

Research Article

Comparison of Phase Angle and Various Anthropometric Parameters in Patients Diagnosed With and Without Cancer

Tugce Aytulu ¹ and Nil Kler Molinas Mandel ^{2,3}

¹Division of Nutrition and Dietetics, American Hospital, Istanbul, Turkey

²School of Medicine, Division of Medical Oncology, Koc University, Istanbul, Turkey

³Division of Medical Oncology, American Hospital, Istanbul, Turkey

Correspondence should be addressed to Tugce Aytulu; tugcea@amerikanhastanesi.org

Received 12 December 2024; Accepted 10 April 2025

Academic Editor: Sowjanya Thatikonda

Copyright © 2025 Tugce Aytulu and Nil Kler Molinas Mandel. European Journal of Cancer Care published by John Wiley & Sons Ltd. This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

Purpose: This study aimed to compare the phase angle (PhA) and other anthropometric values in patients with and without a cancer diagnosis.

Materials and Methods: A retrospective study in Istanbul, Turkey, included 82 patients in a hospital's Nutrition and Dietetics Outpatient Clinic in 2023. The participants were divided into cancer and control groups. Anthropometric measurements included weight (kg), height (cm), and various body composition parameters such as body mass index (BMI) (kg/m^2), skeletal muscle mass (SMM), skeletal muscle mass index (SMMI), fat mass (FM) (kg), fat-free mass (FFM) (kg), muscle mass (MM) (kg), and total body water (TBW) (kg).

Results: Statistically significant difference was found in BMI ($t = -3.293$; $p < 0.01$), FFM ($U = 502.5$; $p < 0.01$), MM ($U = 480$; $p < 0.001$), FM ($U = 573$; $p < 0.05$), and TBW ($U = 550$; $p < 0.01$) between the groups. Also, a significant difference was found in PhA ($t = -3.689$; $p < 0.001$), SMM ($U = 502.5$; $p < 0.01$), and SMMI ($t = -3.189$; $p < 0.01$). The study revealed significant differences in FFM, MM, and TBW values based on PhA groups among patients with and without a cancer diagnosis. For cancer patients, high PhA values correlated with significantly higher mean FFM, MM, and TBW values than those with low PhA values ($p < 0.05$). Additionally, age was associated with decreased PhA, and SMMI was linked to increased PhA among patients with cancer ($p < 0.01$; $p < 0.001$, respectively).

Conclusion: Our study found that certain measurements were significantly lower in cancer patients than those without cancer. These findings suggest that BIA can benefit all cancer patients, and conducting future studies on this topic will help enhance patient treatment and follow-up.

Keywords: anthropometric parameters; bioelectrical impedance; cancer; nutritional status; phase angle

1. Introduction

In health care, anthropometric measurements are used to evaluate the proportions and the size of the human body. Following guidelines from the European Society for Clinical Nutrition and Metabolism (ESPEN), the National Institute for Health and Care Excellence (NICE), and the British Association for Parenteral and Enteral Nutrition (BAPEN) on recording anthropometric data is vital for many clinical interventions [1]. Many studies have shown that different

body size parameters may help assess the effects of treatment or patients' prognoses [2].

Bioelectrical impedance analysis (BIA) is a reliable, cost effective, objective, and noninvasive method with high repeatability and minimal training requirements. Recent studies have also suggested the potential benefits of using BIA to assess body composition in cancer patients [3]. BIA does not directly measure the body composition but calculates total body water (TBW) by measuring impedance (Z), which is determined by resistance (R) and reactance

(Xc) components, by recording the voltage drop in the applied current [3–5].

In recent years, phase angle (PhA) has also started to be included among the parameters used in the evaluation of patients. Human studies have shown that PhA correlates with cellular health [6] and PhA is influenced by many factors, such as disease, nutritional status, and the level of physical activity [7, 8]. The PhA value indicates the health of a cell. A lower PhA value indicates cell death or reduced cell integrity, while a higher PhA indicates a strong cell membrane. Because it is associated with cellular integrity, PhA is considered a more sensitive indicator of nutritional status than impedance [9]. Most studies have shown a direct relationship between fat-free mass (FFM), muscle mass (MM), FFM components, and PhA. It can be concluded that the PhA is directly related to lean mass and MM in different age groups (such as children, adolescents, adults, and older adults) and individuals with varying diagnoses of health (such as HIV, cancer, hemodialysis, sarcopenia, and healthy individuals) [10]. PhA is reported to be a good indicator of prognosis and mortality in hemodialysis, cancer, human immunodeficiency virus (HIV), and liver and geriatric diseases. The PhA is a valuable and efficient tool for assessing nutritional status and risk of mortality. In contrast, although noninvasive, other nutritional screening tools are more time consuming and highly subjective. In adults, FFM should contain 69%–75% water to calculate a reliable PhA value with the BIA method. A low PhA value reflects low reactance, cell death, or impaired selective permeability of the cell membrane. For an ideal cell membrane structure, the PhA should be between 5° and 7°. It is generally said that the PhA is between 5° and 7° in healthy individuals; however, it can reach up to 9.5° in athletes. For an ideal cell membrane structure, PhA should be between 5° and 7°. The decrease in reactance is linked to muscle loss, aging, increased adipose tissue, and reduced body water, leading to higher resistance and lower PhA [11].

Although the high potential of PhA in health and disease conditions has been demonstrated, its relationship with body composition components remains unclear and results are contradictory [10]. PhA is a viable tool for assessing cellular health and integrity and may be a potential marker for inflammation and oxidative stress. Lower PhA has consistently been associated with higher levels of CRP, interleukins, and TNF- α , as well as lower albumin levels, despite heterogeneity in populations, study designs, and BIA devices [12]. Therefore, the study aimed to compare the PhA and other anthropometric values in patients with and without a cancer diagnosis.

2. Methods

2.1. Study Design and Setting. This retrospective study was conducted in Istanbul, Türkiye, and evaluated the patients who consulted a hospital's Nutrition and Dietetics Out-patient Clinic in 2023.

2.2. Study Population and Sample. Participants in the study were randomized using the "Research Randomizer" program (<https://www.randomizer.org>) and subsequently

divided into two groups: patients diagnosed with cancer and a control group consisting of patients not diagnosed with cancer. The randomization and assignment of participants to groups were conducted by the Researcher 1, while the evaluation was performed by Researcher 2 who was blinded to the group assignments.

2.3. Inclusion and Exclusion Criteria. The inclusion criteria for patients diagnosed with cancer were patients between the ages of 18–69 who had any active cancer diagnosis. Exclusion criteria for both groups were those with a history of wrist or finger fractures in the last year and those unable to mobilize and communicate. This exclusion was applied to both groups to ensure consistency in data collection and analysis. These excluded patients were not included in any subsequent calculations. The exclusion criteria were meticulously followed to maintain the integrity of the study and to prevent potential biases that could arise from including patients with such injuries. The study focused on participants who met the inclusion criteria and did not have any of the specified exclusions.

2.4. Data Collection. The anthropometric measurements included weight (kg), height (cm), and various body composition parameters such as body mass index (BMI) (kg/m²), fat mass (FM) (kg), FFM (kg), MM (kg), and TBW (kg). Body composition and PhA values were measured using a multiple frequency BIA (TANITA MC 780). BIA was measured with the subjects after an overnight fast and when the bladder was emptied. Patients were instructed to stand upright with bare feet on the device's footpads and to remove any jewelry and metal objects before the measurement.

Skeletal muscle mass (SMM) was calculated using the participants' FFM, determined by BIA ($SMM\text{ (kg)} = 0.566 \times FFM$). SMM was adjusted by height and divided by height squared to calculate the skeletal muscle mass index (SMMI).

2.5. Statistical Analyses. Categorical variables are shown as frequency and percentage in the descriptive statistics. The normal distribution of numerical variables was assessed using the Shapiro–Wilk Test. Descriptive statistics for numerical variables are presented as mean $\pm$ standard deviation ($M \pm SD$) for normally distributed data and median (min–max) for data not showing normal distribution. A comparison of two independent groups with normal distribution was conducted using the independent samples *T* test, while the Mann–Whitney *U* Test was used to compare two independent groups without normal distribution. The effect between variables was examined using multiple regression analysis. The statistical significance level was set at " $p < 0.05$, $p < 0.01$, $p < 0.001$ " and hypotheses were established in two directions. The statistical analysis was performed using the SPSS v27 (IBM Inc., Chicago, IL, USA) software package.

2.6. Ethical Issues. The study was conducted in accordance with the ethical principles outlined in the Koc University's Institutional Review Board (IRB) guidelines and received

IRB approval (IRB number: 2024.175.IRB2.075, Date: 07/05/2024). The study was conducted in accordance with the relevant ethical standards and institutional approvals, as required by the hospital where the study was conducted. The study was carried out following the ethical principles stated in the Declaration of Helsinki.

3. Results

In the study, a total of 82 patients were included. Among individuals without a cancer diagnosis, 56.1% were female ($n: 23$), with a mean age of 45.88 ± 12.47 years, 14.6% had undergone surgery, and 19.5% had insulin resistance. On the other hand, 68.3% of individuals diagnosed with cancer were female ($n: 28$), with a mean age of 53.17 ± 12.40 years. Furthermore, 70.7% had undergone surgery, and 17.1% had insulin resistance (Table 1).

In the study, a statistically significant difference was found in the BMI ($t = -3.293$; $p < 0.01$), FFM ($U = 502.5$; $p < 0.01$), MM ($U = 480$; $p < 0.001$), FM ($U = 573$; $p < 0.05$), and TBW ($U = 550$; $p < 0.01$) between the study groups (Table 1).

Comparing the study groups, it was observed that the mean BMI value of individuals without a cancer diagnosis (28.43 ± 4.46) was higher than the mean of individuals with a cancer diagnosis (24.97 ± 5.05). Additionally, the median FFM value of individuals without a cancer diagnosis [56.6 (37.5 – 82.3)] was higher than the median of individuals with a cancer diagnosis [46.7 (33.1 – 83.1)]. Similarly, the median MM value of individuals without a cancer diagnosis [53.7 (35.6 – 78.3)] was higher than the median of individuals with a cancer diagnosis [43.8 (11.8 – 79)]. The median FM value of individuals without a cancer diagnosis [22.3 (12.8 – 50.6)] was also higher than the median of individuals with a cancer diagnosis [19.8 (2.3 – 47.7)]. Furthermore, the median TBW value of individuals without a cancer diagnosis [39.2 (39.2)] was higher than the median of individuals with a cancer diagnosis [33 (22.3 – 61.5)] (Table 2).

In the study, a significant difference was observed in the PhA ($t = -3.689$; $p < 0.001$), SMM ($U = 502.5$; $p < 0.01$), and SMMI ($t = -3.189$; $p < 0.01$) between the groups. Upon analyzing the results, it was found that the mean PhA value of individuals without a cancer diagnosis (5.85 ± 0.82) was statistically higher than that of individuals with a cancer diagnosis (5.16 ± 0.89). Similarly, the median SMM value of individuals without a cancer diagnosis [32 (21.2 – 46.6)] was statistically higher than that of individuals with a cancer diagnosis [26.4 (18.7 – 47)], and the mean SMMI value of individuals without a cancer diagnosis (11.10 ± 1.34) was statistically higher than that of individuals with a cancer diagnosis (10.09 ± 1.51) (Table 2).

The study discovered statistically significant differences in the FFM, MM, and TBW values of individuals with and without a cancer diagnosis based on their PhA groups. For individuals with a cancer diagnosis, those with high PhA values had significantly higher mean FFM values (57.02 ± 12.41) compared to those with low PhA values (46.57 ± 7.36). Similarly, the median MM values for individuals diagnosed with cancer with high PhA (54.5) were

higher than those with low PhA (43.2), and the mean TBW values for high PhA individuals (41.03 ± 5.09) were statistically higher than those with low PhA (32.29 ± 5.09) (Table 3).

There were also significant differences in FFM, MM, and TBW values for individuals without a cancer diagnosis based on their PhA groups. Those with high PhA values had significantly higher mean FFM (63.08 ± 10.11) and MM values (59.93 ± 9.64) compared to those with low PhA values. Additionally, the median TBW values for individuals with high PhA [44.9 (30.6 – 58.1)] were significantly higher than those with low PhA [31.7 (26.4 – 49.7)] (Table 3).

In the study, it was observed that the age and SMMI values of individuals diagnosed with cancer had a statistically significant impact on PhA values ($p < 0.01$; $p < 0.001$). The results showed that with each unit increase in age among individuals with cancer, there was a 0.026-fold decrease in PhA values, and for each unit increase in SMMI values, there was a 0.400-fold increase in PhA values (Table 4).

Similarly, for individuals without a cancer diagnosis, the age, BMI, and SMMI values had a statistically significant impact on PhA values ($p < 0.05$; $p < 0.01$; $p < 0.001$). The findings revealed that with each unit increase in age among individuals without a cancer diagnosis, there was a 0.018-fold decrease in PhA values. With each unit increase in BMI, there was a 0.088-fold decrease, and for each unit increase in SMMI values, there was a 0.565-fold increase in PhA values (Table 4).

4. Discussion

The study compared the anthropometric measurements of individuals with a cancer diagnosis to those without. The study retrospectively compared the BIA parameters such as BMI, FFM, MM, FM, TBW, PhA, SMM, and SMMI values of 41 patients who had cancer and visited the Nutrition and Dietetics Outpatient Clinic with the parameters of 41 individuals without a cancer diagnosis.

The study showed that BMI, FFM, MM, FM, TBW, PhA, SMM, and SMMI values were statistically significantly lower in patients diagnosed with cancer than those without cancer. Results of a retrospective study including geriatric patients ($n: 210$, age ≥ 65 years) undergoing gastrectomy for gastric cancer showed that low PhA and total gastrectomy were independent risk factors for both severe and overall complications [13].

The study found that cancer patients with high PhA values had higher mean FFM and TBW values than those with low PhA values. Similarly, the median MM values for cancer patients with high PhA were higher than those with low PhA. A retrospective study of 366 patients with advanced cancer found that PhA was significantly associated with BMI, sex, and age at all frequencies and on both sides, except at 250 kHz for sex [14]. In one study, patients with head and neck cancer (139 subjects) were separated into two groups: normal PhA and low PhA groups. Over a two-year follow-up period, functional and symptom scales were statistically different, with patients with low PhA having

TABLE 1: Descriptive statistics of demographic and health findings of individuals according to study groups.

	Diagnosed with cancer		Control group	
	<i>n</i>	%	<i>n</i>	%
<i>Gender</i>				
Male	13	31.7	18	43.9
Female	28	68.3	23	56.1
Age (years) ($\bar{X} \pm SS$)	53.17 $\pm$ 12.40		45.88 $\pm$ 12.47	
<i>Surgeries</i>				
Yes	29	70.7	6	14.6
No	12	29.3	35	85.4
<i>Disease status</i>				
Hypertension	5	12.2	4	9.8
Diabetes	5	12.2	4	9.8
Insulin resistance	7	17.1	8	19.5
Congestive heart failure	1	2.4	1	2.4
Coronary heart disease	3	7.3	2	4.9
Hypothyroid	2	4.9	3	7.3

TABLE 2: Comparison of anthropometric findings of individuals participating in the study according to study groups.

	Diagnosed with cancer		Control group		<i>tU</i>	<i>p</i>
	$\bar{X} \pm SS$	Median (min-max)	$\bar{X} \pm SS$	Median (min-max)		
BMI (kg/m ²)	24.97 $\pm$ 5.05	24.6 (15.1–40.3)	28.43 $\pm$ 4.46	28.3 (21.3–38.8)	<i>t</i> = −3.293	0.001**
FFM (kg)	49.38 $\pm$ 9.99	46.7 (33.1–83.1)	57.21 $\pm$ 11.82	56.6 (37.5–82.3)	<i>U</i> = 502.5	0.002**
MM (kg)	45.83 $\pm$ 10.89	43.8 (11.8–79)	54.34 $\pm$ 11.26	53.7 (35.6–78.3)	<i>U</i> = 480	< 0.001***
FM (kg)	20.02 $\pm$ 9.88	19.8 (2.3–47.7)	25.29 $\pm$ 8.72	22.3 (12.8–50.6)	<i>U</i> = 573	0.013*
TBW (kg)	34.63 $\pm$ 7.52	33 (22.3–61.5)	39.83 $\pm$ 8.70	39.2 (26.4–58.1)	<i>U</i> = 550	0.007**
PhA	5.16 $\pm$ 0.89	5 (3, 4–7)	5.85 $\pm$ 0.82	5.8 (3.8–7.7)	<i>t</i> = −3.689	< 0.001***
SMM	27.95 $\pm$ 5.65	26.4 (18.7–47)	32.38 $\pm$ 6.69	32 (21.2–46.6)	<i>U</i> = 502.5	0.002**
SMMI	10.09 $\pm$ 1.51	9.7 (7.2–14.2)	11.10 $\pm$ 1.34	11 (8.8–13.9)	<i>t</i> = −3.189	0.002**

Note: *t*: independent samples *T* test; *U*: Mann–Whitney *U* test.

Abbreviations: FFM; fat-free mass; FM, fat mass; MM, muscle mass; PhA, phase angle; SMM, skeletal muscle mass; SMMI, skeletal muscle mass index; TBW, total body water.

**p* < 0.05.

***p* < 0.01.

****p* < 0.001.

lower functional scores and higher symptoms [15]. In another study of a total of 51 males with hepatocellular carcinoma (HCC), PhA has been associated with lower muscle function, lower MM, disease progression, more severe malnutrition risk, and increased mortality in HCC [16]. The results of our study align with the existing literature.

Another important finding from our study was that the age and SMMI values of patients with cancer significantly affected PhA values. With each unit increase in age, PhA values decreased by 0.026, while each unit increase in SMMI values led to a 0.400 increase in PhA values. SMM differs from FFM in that SMM only refers to SMM, whereas FFM includes whole-body lean mass, including SMM and internal organs [17]. BIA is a valid alternative to total skeletal muscle as it correlates highly with whole body imaging results in longitudinal and cross-sectional analyses [18]. In Sauza et al.'s cross-sectional study [19], which included 190 patients with colorectal cancer, PhA was associated with low SMMI, and PhA had good diagnostic accuracy for detecting low SMMI. In a prospective case-control study, patients with advanced cancer (*n*=40) were compared to a sex- and

age-matched control group (*n*=40). The study found that patients with advanced cancer had significantly lower SMMI compared to the control group [20].

In the study, age, BMI, and SMMI values of individuals without a cancer diagnosis significantly impacted PhA values. Each unit increase in age led to a 0.018-fold decrease in PhA values, each unit increase in BMI led to a 0.088-fold decrease, and each unit increase in SMMI values led to a 0.565-fold increase in PhA values. In a study of healthy subjects, in univariate logistic regression analysis, weight and height emerged as strong significant predictors of PhA, while MM and visceral fat (*p* < 0.05) predicted it significantly. In contrast with our study, the influence of age, gender, and BMI was not significant. Another study of 81 female patients who were under treatment for postmenopausal osteoporosis showed significant positive correlations of PhA with appendicular SMMI and significant negative correlations with age [21].

4.1. Limitations of the Study. The study has several limitations. It included a diverse group of patients with different types of cancer, various treatments (e.g., surgery and

TABLE 3: Comparison of anthropometric measurement values of individuals according to study groups and phase angle groups.

	PhA	Diagnosed with cancer	Control group
		$\bar{X} \pm SS$ Median (min-max)	$\bar{X} \pm SS$ Median (min-max)
BMI	Low	24.66 $\pm$ 5.33	25.4 (21.3–38.8)
	High	25.79 $\pm$ 4.33	29.1 (23.6–37.4)
	<i>tU</i>	<i>t</i> = –0.628	<i>U</i> = 136
	<i>p</i>	0.534	0.062
FFM	Low	46.57 $\pm$ 7.36	49.72 $\pm$ 9.52
	High	57.02 $\pm$ 12.41	63.08 $\pm$ 10.11
	<i>T</i>	<i>t</i> = –2.627	<i>t</i> = –4.308
	<i>p</i>	0.021*	< 0.001***
MM	Low	43.2 (11.8–62.5)	47.20 $\pm$ 9.05
	High	54.5 (40–79)	59.93 $\pm$ 9.64
	<i>tU</i>	<i>U</i> = 79	<i>t</i> = –4.311
	<i>p</i>	0.011*	< 0.001***
FM	Low	21.05 $\pm$ 10.11	20.1 (15.7–50.6)
	High	17.21 $\pm$ 9.05	23.3 (12.8–40.6)
	<i>tU</i>	<i>t</i> = 1.107	<i>U</i> = 177.5
	<i>p</i>	0.275	0.438
TBW	Low	32.29 $\pm$ 5.09	31.7 (26.4–49.7)
	High	41.03 $\pm$ 9.46	44.9 (30.6–58.1)
	<i>tU</i>	<i>t</i> = –2.912	<i>U</i> = 73
	<i>p</i>	0.013*	< 0.001***

Note: *t*: independent samples *T* test; *U*: Mann–Whitney *U* test. Bold values indicate the statistical significance.

Abbreviations: BMI, body mass index; FFM, fat-free mass; FM, fat mass; MM, muscle mass; PhA, phase angle; TBW, total body water.

**p* < 0.05.

****p* < 0.001.

TABLE 4: Effects of age, BMI, surgery history, and SMMI findings on phase angle findings of individuals participating in the study according to study groups.

Diagnosed with cancer						
Model	Unstandardized coefficients		t	p	Confidence interval for 95% β	
	β	SE			Lower limit	Upper limit
PhA						
(Constant)	2856	0.818	3493	0.001**	1198	4514
Age	-0.026	0.009	-2962	0.005**	-0.044	-0.008
BMI	-0.013	0.030	-0.420	0.677	-0.075	0.049
Surgery status (ref: Undergone)						
Not undergone	-0.063	0.237	-0.266	0.792	-0.543	0.417
SMMI	0.400	0.102	3933	< 0.001***	0.194	0.606
Control group						
Model	Unstandardized coefficients		t	p	Confidence interval for 95% β	
	β	SE			Lower limit	Upper limit
PhA						
(Constant)	2572	0.829	3101	0.004**	0.889	4256
Age	-0.018	0.008	-2330	0.026*	-0.033	-0.002
BMI	-0.088	0.029	-3052	0.004**	-0.147	-0.029
Surgery status (ref: Undergone)						
Not undergone	0.380	0.258	1477	0.149	-0.142	0.903
SMMI	0.565	0.096	5893	< 0.001***	0.370	0.759

Note: β : beta coefficient. Bold values indicate the statistical significance.

Abbreviations: BMI, body mass index; PhA, phase angle; SE, standard error; SMMI, skeletal muscle mass index.

**p* < 0.05.

***p* < 0.01.

****p* < 0.001.

chemotherapy), and different stages of cancer, which made the population heterogeneous. The study was carried out in only one center with a relatively small population of patients.

5. Conclusion

Our study found that anthropometric values such as PhA, BMI, FFM, MM, FM, TBW, SMM, and SMMI were significantly lower in patients diagnosed with cancer than those not diagnosed with cancer. Additionally, the age and SMMI values of patients with a cancer diagnosis significantly affected the PhA values. Studies have identified disruption of cellular integrity as a prognostic factor. Therefore, BIA can be used for all cancer patients, regardless of cancer type and stage. Conducting randomized controlled prospective studies on this topic in the future will help improve patient treatment and follow-up.

Data Availability Statement

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

Conflicts of Interest

The authors declare no conflicts of interest.

Author Contributions

Nil Kler Molinas Mandel and Tugce Aytulu conceptualized and led the project. Tugce Aytulu organized the recruitment of the participants for the study. Tugce Aytulu collected the data and Nil Kler Molinas Mandel performed the statistical analyses. Tugce Aytulu drafted the manuscript. Nil Kler Molinas Mandel supervised the project. All authors reviewed and approved the final version of the manuscript.

Funding

No funding was received for this research.

References

- [1] F. Tabacchi, V. Iatridi, J. Tammam, E. Watson, and S. Coe, "Under-Identification of Cancer Outpatients at Risk of Malnutrition: Are We Making the Most of Anthropometric Data?" *Future Healthcare Journal* 9, no. 3 (2022): 310–312, <https://doi.org/10.7861/fhj.2022-0072>.
- [2] L. Yin, L. Zhang, N. Li, et al., "Several Anthropometric Measurements and Cancer Mortality: Predictor Screening, Threshold Determination, and Joint Analysis in a Multicenter Cohort of 12138 Adults," *European Journal of Clinical Nutrition* 76, no. 5 (2022): 756–764, <https://doi.org/10.1038/s41430-021-01009-x>.
- [3] M. G. Branco, C. Mateus, M. L. Capelas, et al., "Bioelectrical Impedance Analysis (BIA) for the Assessment of Body Composition in Oncology: A Scoping Review," *Nutrients* 15, no. 22 (2023): 4792, <https://doi.org/10.3390/nu15224792>.
- [4] J. Gulín, E. Ipavic, D. M. Mastnak, E. Breclj, I. Edhemovic, and N. R. Kozjek, "Phase Angle as a Prognostic Indicator of Surgical Outcomes in Patients With Gastrointestinal Cancer," *Radiology and Oncology* 57, no. 4 (2023): 524–529, <https://doi.org/10.2478/raon-2023-0060>.
- [5] D. Gupta, C. A. Lammersfeld, P. G. Vashi, et al., "Bioelectrical Impedance Phase Angle as a Prognostic Indicator in Breast Cancer," *BMC Cancer* 8, no. 1 (2008): 249, <https://doi.org/10.1186/1471-2407-8-249>.
- [6] N. I. Siddiqui, S. A. Khan, M. Shoeb, and S. Bose, "Anthropometric Predictors of Bio-Impedance Analysis (BIA) Phase Angle in Healthy Adults," *Journal of Clinical and Diagnostic Research: Journal of Clinical and Diagnostic Research* 10, no. 6 (2016): CC01–CC4, <https://doi.org/10.7860/JCDR/2016/17229.7976>.
- [7] P. Detopoulou, E. Fragopoulou, T. Nomikos, and S. Antonopoulou, "Associations of Phase Angle With Platelet-Activating Factor Metabolism and Related Dietary Factors in Healthy Volunteers," *Frontiers in Nutrition* 10 (2023): 1237086, <https://doi.org/10.3389/fnut.2023.1237086>.
- [8] F. Ayyıldız and E. Köksal, "Hastalık Riski, Beslenme Ve Hidrasyon Durumunun Değerlendirilmesinde Güncel Yaklaşım: Bioelektrik İmpedans Vektör Analizi," *JHS* 25 (2016): 155–160.
- [9] D. Baş, C. Atahan, and E. Tezcanli, "An Analysis of Phase Angle and Standard Phase Angle Cut-Off Values and Their Association With Survival in Head and Neck Cancer Patients Undergoing Radiotherapy," *Clinical Nutrition* 42, no. 8 (2023): 1445–1453, <https://doi.org/10.1016/j.clnu.2023.06.020>.
- [10] P. C. Martins, C. A. S. Alves Junior, A. M. Silva, and D. A. S. Silva, "Phase Angle and Body Composition: A Scoping Review," *Clinical Nutrition ESPEN* 56 (2023): 237–250, <https://doi.org/10.1016/j.clnesp.2023.05.015>.
- [11] E. Canbolat, "Possible Role of Phase Angle From Bioelectric Impedance Analysis Parameters as Diagnostic Criteria (Biyoelektrik İmpedans Analizi Parametrelerinden Faz Açısının, Tanısal Kriter Olarak Olası Rolü)," *Annals of Health Sciences Research* 7, no. 1 (2018): 58–65.
- [12] B. R. da Silva, C. E. Orsso, M. C. Gonzalez, et al., "Phase Angle and Cellular Health: Inflammation and Oxidative Damage," *Reviews in Endocrine & Metabolic Disorders* 24, no. 3 (2022): 543–562, <https://doi.org/10.1007/s11154-022-09775-0>.
- [13] B. Yu, K. B. Park, J. Y. Park, S. S. Lee, O. K. Kwon, and H. Y. Chung, "Bioelectrical Impedance Analysis for Prediction of Early Complications After Gastrectomy in Elderly Patients With Gastric Cancer: The Phase Angle Measured Using Bioelectrical Impedance Analysis," *Journal of Gastric Cancer* 19, no. 3 (2019): 278–289, <https://doi.org/10.5230/jgc.2019.19.e22>.
- [14] D. Hui, R. Dev, L. Pimental, et al., "Association Between Multi-Frequency Phase Angle and Survival in Patients With Advanced Cancer," *Journal of Pain and Symptom Management* 53, no. 3 (2017): 571–577, <https://doi.org/10.1016/j.jpainsymman.2016.09.016>.
- [15] D. Sat-Muñoz, B. E. Martínez-Herrera, J. A. González-Rodríguez, et al., "Phase Angle, a Cornerstone of Outcome in Head and Neck Cancer," *Nutrients* 14, no. 15 (2022): 3030, <https://doi.org/10.3390/nu14153030>.
- [16] A. P. Pagano, J. M. F. Sicchieri, A. S. d. M. Morgado, et al., "Phase Angle But Not Psoas Muscle Predicts Nutritional Risk and Prognosis in Males With Hepatocellular Carcinoma," *Nutrition and Cancer* 76, no. 10 (2024): 963–973, <https://doi.org/10.1080/01635581.2024.2378504>.
- [17] G. Sergi, M. De Rui, B. Stubbs, N. Veronese, and E. Manzato, "Measurement of Lean Body Mass Using Bioelectrical Impedance Analysis: A Consideration of the Pros and Cons," *Aging-Clinical & Experimental Research* 29, no. 4 (2017): 591–597, <https://doi.org/10.1007/s40520-016-0622-6>.

- [18] C. O. Walowski, W. Braun, M. J. Maisch, et al., “Reference Values for Skeletal Muscle Mass—Current Concepts and Methodological Considerations,” *Nutrients* 12, no. 3 (2020): 755, <https://doi.org/10.3390/nu12030755>.
- [19] N. C. Souza, C. M. Avesani, C. M. Prado, et al., “Phase Angle as a Marker for Muscle Abnormalities and Function in Patients With Colorectal Cancer,” *Clinical Nutrition* 40, no. 7 (2021): 4799–4806, <https://doi.org/10.1016/j.clnu.2021.06.013>.
- [20] M. Lipshitz, J. Visser, R. Anderson, et al., “Emerging Markers of Cancer Cachexia and Their Relationship to Sarcopenia,” *Journal of Cancer Research and Clinical Oncology* 149, no. 19 (2023): 17511–17527, <https://doi.org/10.1007/s00432-023-05465-9>.
- [21] Y. Ono, Y. Kasukawa, K. Sasaki, and N. Miyakoshi, “Association of the Bioimpedance Phase Angle and Quality of Life in Postmenopausal Osteoporosis,” *Medical Principles and Practice* 32, no. 1 (2023): 71–76, <https://doi.org/10.1159/000528004>.