

## ORIGINAL RESEARCH ARTICLE

# Nutritional assessment in daily practice among oncology outpatients: A clinic experience

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## Abstract

**Introduction:** Malnutrition is a common yet frequently underdiagnosed complication in cancer patients and is strongly associated with poor prognosis. Early identification through accurate screening and comprehensive nutritional assessment is essential for improving nutritional status and quality of life.

**Objective:** The objective of this study was to evaluate the nutritional status of adult cancer patients using the Patient-Generated Subjective Global Assessment (PG-SGA) in combination with anthropometric, biochemical, and dietary parameters.

**Methods:** This cross-sectional study assessed the nutritional status of 279 adult cancer outpatients using the PG-SGA, supplemented by medical and dietary histories, physical examinations, anthropometric measurements, and laboratory parameters.

**Results:** According to PG-SGA scores, 31.3% of men and 12.6% of women were classified as severely malnourished. Anthropometric values showed a significant decline across PG-SGA categories, from well-nourished (PG-SGA-A) to severely malnourished (PG-SGA-C) patients ( $p < 0.05$ ). Serum albumin, total protein, hemoglobin, and total cholesterol levels were significantly higher in PG-SGA-A patients, whereas C-reactive protein was elevated in PG-SGA-C patients ( $p < 0.05$ ). Analysis of nutrient intake revealed higher consumption of fiber, fat, saturated fat, and cholesterol among PG-SGA-A patients compared with PG-SGA-C patients ( $p < 0.05$ ). Body weight, body mass index, mid-upper arm circumference, triceps skinfold thickness, mid-upper arm muscle area, mid-upper arm muscle circumference, and lean body mass were all negatively correlated with malnutrition severity ( $p < 0.05$ ).

**Conclusion:** These findings confirm the high prevalence of malnutrition in oncology outpatients and underscore the importance of integrating both subjective and objective tools for early detection and timely management of malnutrition in cancer care.

**Keywords:** Cancer; Malnutrition; Patient-Generated Subjective Global Assessment; Nutrition assessment; Nutritional status

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## 1. Introduction

Malnutrition represents a frequent and clinically significant complication in oncology, with prevalence rates ranging from 20% to 80% depending on patient age, tumor type and stage, comorbidities, and treatment modalities.<sup>1,2</sup> Of the approximately 9.7 million

annual deaths from cancer, nearly 20% are attributable to malnutrition and its complications rather than to the malignancy itself.<sup>3,4</sup> Malnutrition adversely affects prognosis by complicating treatment, increasing mortality, and reducing quality of life.<sup>5</sup> Therefore, early identification and timely nutritional interventions are critical to improving clinical outcomes.<sup>6</sup>

Guidelines recommend nutritional risk screening at the time of cancer diagnosis, followed by a comprehensive assessment for patients identified as at risk.<sup>7-9</sup> This process typically includes screening, assessment, and intervention as complementary steps.<sup>6,10</sup> Screening enables the early detection of risk through simple tools, whereas assessment identifies and quantifies the type and degree of malnutrition, thereby determining its severity. The resulting data must be interpreted by healthcare professionals to identify nutritional problems and implement targeted interventions.<sup>6,11</sup>

The goal of comprehensive nutritional evaluation is to tailor therapy according to the patient's clinical status, treatment plan, and expected symptom burden. According to the American Society for Parenteral and Enteral Nutrition, nutritional assessment should integrate medical and dietary history, physical examination, anthropometric measurements, and laboratory data, guiding therapy aimed at improving treatment tolerance, symptom control, and quality of life.<sup>9</sup>

Among available tools, the Patient-Generated Subjective Global Assessment (PG-SGA) is the screening and assessment instrument most widely recommended by the American Dietetic Association's Oncology Nutrition Group for oncology patients.<sup>12</sup> PG-SGA scores are strongly associated with weight loss, length of hospital stay, quality of life, and dietary intake, while also capturing key prognostic indicators such as dietary barriers and functional status.<sup>12</sup>

Supportive care, including nutritional management, constitutes a central component of oncology practice, as nutrition substantially influences both treatment response and quality of life.<sup>11</sup> In this context, the present study aimed to comprehensively evaluate the nutritional status of cancer outpatients using the PG-SGA in combination with clinical and dietary history, anthropometric and biochemical measurements, and assessment of physical activity.

## 2. Materials and methods

### 2.1. Ethical approval

Ethical approval for the study was obtained under decision number 95/2017, granted by the Clinical Research Ethics

Committee of the Zekai Tahir Burak Women's Health Education and Research Hospital. Detailed information about the study was provided to all participants, who subsequently gave their written informed consent.

### 2.2. Study design and participants

This study included 279 adult cancer patients (135 females and 144 males, aged  $\geq 18$  years) who were receiving treatment at the medical or radiation oncology units of Dr. Abdurrahman Yurtaslan Ankara Oncology Hospital. Patients were excluded if they had missing anthropometric data; physical or psychiatric conditions that impaired participation; language barriers; or declined to provide consent. General information (age, sex, and weight loss at 1 and 6 months) was collected through face-to-face interviews, whereas cancer-related characteristics (type, location, stage, duration, and treatment) were obtained from medical records. Anthropometric and dietary assessments were performed by a trained dietitian.

### 2.3. Anthropometric measurements

Body weight and composition were measured using the TANITA BC 532 (Tanita Corporation, Tokyo, Japan) device under standardized conditions (e.g.,  $\geq 4$  h fasting, minimal clothing, no contact with metal objects, and no recent rigorous physical activity). Height was measured with a portable stadiometer, with feet together and the head in the Frankfurt plane.<sup>13</sup> Body mass index (BMI) was calculated as body weight (kg) divided by height squared ( $m^2$ ).<sup>14,15</sup> Mid-upper arm circumference (MUAC) was measured midway between the acromion and olecranon, with the arm positioned at  $90^\circ$  flexion, using a non-elastic tape. Triceps skinfold thickness (TSF) was measured using a Holtain caliper at the same midpoint, with the arm relaxed after the measurement site was marked. Measurements were taken 3 times, and the average was recorded.<sup>13</sup> Mid-upper arm muscle area (MUAMA) was calculated using the standard formula (Equation [I]):<sup>16</sup>

$$MUAMA \text{ (cm}^2\text{)} = \frac{[MUAC - (\pi * TSF)]^2}{4\pi} - x \quad (I)$$

where  $\pi = 3.1416$ , and  $x = 10 \text{ cm}^2$  for males and  $6.5 \text{ cm}^2$  for females.

Mid-upper arm muscle circumference (MUAMC) is less affected by malnutrition than MUAMA; therefore, MUAMA more accurately reflects muscle atrophy. MUAMC was calculated using the standard formula:<sup>16</sup>

$$MUAMC \text{ (cm)} = MUAC - (\pi * TSF) \quad (II)$$

where  $\pi = 3.1416$ .

## 2.4. Biochemical results

Serum albumin, total protein, lymphocyte count, C-reactive protein (CRP), hemoglobin, hematocrit, calcium, and total cholesterol values for the previous 3 months were obtained from hospital records. As this was a retrospective analysis, fasting conditions were not consistently recorded in patient files; however, blood samples were collected in the morning according to standard clinical practice.

## 2.5. Assessment of nutritional intake

### 2.5.1. Food intake

Food intake was assessed using a single 24-h dietary recall conducted by an expert dietitian. Portion sizes were estimated based on the “Standard Food Recipes” and “Examples from Turkish Cuisine” references,<sup>17,18</sup> whereas Gram equivalents were determined using the “Food and Food Photograph Catalog”<sup>19</sup> to standardize portion size estimation and ensure consistent reporting. Daily energy and nutrient intakes were analyzed using a Turkey-specific BeBiS program (Ebispro for Windows, Stuttgart, Germany; Turkish Version), and adequacy was evaluated based on Dietary Reference Intake (DRI) recommendations.<sup>20</sup>

### 2.5.2. Assessment of nutritional status

The nutritional status of patients was assessed using the PG-SGA, which includes questions on weight loss, common nutrition-related symptoms, and a physical examination evaluating fat stores, muscle mass, and fluid status.<sup>12</sup> The physical examination was conducted by a clinical physician, whereas nutritional status scoring was performed by a trained dietitian. Each PG-SGA item was scored from 0 to 4 based on its impact on nutritional status; higher scores indicate greater risk. Scores  $\geq 9$  require immediate nutritional intervention; scores 4–8 require dietitian-led care in collaboration with medical staff; scores 2–3 warrant symptom-based management; and scores 0–1 indicate no need for nutritional intervention.<sup>21,22</sup> Based on total PG-SGA scores, patients were classified as well-nourished (A), moderately/suspected malnourished (B), or severely malnourished (C).<sup>12</sup>

## 2.6. Statistical analysis

Data analysis was performed using SPSS version 22.0 (IBM, United States of America). For comparisons between two independent groups, the independent samples *t*-test was applied to normally distributed variables, whereas the Mann–Whitney U test was used for non-normally distributed data. One-way ANOVA was employed to compare three groups with normally distributed data; Tukey or Tamhane's T2 tests were applied *post hoc* based

on Levene's test results. For non-normally distributed data across three groups, the Kruskal–Wallis test was used, followed by Bonferroni-corrected Mann–Whitney U tests for pairwise comparisons. The Chi-square test was used to analyze associations between categorical variables. Correlation analyses were performed using Pearson or Spearman correlation coefficients, depending on data distribution. Statistical significance was set at  $p < 0.05$ .

## 3. Results

### 3.1. General characteristics of cancer patients

This study included 114 men (mean age  $59.7 \pm 11.8$ ) and 135 women (mean age  $52.9 \pm 11.2$ ). According to the PG-SGA, 54.2% of men and 23.7% of women scored  $\geq 9$ , indicating a need for urgent nutritional intervention. The distributions of PG-SGA stage A, B, and C were 45.8%, 22.9%, and 31.3% in men, and 76.3%, 11.1%, and 12.6% in women, respectively. Weight loss  $\geq 5\%$  in 1 month was reported by 88.1% of men and 96.3% of women, whereas losses  $> 5\%$  over 6 months occurred in 41% of men and 20% of women, respectively. Only 14.6% of men and 9.6% of women reported no nutritional problems. Common nutrition-impact symptoms included dry mouth, taste changes, mouth sores, loss of appetite, nausea, and constipation (Table 1).

### 3.2. PG-SGA distributions according to cancer history

The most common cancer types among participants were breast (31.2%), gastrointestinal (26.5%), thoracic (12.2%), and genitourinary (11.5%). Based on the PG-SGA, 43.2% of breast cancer patients were well-nourished, whereas 30.9% of gastrointestinal cancer patients and 22.7% of thoracic cancer patients were classified as moderately to severely malnourished. When cancers were grouped anatomically, patients with abdominal malignancies (including gastrointestinal and gynecological cancers) showed a higher prevalence of moderate-to-severe malnutrition compared with those with non-abdominal tumor sites. Among stage IV patients, 60.9% had moderate or severe malnutrition. Regarding treatment types, 30.8% received only chemotherapy and 23.3% received only radiotherapy (Table 2).

### 3.3. Anthropometric and biochemical parameters

Anthropometric and biochemical parameters by PG-SGA groups are presented in Table 3. Anthropometric measurements showed a significant decrease from well-nourished (PG-SGA-A) to severely malnourished (PG-SGA-C) patients ( $p < 0.05$ ). Similarly, most biochemical parameters declined across groups, except for CRP, which increased with worsening nutritional status.

**Table 1. General characteristics of the participants and PG-SGA distributions**

Specifications	Male (n=144)	Female (n=135)
Age (years)	59.7±11.8	52.9±11.2
BMI (kg/m <sup>2</sup> )	26.4±4.4	29.5±5.4
Duration since diagnosis (months)	16.1±28.9	22.7±41.2
Age of diagnosis (years)	57.9±11.6	50.6±11.1
Nutritional diagnosis		
Well-nourished (stage A)	66 (45.8)	103 (76.3)
Moderate or suspected malnutrition (stage B)	33 (22.9)	15 (11.1)
Severe malnutrition (stage C)	45 (31.3)	17 (12.6)
Nutritional intervention		
No intervention required (0–1 point)	6 (4.2)	7 (5.2)
Nutrition education required for patient and family (2–3 points)	17 (11.8)	18 (13.3)
Nutritional intervention required (4–8 points)	43 (29.9)	78 (57.8)
Critical nutrition intervention required (≥ 9 points)	78 (54.2)	32 (23.7)
Body weight loss		
In 1 month		
<5%	127 (88.1)	130 (96.3)
≥5%	17 (11.9)	5 (3.7)
In 6 months		
≤5%	85 (59.0)	108 (80.0)
>5%	59 (41.0)	27 (20.0)
Physical activity (according to PG-SGA)		
Normal, no limitations	47 (32.6)	31 (23.0)
Fairly normal activities	53 (36.8)	64 (47.4)
Less than half of the day in bed	20 (13.9)	26 (19.3)
Rarely out of bed	24 (16.7)	14 (10.4)
Nutrition-impact symptoms <sup>a</sup>		
No problem eating	21 (14.6)	13 (9.6)
No appetite	48 (33.3)	11 (8.1)
Nausea	43 (29.9)	46 (34.1)
Vomiting	23 (16.0)	13 (9.6)
Constipation	59 (41.0)	46 (34.1)
Diarrhea	23 (16.0)	12 (8.9)
Sore mouth	18 (12.5)	18 (13.3)
Dry mouth	56 (38.9)	60 (44.4)
Things taste funny	46 (31.9)	52 (38.5)
Smells bother me	33 (22.9)	52 (38.5)
Feel full quickly	29 (20.1)	40 (29.6)
Pain	38 (26.4)	26 (19.3)
Problem swallowing	22 (15.3)	31 (23.0)
Other	6 (4.2)	14 (10.4)

Note: Data are presented as mean±standard deviation or n (%).

<sup>a</sup>Patients could report more than one symptom.

Abbreviations: BMI: Body mass index; PG-SGA: Patient-Generated Subjective Global Assessment; SD: Standard deviation.

### 3.4. Dietary intake

Daily energy and nutrient intakes by PG-SGA groups and DRI coverage rates are presented in Table 4. Fiber, fat, saturated fatty acid, and cholesterol intakes were significantly higher in the PG-SGA-A group than in the PG-SGA-C group ( $p<0.05$ ). The percentage of DRI energy coverage was 78.4±32.14 in men and 78.4±29.62 in women, while protein intake was adequate in both sexes.

Correlations with PG-SGA scores are shown in Table 5. A positive correlation was found between PG-SGA score and age ( $r=0.146$ ,  $p=0.015$ ), whereas body weight, BMI, MUAC, TSF, MUAMA, MUAMC, and lean body mass were negatively correlated with PG-SGA scores ( $p<0.05$ ). Albumin and total protein levels also showed significant negative correlations with PG-SGA scores. Similarly, energy and macronutrient intakes were inversely associated with PG-SGA scores ( $p<0.05$ ).

## 4. Discussion

Malnutrition is a common comorbidity in cancer patients, influenced by both the disease process and anticancer treatments.<sup>2</sup> Its development is multifactorial, with determinants including patient age, tumor type and stage, treatment-related side effects, and functional status.<sup>23</sup> In the present study, nutritional status was comprehensively assessed using the PG-SGA, anthropometric measurements, dietary parameters, and biochemical markers. Consistent with previous reports, malnutrition was more prevalent among older patients, reflecting the influence of comorbidities, polypharmacy, reduced mobility, and age-related physiological changes.<sup>8,24–26</sup> The mean age at diagnosis was 57.9±11.6 years in men and 50.6±11.1 years in women, and according to the PG-SGA, 54.2% of men and 23.7% of women were classified in the combined categories B and C, indicating a need for nutritional intervention. These findings align with earlier studies reporting a high but variable prevalence of malnutrition depending on the care setting, comorbidity burden, cancer characteristics, and the assessment methods employed.<sup>1,23</sup>

In our cohort, women had a higher BMI and were predominantly diagnosed with breast cancer. This context likely contributes to the apparent lower severity of malnutrition among women by masking nutritional deficits with weight gain and adiposity. Weight gain during and after breast cancer treatment, linked to chemotherapy, endocrine therapy, reduced activity, and treatment-related metabolic changes, is well documented<sup>27</sup> and may coexist with loss of muscle mass (sarcopenic obesity), thereby underestimating malnutrition when BMI is used alone. These patterns can lead to lower PG-SGA severity classifications despite clinically relevant nutrition risk.

Table 2. Information on participants' cancer histories and treatments

Cancer characteristics	Total (N=279)	PG-SGA		p-value
	n (%)	A (well-nourished) (n=169)	B+C (moderate+severe malnutrition) (n=110)	
Cancer type				
Breast	87 (31.2)	73 (43.2)	14 (12.7)	<0.001*
Gastrointestinal	74 (26.5)	40 (23.7)	34 (30.9)	
Thoracic	34 (12.2)	9 (5.3)	25 (22.7)	
Genitourinary	32 (11.5)	19 (11.2)	13 (11.8)	
Head and neck	16 (5.7)	6 (3.6)	10 (9.1)	
Gynecological	15 (5.4)	8 (4.7)	7 (6.4)	
Brain	7 (2.5)	4 (2.4)	3 (2.7)	
Lymphoid	5 (1.8)	4 (2.4)	1 (0.9)	
Other	9 (3.2)	6 (3.6)	3 (2.7)	
Cancer stage				
I	28 (10.0)	22 (13.0)	6 (5.5)	<0.001*
II	55 (19.7)	42 (24.9)	13 (11.8)	
III	72 (25.8)	48 (28.4)	24 (21.8)	
IV	124 (44.5)	57 (33.7)	67 (60.9)	
Treatment				
Only CT	86 (30.8)	42 (24.9)	44 (40.0)	<0.001*
Only RT	65 (23.3)	47 (27.8)	18 (16.2)	
CRT	56 (20.1)	23 (13.6)	33 (30.0)	
Targeted therapy	13 (4.7)	12 (7.1)	1 (0.9)	
Immunotherapy	6 (2.2)	4 (2.4)	2 (1.8)	
CT and targeted therapy	39 (14.0)	29 (17.2)	10 (9.1)	
CT and immunotherapy	1 (0.3)	1 (0.6)	-	
CRT and targeted therapy	1 (0.3)	1 (0.6)	-	
RT and targeted therapy	12 (4.3)	10 (5.9)	2 (1.8)	

Note: \* $p < 0.05$ ; one-way ANOVA test.

Abbreviations: CRT: Chemoradiotherapy; CT: Chemotherapy; PG-SGA: Patient-generated subjective global assessment; RT: Radiotherapy.

Accordingly, sex-specific screening that incorporates body composition and functional measures may better capture hidden malnutrition in women with breast cancer.

Physical inactivity represents another important contributor to adverse outcomes in oncology. It is a recognized risk factor for cancer development,<sup>13</sup> and accumulating evidence suggests that higher levels of physical activity during treatment are associated with improved aerobic capacity, muscle strength, quality of life, and reduced fatigue and anxiety.<sup>7</sup> Several studies have demonstrated an inverse association between regular physical activity and cancer-related mortality.<sup>28,29</sup> In a cohort of colorectal cancer patients, 73.4% reported no regular physical activity, primarily due to chemotherapy

or radiotherapy and their associated side effects, such as fatigue and reduced physical performance.<sup>30</sup> Nevertheless, meta-analyses of randomized controlled trials confirm that physical activity is both safe and well-tolerated across different cancer types and stages.<sup>7,31</sup> These results highlight the importance of incorporating structured exercise and rehabilitation into supportive cancer care.

Weight loss in cancer patients is driven by both tumor-related metabolic alterations and reduced dietary intake. Symptoms such as anorexia, nausea, altered taste, dry mouth, dysphagia, and constipation frequently impair food intake.<sup>32</sup> In line with these reports, 87.8% of participants in our study experienced at least one symptom affecting oral intake, most commonly taste alterations,



**Table 3. Distribution of anthropometric measurements and biochemical parameters according to PG-SGA classification**

Anthropometry	PG-SGA			<i>p</i> -value
	A ( <i>n</i> =169)	B ( <i>n</i> =48)	C ( <i>n</i> =62)	
Body weight (kg)	76.6±14.08 <sup>a</sup>	74.3±13.51 <sup>a,b</sup>	68.2±12.98 <sup>b</sup>	<0.001*
BMI (kg/m <sup>2</sup> )	29.1±4.92 <sup>a</sup>	27.0±4.34 <sup>b</sup>	25.4±5.20 <sup>b</sup>	<0.001*
MUAC (cm)	29.5±3.84 <sup>a</sup>	28.0±3.56 <sup>b</sup>	26.0±4.27 <sup>c</sup>	<0.001*
TSF (mm)	18.9±8.28 <sup>a</sup>	13.6±7.23 <sup>b</sup>	11.6±7.51 <sup>b</sup>	<0.001*
MUAMA (cm <sup>2</sup> )	37.0±10.05 <sup>a</sup>	36.1±8.12 <sup>a</sup>	31.4±9.73 <sup>b</sup>	0.001*
MUAMC (cm)	23.6±2.75 <sup>a</sup>	23.7±2.35 <sup>a</sup>	22.4±2.59 <sup>b</sup>	0.007*
Body fat ratio (%)	32.4±8.42 <sup>a</sup>	27.6±7.88 <sup>b</sup>	23.5±10.34 <sup>c</sup>	<0.001*
Biochemical parameters				
Albumin (g/dL)	4.0 (0.43) <sup>a</sup>	3.8 (0.40) <sup>b</sup>	3.7 (0.93) <sup>b</sup>	<0.001*
Total protein (g/dL)	6.8±0.69 <sup>a</sup>	6.5±0.80 <sup>b</sup>	6.5±0.96 <sup>b</sup>	0.017*
Lymphocyte %	24.1±11.38 <sup>a</sup>	23.6±9.89 <sup>a,b</sup>	19.9±8.85 <sup>b</sup>	0.027*
CRP (g/L) <sup>‡</sup>	7.9 (19.30) <sup>a</sup>	28.7 (98.98) <sup>b</sup>	43.2 (93.00) <sup>b</sup>	<0.001*
Hemoglobin (g/dL)	12.2±1.63 <sup>a</sup>	11.9±1.94 <sup>a,b</sup>	11.5±1.83 <sup>b</sup>	0.021*
Hematocrit (%)	37.7±4.73 <sup>a</sup>	36.7±5.60 <sup>a,b</sup>	35.6±5.15 <sup>b</sup>	0.013*
Calcium (mg/dL)	9.3±0.57 <sup>a</sup>	9.0±0.70 <sup>b</sup>	9.0±0.79 <sup>b</sup>	<0.001*
Total cholesterol (mg/dL) <sup>§</sup>	216.0±48.74 <sup>a</sup>	200.1±49.85 <sup>a,b</sup>	183.9±50.71 <sup>b</sup>	0.004*

Notes: Data are expressed as mean±standard deviation for normally distributed variables and as median (interquartile range) for non-normally distributed variables. \**p*<0.05; depending on the normality, one-way ANOVA or Kruskal–Wallis test. Different letters represent differences between groups. <sup>‡</sup>CRP levels were examined in 169 patients. <sup>§</sup>Total cholesterol levels were measured in 171 patients.

Abbreviations: BMI: Body mass index; CRP: C-reactive protein; IQR: Interquartile range; MUAC: Mid-upper arm circumference; MUAMA: Mid-upper arm muscle area; MUAMC: Mid-upper arm muscle circumference; SD: Standard deviation; PG-SGA: Patient-generated subjective global assessment; TSF: Triceps skinfold thickness.

odor sensitivity, early satiety, dry mouth, and nausea. These findings are comparable to previous studies in patients with head and neck cancers and in hospitalized cancer patients, where advanced disease and treatment-related symptoms were shown to significantly contribute to malnutrition.<sup>23,33</sup> Together, this evidence emphasizes that both metabolic alterations and nutrition-impact symptoms must be addressed to effectively prevent and manage malnutrition in oncology care. Recent research also underlines the importance of integrating subjective and objective nutritional assessment tools—such as the PG-SGA Short Form and biochemical or anthropometric parameters—for early detection and effective management of malnutrition.<sup>34,35</sup>

Nutritional status is also strongly influenced by cancer type, disease stage, and treatment modality.<sup>8,15</sup> Based on global cancer statistics reported by the International Agency for Research on Cancer, the most frequently diagnosed cancers in men are lung, prostate, and colorectal cancers, whereas in women, breast cancer remains the leading type, followed by colorectal and lung cancers.<sup>36</sup> In our cohort, the most frequent cancer types were breast, gastrointestinal, and thoracic cancers. Nearly half of the

participants (44.5%) were diagnosed with stage IV disease. Previous studies found malnutrition risks of 21.6% in stage III and 56.9% in stage IV patients, regardless of cancer type,<sup>37</sup> supporting the strong association between advanced disease stage and poorer nutritional status. Treatment variability further affects nutrition. In our study, 30.8% of patients received chemotherapy, 23.3% radiotherapy, and 20.1% chemoradiotherapy. These results are consistent with earlier studies identifying chemotherapy as the most commonly administered treatment modality.<sup>1,15</sup> Differences in treatment distribution across studies may reflect variations in sample size, cancer type, and data collection timing.

Anthropometric measurements are widely applied to assess nutritional status; however, conventional indices such as body weight and height may be misleading in cancer patients due to factors including edema, dehydration, or tumor mass.<sup>38</sup> To overcome these limitations, we incorporated TSF and MUAC, along with calculated MUAMA and MUAMC values. Comprehensive evaluations that integrate weight loss, appetite reduction, and lean body mass depletion are particularly important in this population.<sup>38,39</sup> In our cohort, body weight, BMI, and all

**Table 4. Distribution of daily energy, macronutrient, and micronutrient intakes based on 24-h dietary recall, according to PG-SGA and DRI percentages by gender**

Energy and nutrients	PG-SGA			$p^1$	DRI (%)		$p^2$
	A ( $n=169$ ), $\bar{X} \pm SD^c$ or median <sup>d</sup> (IQR)	B ( $n=48$ ), $\bar{X} \pm SD^c$ or median <sup>d</sup> (IQR)	C ( $n=62$ ), $\bar{X} \pm SD^c$ or median <sup>d</sup> (IQR)		Male ( $n=144$ ), $\bar{X} \pm SD^c$ or median <sup>d</sup> (IQR)	Female ( $n=135$ ), $\bar{X} \pm SD^c$ or median <sup>d</sup> (IQR)	
Energy (kcal)	1,812.6 (870.95)	1,625.8 (968.67)	1,746.9 (961.80)	0.077	78.4 $\pm$ 32.14 <sup>f</sup>	78.4 $\pm$ 29.62 <sup>f</sup>	0.988
Energy (kcal/kg)	24.6 (12.89)	23.5 (12.07)	25.3 (19.12)	0.746	ND		-
Protein (g)	67.7 $\pm$ 26.78	63.4 $\pm$ 23.36	60.9 $\pm$ 32.48	0.216	126.0 $\pm$ 53.77 <sup>c</sup>	130.4 $\pm$ 51.56 <sup>c</sup>	0.490
Protein (g/kg)	0.8 (0.47)	0.8 (0.43)	1.0 (0.85)	0.768	ND		-
Protein (TE %)	14.2 $\pm$ 2.63	14.4 $\pm$ 2.97	14.7 $\pm$ 3.59	0.452	ND		-
Carbohydrate (g)	220.8 $\pm$ 106.81	201.0 $\pm$ 75.21	187.6 $\pm$ 94.98	0.211	172.3 (90.28) <sup>c</sup>	132.3 (72.43) <sup>c</sup>	<0.001*
Carbohydrate (TE %)	44.9 $\pm$ 8.94	45.5 $\pm$ 8.50	46.1 $\pm$ 10.08	0.666	ND		-
Fiber (g)	21.8 (14.54) <sup>a</sup>	18.0 (14.28) <sup>a,b</sup>	16.3 (15.85) <sup>b</sup>	0.014*	72.7 $\pm$ 38.30 <sup>f</sup>	93.3 $\pm$ 51.10 <sup>f</sup>	<0.001*
Fat (g)	81.9 (46.79) <sup>a</sup>	81.5 (41.42) <sup>a,b</sup>	70.4 (51.97) <sup>b</sup>	0.016*	ND		-
Fat (TE %)	40.9 $\pm$ 8.24	40.2 $\pm$ 7.39	39.2 $\pm$ 9.00	0.357	ND		-
SFA (g)	25.0 (16.01) <sup>a</sup>	26.0 (15.40) <sup>a,b</sup>	21.1 (17.54) <sup>b</sup>	0.013*	ND		-
Cholesterol (mg)	311.0 $\pm$ 180.41 <sup>a</sup>	274.1 $\pm$ 164.70 <sup>a,b</sup>	243.0 $\pm$ 185.07 <sup>b</sup>	0.032*	ND		-
Vitamin A (mcg)	917.7 (1168.24) <sup>a</sup>	870.7 (967.17) <sup>a,b</sup>	769.3 (769.83) <sup>b</sup>	0.004*	89.1 (98.66) <sup>c</sup>	138.7 (150.04) <sup>c</sup>	<0.001*
Vitamin E (mg)	22.2 (18.61) <sup>a</sup>	19.1 (16.98) <sup>a,b</sup>	16.8 (19.20) <sup>b</sup>	0.032*	149.0 (135.22) <sup>f</sup>	132.2 (117.67) <sup>f</sup>	0.120
Vitamin B1 (mg)	0.9 (0.51)	0.8 (0.61)	0.8 (0.67)	0.058	75.4 (54.79) <sup>c</sup>	74.5 (43.64) <sup>c</sup>	0.926
Vitamin B2 (mg)	1.3 (0.69)	1.3 (0.72)	1.2 (0.80)	0.132	97.3 (62.69) <sup>c</sup>	114.5 (60.91) <sup>c</sup>	0.031*
Niacin equivalent (mg)	23.3 $\pm$ 10.47 <sup>a</sup>	20.1 $\pm$ 7.96 <sup>a,b</sup>	19.0 $\pm$ 11.85 <sup>b</sup>	0.012*	13.9 (86.03) <sup>c</sup>	140.5 (81.14) <sup>c</sup>	0.467
Vitamin B6 (mg)	1.4 (0.84) <sup>a</sup>	1.3 (0.86) <sup>a,b</sup>	1.2 (1.03) <sup>b</sup>	0.017*	93.8 $\pm$ 51.60 <sup>c</sup>	96.7 $\pm$ 45.75 <sup>c</sup>	0.617
Folic acid (mcg)	354.1 $\pm$ 162.74 <sup>a</sup>	309.4 $\pm$ 163.05 <sup>a,b</sup>	278.4 $\pm$ 159.55 <sup>b</sup>	0.005*	84.1 $\pm$ 43.63 <sup>c</sup>	80.6 $\pm$ 38.43 <sup>c</sup>	0.483
Vitamin B12 (mcg)	3.5 (3.10)	4.2 (3.96)	3.1 (2.82)	0.122	139.2 (133.96) <sup>c</sup>	150.8 (132.50) <sup>c</sup>	0.852
Calcium (mg)	677.7 $\pm$ 314.94	691.0 $\pm$ 299.17	611.4 $\pm$ 366.10	0.325	58.6 $\pm$ 30.95 <sup>f</sup>	58.8 $\pm$ 27.29 <sup>f</sup>	0.960
Iron (mg)	12.9 $\pm$ 5.78	12.0 $\pm$ 5.85	10.8 $\pm$ 6.79	0.073	149.2 (96.06) <sup>c</sup>	85.9 (101.22) <sup>c</sup>	<0.001*
Zinc (mg)	9.4 (5.02)	9.7 (6.31)	8.8 (8.42)	0.403	86.8 (60.36) <sup>c</sup>	113.3 (65.63) <sup>c</sup>	0.001*

Notes: <sup>a,b</sup>Different letters denote differences between groups. <sup>c</sup>For variables with normal distribution; <sup>d</sup>For variables without normal distribution.

<sup>e</sup>Recommended dietary allowances; <sup>f</sup>Adequate intakes. \* $p < 0.05$ ;  $p^1$  For three-group comparisons, parametric data were evaluated with one-way ANOVA and non-parametric data with the Kruskal–Wallis test.  $p^2$  For comparisons between two independent groups, the independent samples  $t$ -test was applied to normally distributed data, while the Mann–Whitney U test was used for non-normally distributed variables.

Abbreviations: DRI: Dietary reference intakes; ND: Not determined; PG-SGA: Patient-Generated Subjective Global Assessment; SD: Standard deviation; SFA: Saturated fatty acids; TE: Total energy.

anthropometric indicators were significantly higher in well-nourished patients and showed a stepwise decline across moderate and severe malnutrition groups ( $p < 0.05$ ). PG-SGA scores were inversely correlated with all anthropometric parameters ( $p < 0.05$ ). Similar findings have been reported previously, demonstrating decreases in anthropometric values from PG-SGA-A to PG-SGA-C and a strong negative correlation between PG-SGA scores and anthropometric indicators.<sup>40</sup> These results confirm that anthropometric values reliably decline with worsening nutritional status.

Biochemical measurements also provide valuable insights into nutritional status. In our study, serum albumin and total protein levels were significantly higher

in well-nourished patients, whereas CRP was elevated in malnourished groups, with significant differences across PG-SGA categories ( $p < 0.05$ ). PG-SGA scores were negatively correlated with serum albumin and protein levels ( $p < 0.05$ ). These observations are consistent with studies in gastric cancer and large mixed cancer cohorts, in which malnourished patients exhibited lower serum albumin, total cholesterol, and lymphocyte counts compared with well-nourished patients.<sup>40,41</sup> These findings support the expected inverse relationship between nutritional biomarkers and PG-SGA scores, as cancer-related inflammation and metabolic changes frequently reduce serum protein levels.

Table 5. Correlations between PG-SGA and anthropometric measurements, biochemical parameters, energy intake, and macronutrients

Variables	Body weight (kg)	BMI (kg/m <sup>2</sup> )	MUAC (cm)	TSF (mm)	MUAMA (cm <sup>2</sup> )	MUAMC (cm)	Lean body mass (kg)	PG-SGA score	Serum albumin (g/dL)	Serum protein (g/dL)	Energy (kcal)	Carbohydrate (g)	Protein (g)	Fat (g)
Age (y)	0.066, p=0.269	0.081, p=0.176	-0.060, p=0.322	-0.232, **p<0.001	0.086, p=0.153	0.140, *p=0.020	0.072, p=0.233	0.146, *p=0.015	-0.173, **p=0.004	-0.103, p=0.087	-0.112, p=0.063	-0.094, p=0.117	-0.021, p=0.727	-0.141, *p=0.019
Body weight (kg)	-	0.819, **p<0.001	0.754, **p<0.001	0.392, **p<0.001	0.754, **p<0.001	0.767, **p<0.001	0.717, **p<0.001	-0.220, **p<0.001	0.143, *p=0.017	0.109, p=0.070	0.024, p=0.686	0.037, p=0.535	-0.026, p=0.669	0.026, p=0.665
BMI (kg/m <sup>2</sup> )	-	-	0.870, **p<0.001	0.691, **p<0.001	0.708, **p<0.001	0.647, **p<0.001	0.266, **p<0.001	-0.258, **p<0.001	0.189, **p=0.002	0.159, **p=0.008	-0.121, *p=0.044	-0.131, *p=0.028	-0.137, *p=0.022	-0.072, p=0.233
MUAC (cm)	-	-	-	0.769, **p<0.001	0.841, **p<0.001	0.770, **p<0.001	0.253, **p<0.001	-0.324, **p<0.001	0.247, **p<0.001	0.150, *p=0.012	-0.081, p=0.179	-0.106, p=0.076	-0.092, p=0.127	-0.024, p=0.688
TSF (mm)	-	-	-	-	0.313, **p<0.001	0.183, **p=0.002	-0.208, **p<0.001	-0.314, **p<0.001	0.214, **p<0.001	0.132, *p=0.027	-0.165, **p=0.006	-0.213, **p<0.001	-0.146, *p=0.015	-0.077, p=0.197
MUAMA (cm <sup>2</sup> )	-	-	-	-	-	0.980, **p<0.001	0.479, **p<0.001	-0.220, **p<0.001	0.196, **p=0.001	0.123, *p=0.041	-0.004, p=0.943	-0.004, p=0.944	-0.029, p=0.635	0.010, p=0.863
MUAMC (cm)	-	-	-	-	-	-	0.596, **p<0.001	-0.185, **p=0.002	0.166, **p=0.005	0.099, p=0.100	0.041, p=0.496	0.049, p=0.411	0.004, p=0.942	0.040, p=0.504
Lean body mass (kg)	-	-	-	-	-	-	-	-0.032, p=0.592	0.008, p=0.889	0.025, p=0.673	0.205, **p=0.001	0.239, **p<0.001	0.119, *p=0.048	0.153, *p=0.010
PG-SGA score	-	-	-	-	-	-	-	-	-0.257, **p<0.001	-0.096, p=0.109	-0.229, **p<0.001	-0.215, **p<0.001	-0.182, **p=0.002	-0.221, **p<0.001
Serum albumin (g/dL)	-	-	-	-	-	-	-	-	-	0.411, **p<0.001	0.004, p=0.947	-0.014, p=0.811	-0.003, p=0.964	0.026, p=0.670
Serum protein (g/dL)	-	-	-	-	-	-	-	-	-	-	0.008, p=0.893	-0.009, p=0.887	0.020, p=0.743	0.026, p=0.661
Energy (kcal)	-	-	-	-	-	-	-	-	-	-	-	0.925, **p<0.001	0.897, **p<0.001	0.913, **p<0.001
Carbohydrate (g)	-	-	-	-	-	-	-	-	-	-	-	-	0.771, **p<0.001	0.702, **p<0.001
Protein (g)	-	-	-	-	-	-	-	-	-	-	-	-	-	0.816, **p<0.001

Notes: \*p<0.05; \*\*p<0.01.

Abbreviations: BMI: Body mass index; MUAC: Mid-upper arm circumference; MUAMA: Mid-upper arm muscle area; MUAMC: Mid-upper arm muscle circumference; PG-SGA: Patient-Generated Subjective Global Assessment; TSF: Triceps skinfold thickness.



Nutritional intake is another determinant of cancer-related outcomes. Adequate nutritional support is essential to prevent malnutrition and maintain treatment tolerance.<sup>6</sup> European Society for Clinical Nutrition and Metabolism guidelines recommend 25–30 kcal/kg/day of energy and at least 1 g/kg/day of protein intake for cancer patients, comparable to healthy adults.<sup>7</sup> However, requirements may increase in cases of stress, transplantation, or sepsis, reaching >35 kcal/kg/day and up to 2.5 g/kg/day of protein under hypermetabolic or catabolic conditions.<sup>17,40,42</sup> Intake is considered inadequate when patients are unable to eat for more than 1 week or consume < 60% of their energy requirements for longer than 1–2 weeks.<sup>7</sup> In this study, PG-SGA scores correlated negatively with energy, protein, carbohydrate, and fat intake ( $p < 0.05$ ). Comparable findings were reported in older cancer patients, where significant differences in macronutrient intake were observed across PG-SGA categories (A, B, C).<sup>4</sup> In our cohort, energy and protein intake per kilogram, as well as fat intake, declined progressively from PG-SGA-A to PG-SGA-C, although the differences were not always statistically significant. Collectively, these findings confirm that higher PG-SGA scores reflect poorer nutritional status and insufficient nutrient intake. To address such deficiencies, nutritional interventions should focus on individualized, energy- and protein-dense meal plans, early initiation of oral nutritional supplements, and, when necessary, enteral or parenteral support to maintain adequate intake. Supplementation with omega-3 polyunsaturated fatty acids and immunonutrition formulas has shown potential to improve appetite, reduce inflammation, and enhance treatment tolerance.<sup>43,44</sup> Regular follow-up by a clinical dietitian and the integration of nutritional care into routine oncology practice are essential to prevent further deterioration and to support recovery.

The strengths of this study include its comprehensive evaluation of nutritional status using multiple assessment modalities in a relatively large outpatient cohort. However, limitations include its single-center design and cross-sectional nature, which restrict causal inferences and generalizability. Early identification and proactive management of malnutrition are critical to improving outcomes in oncology care. Implementing routine nutritional screening at diagnosis, complemented by advanced techniques such as bioelectrical impedance analysis and metabolic biomarkers, may facilitate timely interventions. Multidisciplinary nutrition support and structured follow-up should be considered essential components of cancer care protocols to reduce malnutrition-related complications, improve treatment adherence, and enhance quality of life. Future multicenter,

longitudinal studies are warranted to validate these findings and determine the long-term benefits of early, personalized nutritional interventions.

## 5. Conclusion

Our findings highlight the high prevalence and multifactorial nature of malnutrition in cancer patients. The PG-SGA is a validated and widely recommended tool for identifying malnutrition in oncology, and our results reinforce its value when combined with anthropometric, biochemical, and dietary assessments. Nutritional interventions should focus on preserving or restoring muscle mass, given its critical role in treatment tolerance and prognosis. In addition, physical inactivity remains common due to treatment side effects and limited awareness. Patients should be encouraged to minimize sedentary behavior through individualized exercise recommendations; even simple daily walking may help prevent muscle atrophy. While general guidelines suggest at least 30 min of physical activity per day, exercise prescriptions must be adapted to functional status and treatment phase.

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## Conflict of interest

The authors declare that they have no competing interests.

## Author contributions

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## Ethics approval and consent to participate

Permission for this study was granted through decision number 95/2017 by the Clinical Research Ethics Committee of the Zekai Tahir Burak Women's Health Education and Research Hospital. All patients participating in the research were informed in detail, and informed consent was obtained from all participants.

## Consent for publication

Written informed consent for publication of anonymized data was obtained from all participants included in this study.

## Availability of data

Data are available from the corresponding author on reasonable request.

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