when EN is inadequate, a combination of EN and PN, or PN alone should be considered.[45] Whatever the nutritional intervention chosen is, monitoring of the patient's compliance is essential.

Micronutrients, macronutrients and muscle preservation

Understanding the nutritional needs of patients and creating targeted plans to prevent or increase low muscle mass in cancer is of great importance. Although evidence varies by the type of the method, in studies on cancer, generally, the following is recommended: energy requirements (25-30 kcal/kg/day), protein (1.0-1.5 g/kg/day), branched-chain amino acids (leucine: 2-4 g/day), glutamine (0.3 g/kg/day), carnitine (4-6 g/day), creatine (5 g/day), fish oil/eicosapentaenoic acid (EPA) (2.0-2.2 g/day eicosapentaenoic acid and 1.5 g/day docosahexaenoic acid), vitamins/minerals (e.g., vitamin D: 600-800 IU/day), and multimodal approaches (nutrition, exercise, pharmaceuticals) aimed at preventing muscle loss. The overall goal is to minimize muscle loss during cancer treatment and to maximize muscle anabolism during recovery. This approach is anticipated to help improve overall health and prognosis by improving treatment tolerance and survival.[59]

Although many patients with cancer are advised to take >1 g/kg/day of protein, this may not be possible all the time. Limited protein intake primarily results from diet-related symptoms that affect dietary intake.[1] In recent guidelines, a higher range of protein intake (1.2–1.5 g/kg/day) is recommended due to the positive effects of higher protein intake on balancing protein and preserving muscle mass. In individuals with sarcopenia and insulin resistance, it is recommended that more energy should be obtained

not from carbohydrates but from fat to reduce glycemic load.[18] The recommended daily carbohydrate intake is <5 g/kg. Physical activity reduces muscle loss by improving insulin sensitivity, suppressing inflammatory mediators, and promoting protein synthesis.[11] Eicosapentaenoic acid (EPA) has been identified as a promising nutrient due to its clinical benefits. Several mechanisms have been proposed to explain the potential benefits of EPA on body composition. Some of them are as follows: inhibition of catabolic stimuli by modulating the production of proinflammatory cytokines, increase in insulin sensitivity which induces protein synthesis, and positive effects on appetite. In several interventional studies, it has been demonstrated that EPA may prevent deterioration of nutritional status and help improve calorie and protein intake. In some other studies, it is stated that n-3 fatty acids may inhibit the proliferation of cancer cells, prevent muscle loss, and reduce CT toxicity.[1,60]

It has been reported that vitamin D deficiency may be related to cancer, and that there is a relationship between low vitamin D levels and muscle loss. Vitamin D may be necessary to optimize the effectiveness of protein supplements. If patients with cancer have vitamin D deficiency, it should be replaced. Then, 600-800 IU of vitamin D supplementation for maintenance purposes is thought to be beneficial in preventing muscle loss. This approach can contribute to the treatment process by supporting patients' general health.[1]

Toward a proactive nutrition care model in oncology

In conclusion, due to the high risk of malnutrition in patients with cancer who undergo treatment, nutritional status should be assessed and monitored at regular intervals and nutritional interventions should be performed when necessary. Oral nutrition and diet education are the basis of nutritional therapy. Depending on the type and location of the disease, individual needs and the level of malnutrition, nutritional and diet counseling should be provided by an oncology dietitian and should be continuously monitored by a multidisciplinary team. In cases of indication, Oral Nutrition Support (ONS), Enteral Nutrition (EN) or Parenteral Nutrition (PN) treatments should be an integral part of the treatment process. The risk of malnutrition should not be ignored in all cancer patients, nutritional therapy should be carried out with proactive interventions on an individual basis, and treatment results should be closely monitored.

Author contribution

The author declare contribution to the paper as follows: Study conception and design: DHB; data collection: DHB; analysis and interpretation of results: DHB; draft manuscript preparation: DHB. The author reviewed the results and approved the final version of the article.

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References

1. Ravasco P. Nutrition in cancer patients. *J Clin Med*. 2019;8:1211. [Crossref]
2. Bossola M. Nutritional interventions in head and neck cancer patients undergoing chemoradiotherapy: a narrative review. *Nutrients*. 2015;7:265-276. [Crossref]
3. de van der Schueren MAE, Laviano A, Blanchard H, Jourdan M, Arends J, Baracos VE. Systematic review and meta-analysis of the evidence for oral nutritional intervention on nutritional and clinical outcomes during chemo(radio)therapy: current evidence and guidance for design of future trials. *Ann Oncol*. 2018;29:1141-1153. [Crossref]
4. Baji DB, Patel JP, Konanur Srinivasa NK, Gande A, Anusha M, Dar H. Nutrition care in cancer surgery patients: a narrative review of nutritional screening and assessment methods and nutritional considerations. *Cureus*. 2022;14:e33094. [Crossref]
5. Fearon K, Strasser F, Anker SD, et al. Definition and classification of cancer cachexia: an international consensus. *Lancet Oncol*. 2011;12:489-495. [Crossref]
6. Martin L, Senesse P, Gioulbasanis I, et al. Diagnostic criteria for the classification of cancer-associated weight loss. *J Clin Oncol*. 2015;33:90-99. [Crossref]
7. Bossi P, Delrio P, Mascheroni A, Zanetti M. The spectrum of malnutrition/cachexia/sarcopenia in oncology according to different cancer types and settings: a narrative review. *Nutrients*. 2021;13:1980. [Crossref]
8. Gannavarapu BS, Lau SKM, Carter K, et al. Prevalence and survival impact of pretreatment cancer-associated weight loss: a tool for guiding early palliative care. *J Oncol Pract*. 2018;14:e238-e250. [Crossref]
9. Bozzetti F. Chemotherapy-induced sarcopenia. *Curr Treat Options Oncol*. 2020;21:7. [Crossref]

10. Ma BW, Chen XY, Fan SD, et al. Impact of sarcopenia on clinical outcomes after radical gastrectomy for patients without nutritional risk. *Nutrition*. 2019;61:61-66. [Crossref]
11. Aprile G, Basile D, Giaretta R, et al. The clinical value of nutritional care before and during active cancer treatment. *Nutrients*. 2021;13:1196. [Crossref]
12. Planas M, Álvarez-Hernández J, León-Sanz M, et al. Prevalence of hospital malnutrition in cancer patients: a sub-analysis of the PREDyCES® study. *Support Care Cancer*. 2016;24:429-435. [Crossref]
13. Arends J, Bodoky G, Bozzetti F, et al. ESPEN guidelines on enteral nutrition: non-surgical oncology. *Clin Nutr*. 2006;25:245-259. [Crossref]
14. Isenring EA, Bauer JD, Capra S. Nutrition support using the American Dietetic Association medical nutrition therapy protocol for radiation oncology patients improves dietary intake compared with standard practice. *J Am Diet Assoc*. 2007;107:404-412. [Crossref]
15. Bauer DJ, Ash S, Davidson LW, et al. Evidence based practice guidelines for the nutritional management of patients receiving radiation therapy of the Dietitians Association of Australia. *Nutr Diet*. 2008;65(Special Issue):1-20. [Crossref]
16. Leis C, Arthur AE, Chen X, Greene MW, Frugé AD. Systematic review of nutrition interventions to improve short term outcomes in head and neck cancer patients. *Cancers (Basel)*. 2023;15:822. [Crossref]
17. Loeliger J, Dewar S, Kiss N, et al. Co-design of a cancer nutrition care pathway by patients, carers, and health professionals: the CanEAT pathway. *Support Care Cancer*. 2023;31:99. [Crossref]
18. Muscaritoli M, Arends J, Bachmann P, et al. ESPEN practical guideline: clinical nutrition in cancer. *Clin Nutr*. 2021;40:2898-2913. [Crossref]
19. Roeland EJ, Bohlke K, Baracos VE, et al. Management of cancer cachexia: ASCO guideline. *J Clin Oncol*. 2020;38:2438-2453. [Crossref]
20. Arends J, Strasser F, Gonella S, et al. Cancer cachexia in adult patients: ESMO clinical practice guidelines. *ESMO Open*. 2021;6:100092. [Crossref]
21. Muscaritoli M, Arends J, Aapro M. From guidelines to clinical practice: a roadmap for oncologists for nutrition therapy for cancer patients. *Ther Adv Med Oncol*. 2019;11:1758835919880084. [Crossref]
22. Ottery FD. Definition of standardized nutritional assessment and interventional pathways in oncology. *Nutrition*. 1996;12:S15-S19. [Crossref]
23. Bauer J, Capra S, Ferguson M. Use of the scored Patient-Generated Subjective Global Assessment (PG-SGA) as a nutrition assessment tool in patients with cancer. *Eur J Clin Nutr*. 2002;56:779-785. [Crossref]
24. Isenring E, Bauer J, Capra S. The scored Patient-generated Subjective Global Assessment (PG-SGA) and its association with quality of life in ambulatory patients receiving radiotherapy. *Eur J Clin Nutr*. 2003;57:305-309. [Crossref]
25. Kwang AY, Kandiah M. Objective and subjective nutritional assessment of patients with cancer in palliative care. *Am J Hosp Palliat Care*. 2010;27:117-126. [Crossref]
26. Laky B, Janda M, Cleghorn G, Obermair A. Comparison of different nutritional assessments and body-composition measurements in detecting malnutrition among gynecologic cancer patients. *Am J Clin Nutr*. 2008;87:1678-1685. [Crossref]
27. Kondrup J, Rasmussen HH, Hamberg O, Stanga Z; Ad Hoc ESPEN Working Group. Nutritional risk screening (NRS 2002): a new method based on an analysis of controlled clinical trials. *Clin Nutr*. 2003;22:321-336. [Crossref]
28. Detsky AS, McLaughlin JR, Baker JP, et al. What is subjective global assessment of nutritional status? *JPEN J Parenter Enteral Nutr*. 1987;11:8-13. [Crossref]
29. Cederholm T, Jensen GL, Correia MITD, et al. GLIM criteria for the diagnosis of malnutrition - a consensus report from the global clinical nutrition community. *Clin Nutr*. 2019;38:1-9. [Crossref]
30. Ruan X, Nakyeyune R, Shao Y, et al. Nutritional screening tools for adult cancer patients: a hierarchical Bayesian latent-class meta-analysis. *Clin Nutr*. 2021;40:1733-1743. [Crossref]
31. Thompson KL, Elliott L, Fuchs-Tarlovsky V, Levin RM, Voss AC, Piemonte T. Oncology evidence-based nutrition practice guideline for adults. *J Acad Nutr Diet*. 2017;117:297-310.e47. [Crossref]
32. Prado CM, Anker SD, Coats AJS, Laviano A, von Haehling S. Nutrition in the spotlight in cachexia, sarcopenia and muscle: avoiding the wildfire. *J Cachexia Sarcopenia Muscle*. 2021;12:3-8. [Crossref]
33. Strasser F, Binswanger J, Cerny T, Kesselring A. Fighting a losing battle: eating-related distress of men with advanced cancer and their female partners. A mixed-methods study. *Palliat Med*. 2007;21:129-137. [Crossref]
34. Ravasco P, Monteiro-Grillo I, Vidal PM, Camilo ME. Dietary counseling improves patient outcomes: a prospective, randomized, controlled trial in colorectal cancer patients undergoing radiotherapy. *J Clin Oncol*. 2005;23:1431-1438. [Crossref]
35. Orell H, Schwab U, Saarilahti K, Österlund P, Ravasco P, Mäkitie A. Nutritional counseling for head and neck cancer patients undergoing (chemo) radiotherapy-a prospective randomized trial. *Front Nutr*. 2019;6:22. [Crossref]
36. Blackwood HA, Hall CC, Balstad TR, et al. A systematic review examining nutrition support interventions in patients with incurable cancer. *Support Care Cancer*. 2020;28:1877-1889. [Crossref]

37. Arends J, Baracos V, Bertz H, et al. ESPEN expert group recommendations for action against cancer-related malnutrition. *Clin Nutr*. 2017;36:1187-1196. [Crossref]

38. Collado-Borrell R, Escudero-Vilaplana V, Romero-Jiménez R, Iglesias-Peinado I, Herranz-Alonso A, Sanjurjo-Sáez M. Oral antineoplastic agent interactions with medicinal plants and food: an issue to take into account. *J Cancer Res Clin Oncol*. 2016;142:2319-2330. [Crossref]

39. PDQ Integrative, Alternative, and Complementary Therapies Editorial Board. Cancer Therapy Interactions With Foods and Dietary Supplements (PDQ®): Health Professional Version. In: PDQ Cancer Information Summaries. Bethesda, MD: National Cancer Institute (US); 2002. Available at: https://www.ncbi.nlm.nih.gov/books/NBK563071/

40. Jung AY, Cai X, Thoene K, et al. Antioxidant supplementation and breast cancer prognosis in postmenopausal women undergoing chemotherapy and radiation therapy. *Am J Clin Nutr*. 2019;109:69-78. [Crossref]

41. Ravasco P, Monteiro-Grillo I, Marques Vidal P, Camilo ME. Impact of nutrition on outcome: a prospective randomized controlled trial in patients with head and neck cancer undergoing radiotherapy. *Head Neck*. 2005;27:659-668. [Crossref]

42. van den Berg MG, Rasmussen-Conrad EL, Wei KH, Lintz-Luidens H, Kaanders JH, Merkx MA. Comparison of the effect of individual dietary counselling and of standard nutritional care on weight loss in patients with head and neck cancer undergoing radiotherapy. *Br J Nutr*. 2010;104:872-877. [Crossref]

43. Ravasco P, Monteiro-Grillo I, Camilo M. Individualized nutrition intervention is of major benefit to colorectal cancer patients: long-term follow-up of a randomized controlled trial of nutritional therapy. *Am J Clin Nutr*. 2012;96:1346-1353. [Crossref]

44. Cereda E, Cappello S, Colombo S, et al. Nutritional counseling with or without systematic use of oral nutritional supplements in head and neck cancer patients undergoing radiotherapy. *Radiother Oncol*. 2018;126:81-88. [Crossref]

45. Arends J, Bachmann P, Baracos V, et al. ESPEN guidelines on nutrition in cancer patients. *Clin Nutr*. 2017;36:11-48. [Crossref]

46. Caccialanza R, Pedrazzoli P, Cereda E, et al. Nutritional support in cancer patients: a position paper from the Italian Society of Medical Oncology (AIOM) and the Italian Society of Artificial Nutrition and Metabolism (SINPE). *J Cancer*. 2016;7:131-135. [Crossref]

47. Polański J, Jankowska-Polańska B, Mazur G. Relationship between nutritional status and quality of life in patients with lung cancer. *Cancer Manag Res*. 2021;13:1407-1416. [Crossref]

48. Baldwin C, Spiro A, Ahern R, Emery PW. Oral nutritional interventions in malnourished patients with cancer: a systematic review and meta-analysis. *J Natl Cancer Inst*. 2012;104:371-385. [Crossref]

49. Isenring EA, Capra S, Bauer JD. Nutrition intervention is beneficial in oncology outpatients receiving radiotherapy to the gastrointestinal or head and neck area. *Br J Cancer*. 2004;91:447-452. [Crossref]

50. Garcia-Peris P, Velasco C, Hernandez M, et al. Effect of inulin and fructo-oligosaccharide on the prevention of acute radiation enteritis in patients with gynecological cancer and impact on quality-of-life: a randomized, double-blind, placebo-controlled trial. *Eur J Clin Nutr*. 2016;70:170-174. [Crossref]

51. Wedlake L, Shaw C, McNair H, et al. Randomized controlled trial of dietary fiber for the prevention of radiation-induced gastrointestinal toxicity during pelvic radiotherapy. *Am J Clin Nutr*. 2017;106:849-857. [Crossref]

52. Pettersson A, Nygren P, Persson C, Berglund A, Turesson I, Johansson B. Effects of a dietary intervention on gastrointestinal symptoms after prostate cancer radiotherapy: long-term results from a randomized controlled trial. *Radiother Oncol*. 2014;113:240-247. [Crossref]

53. Wedlake LJ, McGough C, Shaw C, et al. Clinical trial: efficacy of a low or modified fat diet for the prevention of gastrointestinal toxicity in patients receiving radiotherapy treatment for pelvic malignancies. *J Hum Nutr Diet*. 2012;25:247-259. [Crossref]

54. Allenby TH, Crenshaw ML, Mathis K, et al. A systematic review of home-based dietary interventions during radiation therapy for cancer. *Tech Innov Patient Support Radiat Oncol*. 2020;16:10-16. [Crossref]

55. Chung MK, Kim DH, Ahn YC, Choi JY, Kim EH, Son YI. Randomized trial of vitamin c/e complex for prevention of radiation-induced xerostomia in patients with head and neck cancer. *Otolaryngol Head Neck Surg*. 2016;155:423-430. [Crossref]

56. Harvie M. Nutritional supplements and cancer: potential benefits and proven harms. *Am Soc Clin Oncol Educ Book*. 2014;undefined:e478-e486. [Crossref]

57. Caccialanza R, De Lorenzo F, Pedrazzoli P. The integrating nutritional therapy in oncology (INTO) project: rationale, structure and preliminary results. *ESMO Open*. 2017;2:e000221. [Crossref]

58. Cotogni P, Pedrazzoli P, De Waele E, et al. Nutritional therapy in cancer patients receiving chemoradiotherapy: should we need stronger recommendations to act for improving outcomes? *J Cancer*. 2019;10:4318-4325. [Crossref]

59. Prado CM, Purcell SA, Laviano A. Nutrition interventions to treat low muscle mass in cancer. *J Cachexia Sarcopenia Muscle*. 2020;11:366-380. [Crossref]

60. Murphy RA, Mourtzakis M, Mazurak VC. n-3 polyunsaturated fatty acids: the potential role for supplementation in cancer. *Curr Opin Clin Nutr Metab Care*. 2012;15:246-251. [Crossref]

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Optimizing pediatric home parenteral nutrition with adult-designed commercial multichamber parenteral nutrition bags: a case report

Iffah Syuhaidah Mohd Johari[1], Meng Sheng Teng[1], Mohd Haz Hairul Amran[2], See Bee Ng[1]

[1]Hospital Kuala Lumpur, Ministry of Health, Kuala Lumpur, Malaysia
[2]Hospital Tunku Azizah, Ministry of Health, Kuala Lumpur, Malaysia

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ABSTRACT

Background: Parenteral Nutrition (PN) is a life-sustaining therapy for patients with intestinal failure (IF), especially those with severe bowel dysmotility. Home Parenteral Nutrition (HPN) can reduce hospital stays and improve quality of life. While adult-designed commercial multichamber parenteral nutrition bags (AMCB-PN) are widely used in adults, their application in pediatric patients remains underexplored.

Case Presentation: We report a male patient born in 2008 with bowel dysmotility and malabsorption, requiring long-term PN since infancy. After initial stabilization with a 2-in-1 PN regimen, he was discharged with HPN at one year of age. Despite attempts to wean off PN, he continued to require partial PN support. In 2019, the patient transitioned from a 2-in-1 PN system to a standardized AMCB-PN regimen. This change significantly reduced caregiver burden by eliminating frequent lipid syringe changes and minimizing infusion pump requirements. Over five years of AMCB-PN use, the patient maintained stable weight gain, demonstrated good tolerance to oral intake, and remained free of major complications.

Discussion: This case demonstrates the feasibility and safety of using AMCB-PN in a pediatric patient with chronic intestinal failure. Benefits included improved sleep quality, reduced infection risk, simplified administration, and cost savings of approximately 52% annually. Despite the patient being physically smaller than age norms, he remained active with improved quality of life.

Conclusion: Standardized AMCB-PN can be a safe, cost-effective, and patient-friendly alternative to in-house compounded PN in selected pediatric patients, offering significant clinical and operational advantages in home-based care.

Keywords: parenteral nutrition, home parenteral nutrition, multichamber bag, pediatric intestinal failure, AMCB-PN, case report

Introduction

Parenteral Nutrition (PN) is an intravenous administration method that delivers essential macronutrients, electrolytes, and micronutrients directly into the bloodstream, bypassing the digestive system entirely.[1] It is essential for the management of patients with intestinal failure (IF). Severe protracted intestinal failure can result from short bowel syndrome, congenital diseases, and severe intestinal motility disorders. In these

Corresponding author: Iffah Syuhaidah Mohd Johari
Email: iffah_syuhaidah@ymail.com

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chronic scenarios, long-term parenteral nutrition is often necessary to sustain life.[2] For those requiring prolonged PN support, Home Parenteral Nutrition (HPN) offers the potential to reduce hospital stays and improve the quality of life for both patients and caregivers.[1]

The latest ESPGHAN recommendations endorse the use of standard licensed multichambered bag for patients of the same age group with similar conditions. This approach aims to enhance safety, improve stability, reduce time pressure, ensure better quality control, and optimize resources for better cost-effectiveness while maintaining the quality of care.[3] Individualized PN formulations should only be considered when daily prescription changes are necessary according to the patient's past medical condition and the latest laboratory tests, or when standardized formulas are unable to meet the requirements.[3] With advancements in technology, the use of multichambered or all-in-one (AIO) standardised PN solution bags has proven to be both feasible and safe for use.[4,5] While limited research is available on the use of adult-designed commercial multichambered parenteral nutrition bags (AMCB-PN) in paediatric patients between 2 to 18 years of age, this case underscores the potential for safe and effective application of a standard AMCB-PN within the paediatric population.

Main Points

- Long-term home parenteral nutrition (HPN) was successfully managed in a pediatric patient with bowel dysmotility using initially a 2-in-1 PN formulation, transitioning later to adult-designed commercial multichamber PN bags (AMCB-PN).
- Switching from 2-in-1 PN to AMCB-PN improved safety and convenience by reducing the frequency of lipid syringe changes, lowering infection risk, and simplifying infusion with a single pump.
- The use of adult-designed multichamber PN bags in pediatric patients, although traditionally considered nutritionally inadequate, was demonstrated to be feasible, safe, and effective in this selected case.
- The transition to AMCB-PN resulted in significant cost savings (approximately 52% reduction in annual costs) by decreasing consumable use and pump maintenance expenses.
- Multidisciplinary Nutrition Therapy Teams (NTTs) played a critical role in optimizing PN regimens, monitoring patient progress, and ensuring safe home administration over many years.

Case Presentation

A male patient was born on September 2008 at Hospital Tunku Jaafar with body weight 3.6kg. At 4 months of age, the child was referred from Klinik Kesihatan Beranang to Hospital Kajang due to persistent vomiting and inadequate weight gain, with the child's weight remaining stagnant at 4 kg. Subsequently, he was transferred from Hospital Kajang to Hospital Tunku Azizah, previously known as Institut Pediatrik Hospital Kuala Lumpur, for further evaluation of abdominal distension, vomiting, diarrhoea, and continued poor weight gain. On January 2009, inborn errors of metabolism (IEM) screening were conducted and the result come back as normal, however, a subsequent rectal biopsy was performed, and the finding was ganglionic.

A laparotomy, ileostomy and small bowel biopsy were performed in January 2009. During the operation, the finding was dilated small intestines with edematous appearance and lacteal appearance on the outer surface. His small intestines length is 92cm with no evidence of malrotation or adhesion while large intestines and appendix were found normal. Result of the histopathological examination (HPE) then revealed ganglionic small intestine, ileum and no intramucosal or submucosal dilated lymphatic.

The patient was diagnosed with malabsorption secondary to bowel dysmotility. Parenteral nutrition using a 2-in-1 formulation was initiated in January 2009 via a peripherally inserted central catheter (PICC). Throughout his hospitalization, he was closely monitored for nutritional intake, fluid and electrolyte balance, and catheter care, in accordance with clinical protocols.

In March 2009 the patient underwent bishop-koop procedure and insertion of central venous lines (CVL). Intraoperatively, a prolapsed proximal ileum was seen. HPE result shown morphological appearance on both proximal ileostomy end and distal ileostomy end with no significant inflammation on the appendix.

In September 2009, the HKL team has come to an agreement that the nutritional requirements and the PN regimen had been stabilized and optimized. He was discharged from HKL at the age of 1 years old with home parenteral nutrition (HPN) at the frequency of 3 times per week with duration of 18-hour infusion. Prior to discharge, the patient's mother underwent 3 week in-ward training and demonstrated competence in HPN management, including line care and the preparation of enteral and

parenteral nutrition using strict aseptic technique. His family also has made all the necessary adjustment and renovation of their house in Beranang, Selangor ensuring they have a dedicated room that meets safety standards and is suitable for PN administration, in accordance with the guidelines.

A bowel motility study conducted at the age of 4 demonstrated normal findings. The team then decided to reduce PN and increase oral feeding and subsequently able to off PN in September 2012. However, after 2 weeks his weight shows reducing in trend with his current weight is 11.6kg. He was then started back on same PN regimen with frequency of 3 times per week.

With advancing age, the patient's PN regimen was adjusted annually to ensure adequate nutrient delivery based on age and weight specific requirements. Summary of patient's PN regimen was tabulated in Table 1. As of 2024, at 16 years of age, the patient's estimated energy requirement was approximately 30-55kcal/kg/day.[6] Discussions have been made by healthcare professional regarding his parenteral nutrition treatment including the use of standard AMCB-PN. Even though changing from 2-in-1 PN to AMCB-PN is safe and feasible, 2-in-1 PN still the most preferred PN among healthcare professional as well as patient caretaker.

In December 2019, following a series of discussions, the family agreed to the transition from 2-in-1 formulation to AMCB-PN regimen. Patient's clinical progress are summarized in Table 2. Initially, when home parenteral nutrition began in 2009, the infusion duration was set at 18 hours. As the patient began attending school at the age of six, the infusion duration was gradually reduced to 12 hours, which normally started around 6.00 pm and finish at 6.00am.

Discussion

Parenteral nutrition (PN) is a vital, life-saving therapy, particularly for patients with type II and type III intestinal failure (IF) who require long-term dependency. Despite its benefits, PN is associated with high costs and significant risks, such as line infections, electrolyte imbalances, liver dysfunction, and cardiac failure.[7] To address these challenges and reduce misuse, expert organizations like the British Association for Parenteral and Enteral Nutrition (BAPEN) and NICE strongly recommend that PN patients be managed by multidisciplinary Nutrition Therapy Teams (NTTs).[8] These teams have been shown to improve patient outcomes and achieve cost savings.[9,10]

At our institution, we are proud to have established NTTs composed of doctors and dietitians from Hospital Tunku Azizah (HTA) and pharmacists from Hospital Kuala Lumpur (HKL). Pharmacists oversee the drafting, preparation, and monitoring of PN, while dietitians focus on managing enteral nutrition. Additionally, our NTTs regularly review all active in-ward and home PN patients through a minimum of three-monthly meetings, ensuring thorough oversight and tailored care. This collaborative approach minimizes risks, enhances patient outcomes, and upholds the highest standards of efficiency and quality care.

At our facility, production is conducted within a horizontal laminar flow cabinet housed in a controlled Grade B environment compliant with GMP (Good Manufacturing Practice) standards. Our in-house 2-in-1 parenteral nutrition (PN) system combines amino acids, dextrose, and electrolytes into a single infusion bag, while lipids are administered separately via a Y-site connector using 50 ml syringes. This method requires two infusion pumps and extensive line manipulation, increasing the risk of infection and infusion errors.[11]

In contrast, the 3-in-1 PN system combines all components—amino acids, dextrose, electrolytes, and lipids—into a single-chamber intravenous solution bag. Manual preparation involves extracting specific volumes from bulk bottles and mixing them in the Intravenous bag, making it prone to compounding errors and formulation instability due to complex chemical interactions within a single container. Although it simplifies PN administration, the 3-in-1 system poses risks related to decreased stability of the final formulation.[12]

Our facility lacks the equipment needed to test and maintain the specifications outlined in USP, limiting our ability to ensure long-term product stability and patient safety.[13] To address this, our team uses proprietary stability-checking software from a reputable provider to identify potential incompatibilities. We limit the beyond-use date of in-house compounded PN to two days and transition to AMCB-PN whenever appropriate.

Adult-designed commercial multichambered parenteral nutrition bags (AMCB-PN) is preferred for home PN (HPN) due to its established stability, allowing convenient weekly outpatient dispensing. In our setting, all additives are incorporated under controlled conditions prior to patient use, ensuring consistency and safety. In contrast, in-house compounded PN remains viable for only a few days, requiring more frequent pharmacy visits for HPN patients.

Table 1. Summary of parenteral nutrition regimen delivered from 2011 until 2024

PN Contents	Jan 2011	Mac 2012	Jan 2013	Mac 2014	Apr 2015	Feb 2016	Mac 2017
Macronutrient							
Amino acids (g/kg/day)	3.50	3.50	3.50	3.50	3.50	3.00	3.00
Glucose (g/kg/day)	13.02	11.96	9.03	8.03	8.03	8.57	8.57
Fat (g/kg/day)	3.00	3.00	3.00	3.00	3.00	2.65	2.65
Electrolytes							
Sodium (mmol/kg/day)	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Potassium (mmol/kg/day)	3.00	3.00	3.00	3.00	3.00	2.50	2.50
Calcium (mmol/kg/day)	0.20	0.20	0.20	0.20	0.20	0.18	0.18
Magnesium (mmol/kg/day)	0.09	0.03	0.03	0.03	0.03	0.03	0.03
Phosphate (mmol/kg/day)	0.10	0.09	0.09	0.09	0.09	0.08	0.08
Micronutrient							
Water soluble vitamins (ml/day)	9.50	10	10	10	10	10	10
Fat soluble vitamins (ml/day)							
Trace elements (ml/day)	9.50	10	10	10	10	10	10
Total Volume (ml/kg/day)	100	93	88	80	80	71	71
Total Calorie (kcal/kg/day)	96	91	80	76	76	73	73
Duration of PN infusion (hour)	18	16	12	12	12	12	12
Type of PN bag	2-in-1						
PN Contents	**Mac 2018**	**Dec 2019**	**Jan 2020**	**Apr 2021**	**Aug 2022**	**Nov 2023**	**Mac 2024**
Macronutrient							
Amino acids (g/kg/day)	3.00	2.50	3.00	3.75	3.36	3.19	3.10
Glucose (g/kg/day)	8.58	6.25	7.56	9.35	8.39	7.96	7.70
Fat (g/kg/day)	2.65	2.50	2.27	2.80	2.50	2.40	2.30
Electrolytes							
Sodium (mmol/kg/day)	3.00	2.00	2.43	3.00	2.70	2.50	2.48
Potassium (mmol/kg/day)	2.50	1.50	1.80	2.60	2.00	1.90	1.86
Calcium (mmol/kg/day)	0.18	0.12	0.16	0.19	0.17	0.16	0.16
Magnesium (mmol/kg/day)	0.03	0.25	0.31	0.38	0.33	0.32	0.31
Phosphate (mmol/kg/day)	0.08	0.60	0.77	0.95	0.85	0.81	0.76
Micronutrient							
Water soluble vitamins (ml/day)	10	10	10	10	10	10	10
Fat soluble vitamins (ml/day)							
Trace elements (ml/day)	10	10	10	10	10	10	10
Total Volume (ml/kg/day)	71	50	60	75	67	63	61
Total Calorie (kcal/kg/day)	73	55	65	80	71	68	66
Duration of PN infusion (hour)	12	12	10	12	12	12	12
Type of PN bag	2-in-1	Adult-Designed Commercial Multichamber Parenteral Nutrition					

Table 2. Summary of patient clinical progress.

Date	Event
Sept 2008	Born at Hospital Tunku Jaafar, birth weight 3.6 kg.
Jan 2009	Referred to Hospital Kajang due to vomiting, poor weight gain (4 kg),
	Transferred to Hospital Tunku Azizah (HKL) for further evaluation.
Jan 2009	IEM screening – Normal
	Rectal biopsy – Ganglionic
	Laparotomy, ileostomy, small bowel biopsy performed
	Started on 2-in-1 PN via PICC
Mar 2009	Bishop-Koop procedure and CVL insertion
	HPE: No significant inflammation
Sept 2009	Discharged with Home PN (3 times per week regimen)
Sept 2012	Trial of stopping PN, increased oral feeding. Not successful. Continue same PN regime
Dec 2019	Transitioned from 2-in-1 PN to adult-designed commercial multichamber parenteral nutrition bags

The patient's treatment progress has been consistently monitored by healthcare professionals in collaboration with the family over the years. Currently, the patient's body weight is recorded at range of 25.2 kg to 25.5 kg, which is below the expected weight for his age according to the Malaysian standard growth chart for boys aged 2 to 20 years.[14] However, despite this, he is demonstrating positive weight gain with the use of an AMCB-PN, as indicated by data collected from 2019 to 2024 as shown in Figure 1. Although he is physically smaller than other children of the same age, he remains active and has not experienced any other medical issues.

This patient is receiving 45% to 85%, as per tabulated in Table 3, of their calorie intake through parenteral nutrition, while also benefiting from oral nutrition. He can tolerate oral intake effectively, primarily consisting of three main meals daily. This combined strategy successfully promotes his growth even in the presence of bowel dysmotility, ultimately contributing to an improved survival rate.[15]

As the lipid volume increase, there were more syringes to be infuse. Switching to an AMCB-PN significantly eliminated the need for frequent overnight syringe changes, reducing it from 5 to 6 times per night to none. This improvement greatly enhancing sleep quality for both patients and caregivers.

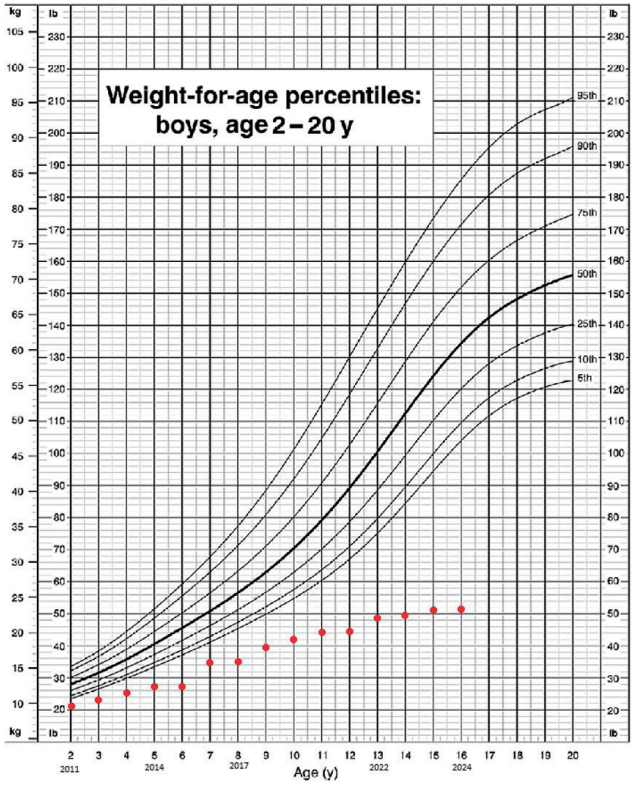

Figure 1. Summary of patient body weight for age from 2011 until 2024

Utilizing an AMCB-PN minimizes interruptions during lipid syringe changes with 2-in-1 preparation, which significantly lowers the risk of infection and ensures a more continuous infusion flow. This practice not only enhances safety for patients but also contributes to improved overall outcomes by promoting consistent PN delivery without the complications associated with frequent handling and connections such as catheter related infection.[16]

Moreover, transitioning to an AMCB-PN system reduces the requirement from two infusion pumps to one. A single infusion pump costs approximately 3000 Malaysian Ringgit (MYR) with an annual maintenance cost of MYR 300. This change significantly reduced pump-related maintenance expenses, contributing to improved cost-effectiveness in patient care without compromising treatment protocols. Additionally, consumables such as extra 0.2-micron filters and dressing set required for 2-in-1 PN administration cost around MYR 30 per day. Eliminating the need for these consumables further reduced the overall cost. Collectively, this transition resulted in an estimated 52% reduction in total annual costs.

Although the use of commercially premixed standardized parenteral nutrition is a common practice in well-developed regions such as Europe and Australia, its adoption in developing countries like Malaysia remains limited due to niche market size and restricted availability. Additionally, adult-designed multichamber parenteral nutrition bags (AMCB-PNs) have been reported to be nutritionally inadequate for paediatric populations.[4,17] However, the present case demonstrates that the use of AMCB-PN may be both feasible and safe in selected paediatric patients.

Conclusion

The case shows the shift from in-house 2-in-1 PN compounding to adult-designed commercial multichambered parenteral nutrition bags (AMCB-PN) was associated with improved ease of administration, fewer line manipulations, and reduced caregiver demands. The patient experienced enhanced sleep quality and demonstrated stable weight gain, maintaining an active lifestyle despite underlying growth limitations. Additionally, the approach helped lower equipment and consumable use, with estimated cost savings of approximately MYR 6,000 per year. These observations may offer insight into the clinical and operational benefits of AMCB-PN in selected cases.

Table 3. Summary of nutrient required and delivered to patient via parenteral route.

Macro & Micronutrients	2017 9 years old		2018 10 years old		2019 11 years old		2021 13 years old		2024 16 years old	
	Body weight: 15.4kg		Body weight: 17.9kg		Body weight: 19.3kg		Body weight: 20kg		Body weight: 25.3kg	
	Requirement	Delivered	Requirement	Delivered	Requirement	Delivered	Requirement	Delivered	Requirement	Delivered
Energy (kcal/kg/day)	55-65	31.40 (48%)	55-65	31.40 (48%)	55-65	31 (48%)	30-55	45.92 (83%)	30-55	36.16 (66%)
Amino Acids (g/kg/day)	2	1.29 (65%)	2	1.29 (65%)	2	1.29 (65%)	2	2.14 (107%)	2	1.66 (83%)
Glucose (g/kg/day)	4.3-8.6	3.71 (43%)	4.3-8.6	3.71 (43%)	4.3-8.6	3.61 (42%)	4.3-8.6	5.34 (62%)	4.3-8.6	4.23 (49%)
Lipids (g/kg/day)	3 (max)	1.14 (38%)	3	1.14 (38%)	3	1.14 (38%)	3	1.60 (53%)	3 (max)	1.26 (42%)
Dextrose to Lipid Ratio	60 : 40	56 : 44	60 : 40	56:44	60 : 40	55:45	60 : 40	57:43	60 : 40	57:43

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Ethical approval

This study has been approved by the Medical Research and Ethics Committee (MREC), Ministry of Health Malaysia (18.07.2025, RSCH ID-25-04700-Q9L). Written informed consent was obtained from the participants.

Author contribution

The authors declare contribution to the paper as follows: Study conception and design: ISMJ, MST, MHHA, SBN; data collection: ISMJ, SBN; analysis and interpretation of results: MST, MHHA; draft manuscript preparation: ISMJ, MST; All authors reviewed the results and approved the final version of the article.

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Conflict of interest

The authors declare that there is no conflict of interest.

References

1. Jochum F, Moltu SJ, Senterre T, et al. ESPGHAN/ESPEN/ESPR/CSPEN guidelines on pediatric parenteral nutrition: fluid and electrolytes. *Clin Nutr*. 2018;37:2344-2353. **[Crossref]**
2. Goulet O, Ruemmele F. Causes and management of intestinal failure in children. *Gastroenterology*. 2006;130:16-28. **[Crossref]**
3. Riskin A, Picaud JC, Shamir R. ESPGHAN/ESPEN/ESPR/CSPEN guidelines on pediatric parenteral nutrition: standard versus individualized parenteral nutrition. *Clin Nutr*. 2018;37:2409-2417. **[Crossref]**
4. Colomb V. Commercially premixed 3-chamber bags for pediatric parenteral nutrition are available for hospitalized children. *J Nutr*. 2013;143:2071-2076. **[Crossref]**
5. Meyer R, Timmermann M, Schulzke S, Kiss C, Sidler MA, Furlano RI. Developing and implementing all-in-one standard paediatric parenteral nutrition. *Nutrients*. 2013;5:2006-2018. **[Crossref]**
6. Joosten K, Embleton N, Yan W, Senterre T. ESPGHAN/ESPEN/ESPR/CSPEN guidelines on pediatric parenteral nutrition: energy. *Clin Nutr*. 2018;37:2309-2314. **[Crossref]**
7. Austin PD, Stroud M, Gales BJ. *Prescribing adult intravenous nutrition*. Pharmaceutical press; 2007. **[Crossref]**
8. Baker M, Harbottle L. Parenteral nutrition. In: Manual of dietetic practice. Wiley-Blackwell; 2014:357-364.
9. Kennedy JF, Nightingale JM. Cost savings of an adult hospital nutrition support team. *Nutrition*. 2005;21:1127-1133. **[Crossref]**
10. Hvas CL, Farrer K, Donaldson E, et al. Quality and safety impact on the provision of parenteral nutrition through introduction of a nutrition support team. *Eur J Clin Nutr*. 2014;68:1294-1299. **[Crossref]**
11. Blackmer AB, Partipilo ML. Three-in-one parenteral nutrition in neonates and pediatric patients: risks and benefits. *Nutr Clin Pract*. 2015;30:337-343. **[Crossref]**
12. Boullata JI, Mirtallo JM, Sacks GS, et al. Parenteral nutrition compatibility and stability: a comprehensive review. *JPEN J Parenter Enteral Nutr*. 2022;46:273-299. **[Crossref]**
13. United States Pharmacopeia (USP). Globule size distribution in lipid injectable emulsions (Chapter 729). In: United States Pharmacopeial Convention. 2010.
14. Kuczmarski RJ. CDC growth charts: United States. US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics; 2000.
15. Bering J, DiBaise JK. Home parenteral and enteral nutrition. *Nutrients*. 2022;14:2558. **[Crossref]**
16. Crooks B, Harrison S, Millward G, et al. Catheter-related infection rates in patients receiving customized home parenteral nutrition compared with multichamber bags. *JPEN J Parenter Enteral Nutr*. 2022;46:254-257. **[Crossref]**
17. Caba Porras I, Cabello Muriel A, Oya Alvarez de Morales B, Marín Pozo JF, García Aranda J, Llácer Pérez C. Assessment of standard parenteral nutrition in children. *Nutr Hosp*. 2010;25:449-455.