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Bioimpedance Analysis of Body Composition in Oncology Patients

[1] Rakhimov Nodir Makhammatkulovich, [1] Shakhanova Shakhnoza Shavkatovna,
[1] Madaminova Sevarakhon Mukhammadjon kizi, [2] Kamolova Barno Zafarovna,
[2] Sharipov Farid Anarbayevich
[1] Samarkand State Medical University

[2] Samarkand Regional Branch of the Republican Specialized Scientific-Practical Medical Center of Oncology and Radiology

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Annotation: Relevance of the Study.
The problem of nutritional disorders and sarcopenia in oncology patients has gained particular importance in recent years. Reduction of skeletal muscle mass and phase angle has been associated with decreased tolerance to anticancer therapy, higher rates of complications, reduced quality of life, and lower survival [Cruz-Jentoft et al., 2019; Paiva et al., 2010]. At the same time, the commonly used body mass index (BMI) does not reflect actual changes in body composition and cannot reliably detect sarcopenia, sarcopenic obesity, or hydration disorders [Norman et al., 2012].

Bioimpedance analysis is considered a non-invasive, reproducible, and accessible method for assessing body composition, enabling quantitative evaluation of skeletal muscle mass, phase angle, fat content, and hydration status [Kazakevich et al., 2019; Norman et al., 2012]. These parameters have direct clinical significance for the early diagnosis of sarcopenia, risk stratification, and planning of personalized nutritional and rehabilitation interventions [Sukhanov et al., 2020; Paiva et al., 2010].

Given the high prevalence of sarcopenia and its complications among oncology patients, the study of bioimpedance indicators and identification of sex-specific characteristics of body composition are highly relevant. The findings may serve as a basis for introducing modern diagnostic

approaches into clinical practice and for developing personalized nutritional programs aimed at improving prognosis and quality of life in oncology patients [Cruz-Jentoft et al., 2019; Kazakevich et al., 2019].

Materials and Methods.

To assess body composition in 217 patients with various oncological diseases, bioimpedance analysis was performed using a Tanita MC-980MA PLUS analyzer (Japan). The device enables standard multi-frequency segmental analysis of body composition, including evaluation of fat mass and fat-free mass, skeletal muscle mass, and phase angle.

Measurements were taken in the morning after an overnight fast, with patients standing, barefoot, and without metal accessories. Prior to testing, patients refrained from vigorous physical activity for 12 hours.

Total Skeletal Muscle Mass (SMM, kg): calculated by the Tanita's built-in algorithms as the segmental sum of muscle mass in the limbs and trunk.

Skeletal Muscle Index (SMI, kg/m²): diagnostic thresholds for sarcopenia (EWGSOP2): men <7.0 kg/m²; women <5.7 kg/m².

Phase Angle (degrees): an integrative marker of cell membrane integrity and nutritional status.

Body Mass Index (BMI, kg/m²).

Fat Mass (FM, kg and %): absolute and relative fat tissue content.

Total Body Water (TBW, %): overall body water; distribution into intra-/extracellular fractions was used to identify hyper- or dehydration.

Reference ranges: men ~50–65% TBW, women ~45–60% TBW.

Sarcopenic obesity was defined as the combination of low SMI (sex-specific, per above) and elevated body fat percentage (men >25%, women >35%).

Table 1. Bioimpedance Analysis Results in Oncology Patients

Parameter	Men (n=93)	Women (n=124)	p-value
BMI (kg/m²)	26.3 ± 3.9	25.8 ± 4.3	0.42 (ns)
SMM (kg)	28.6 ± 4.9	20.4 ± 3.6	<0.001
SMI (kg/m²)	7.9 ± 1.3	6.1 ± 1.1	<0.001
Phase angle (°)	4.6 ± 1.1	4.2 ± 1.0	0.018
Fat mass (%)	22.8 ± 6.4	29.6 ± 7.2	<0.001
TBW (%)	54.8 ± 4.2	50.6 ± 4.3	<0.001

Comparative analysis of bioimpedance parameters in men (n=93) and women (n=124) revealed several statistically significant differences (Table 1). Body Mass Index (BMI): Mean values in men (26.3 ± 3.9 kg/m²) and women (25.8 ± 4.3 kg/m²) did not differ significantly (p=0.42), indicating a comparable prevalence of overweight in both groups. Thus, the groups were similar with respect to this parameter. Skeletal Muscle Mass (SMM): Men had significantly higher values (28.6 ± 4.9 kg) compared with women (20.4 ± 3.6 kg; p<0.001). The difference persisted when adjusted for height as Skeletal Muscle Index (SMI): 7.9 ± 1.3 kg/m² in men versus 6.1 ± 1.1 kg/m² in women (p<0.001). This reflects the physiologically greater muscle mass in men and confirms the need for sex-specific cut-off values in the diagnosis of sarcopenia.

Phase Angle: Men demonstrated higher values (4.6 ± 1.1°) compared with women (4.2 ± 1.0°), and the difference was statistically significant (p=0.018). Higher phase angle values in men may reflect better cell membrane integrity and higher metabolic activity.

Fat Mass (FM): Women had a significantly higher percentage of fat (29.6 ± 7.2%) compared with men (22.8 ± 6.4%; p<0.001), which is consistent with well-recognized physiological differences in

tissue distribution.

Total Body Water (TBW): Men demonstrated higher levels of total body water (54.8 ± 4.2% vs. 50.6 ± 4.3% in women; $p<0.001$), reflecting a greater proportion of fat-free mass.

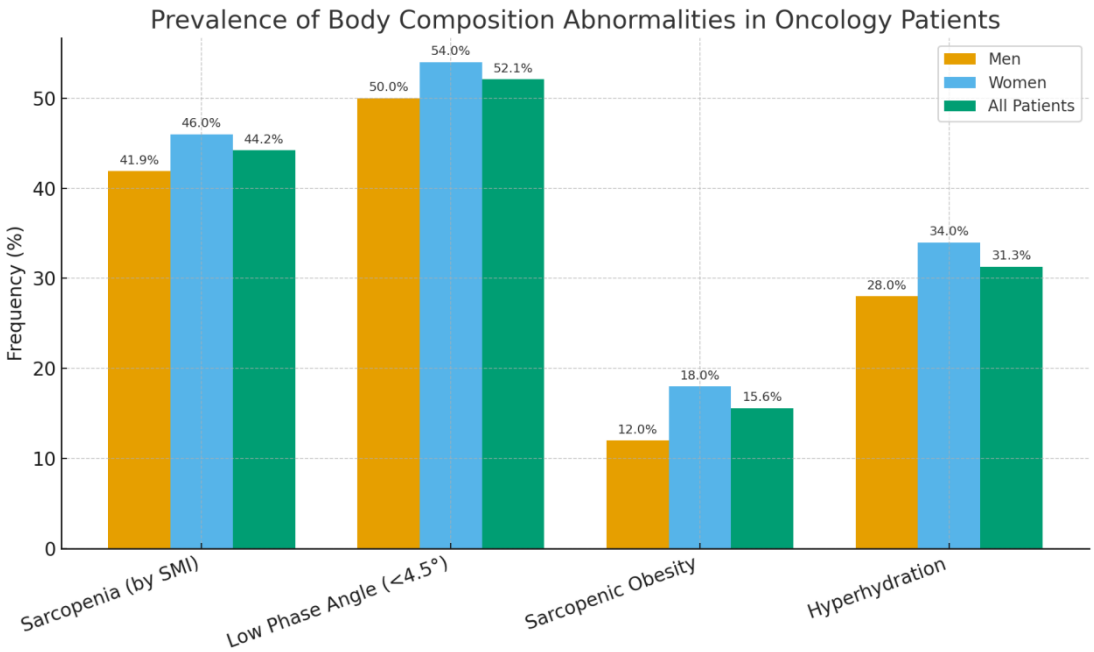
The results highlight important differences in body composition between men and women with oncological diseases. Despite similar BMI values, body structure differed substantially: men had predominance of skeletal muscle mass and water, whereas women showed a significantly higher proportion of fat mass. This confirms the limitations of BMI as a universal criterion for assessing nutritional status: patients with the same BMI may have markedly different balances of muscle and fat mass.

Discussion.

Higher SMM and SMI values in men are expected and correspond to physiological sex-specific differences; however, the observed high prevalence of sarcopenia in both groups (overall ~44.2%) indicates that malignant disease and its treatment attenuate sex-related differences and lead to significant muscle mass loss. Higher phase angle values in men may reflect better cell membrane integrity and preserved metabolism; however, in half of the patients of both sexes, the phase angle was <4.5°, which is associated with poor prognosis and increased risk of complications.

In summary, men were characterized by greater muscle mass, higher phase angle, and higher water content, while women had significantly higher fat mass. At the same time, no differences were observed in BMI, underscoring the limited informativeness of BMI as an independent indicator in the assessment of nutritional status in oncology patients.

Based on this analysis, the findings support the necessity of routine use of bioimpedance analysis in oncology patients regardless of sex and BMI. Sex-specific characteristics of body composition should be taken into account when developing personalized nutritional and rehabilitation programs, while skeletal muscle mass and phase angle can be considered reliable markers of sarcopenia and prognosis in oncology.



Analysis of Frequency Indicators of Bioimpedance Parameters

The analysis of bioimpedance frequency indicators demonstrated a high prevalence of sarcopenia, low phase angle, sarcopenic obesity, and disturbances in water balance among oncology patients of both sexes (Table 3.7).

Sarcopenia (by SMI): diagnosed in 41.9% of men and 46.0% of women; overall prevalence in the

cohort was 44.2%. Differences between sexes were not statistically significant (χ^2=0.56; p>0.05), indicating a comparable frequency of muscle mass loss in oncology patients regardless of sex. Low Phase Angle (<4.5°): observed in approximately half of the patients—about 50% of men and 54% of women (overall 52.1%; p=0.49). This highlights the high prevalence of metabolic impairment and deterioration of cellular status in oncology patients.

Sarcopenic Obesity: present in 12% of men and 18% of women (overall 15.6%; p=0.21). Although slightly more frequent in women, the difference was not statistically significant. This parameter illustrates the coexistence of fat hypertrophy and muscle atrophy, representing an unfavorable variant of nutritional status. Hyperhydration: detected in 28% of men and 34% of women (overall 31.3%; p=0.33). Sex differences were not statistically confirmed. The presence of hyperhydration in nearly one-third of patients underlines the importance of monitoring water-electrolyte balance in therapeutic planning.

Conclusion

This study demonstrated that bioimpedance analysis provides valuable insights into the body composition of oncology patients, revealing a high prevalence of sarcopenia (44.2%), low phase angle (52.1%), sarcopenic obesity (15.6%), and hyperhydration (31.3%). Despite similar BMI values, men and women showed fundamentally different body composition: men had higher skeletal muscle mass, skeletal muscle index, phase angle, and total body water, whereas women had significantly higher fat mass. These findings confirm the limited utility of BMI as a standalone marker of nutritional status in oncology.

The observation that sarcopenia and low phase angle were equally prevalent in both sexes indicates that malignant disease and its treatment exert a universal catabolic effect, diminishing natural physiological differences. Importantly, phase angle values below 4.5°, found in half of the cohort, highlight an unfavorable prognosis and the need for early intervention. The results underscore the necessity of routine implementation of bioimpedance analysis in the comprehensive evaluation of oncology patients. Skeletal muscle index and phase angle can be considered reliable markers for diagnosing sarcopenia and predicting clinical outcomes. Furthermore, sex-specific features of body composition should be taken into account when designing personalized nutritional and rehabilitation programs aimed at improving prognosis and quality of life.

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