Association between phase angle and body cell mass in hospitalized patients

Relação entre ângulo de fase e massa celular corporal em pacientes hospitalizados

DOI: 10.37111/braspenj.2026.41.1.22-en

Sinara de Souza Santos[1]
Carolina Cunha de Oliveira[2]

ABSTRACT

Introduction: Phase angle (PhA) is recognized as a critical parameter in assessing cellular health and body cell mass due to its capacity to measure tissue properties such as membrane cellular integrity. The objective of this study was to analyze the relationship between PhA and body cell mass in hospitalized patients. **Methods:** A cross-sectional study was conducted with patients of both sexes who were hospitalized in the municipality of Lagarto, SE, Brazil. A comprehensive dataset collection process undertaken, encompassing sociodemographic and health-related information. The nutritional parameters evaluated included body mass index, body cell mass, fat-free mass, percentage of body fat, PhA, and body cell mass index. **Results:** The sample consisted of 117 participants, 62.4% of whom were female. A lower mean PhA was observed among the elderly ($p<0.001$), in individuals who were underweight ($p<0.001$), with low muscle reserve ($p=0.033$), and at nutritional risk ($p<0.001$). Individuals with a lower body mass index exhibited lower mean values of PhA, body cell mass, and fat-free mass compared to individuals an adequate body mass index and overweight individuals ($p<0.05$). A positive correlation was identified between PhA, body mass index, fat-free mass, body cell mass, and total body water ($p<0.05$). The regression model incorporating fat-free mass and body cell mass explained 53.7% of the variability observed in PhA. **Conclusion:** PhA has been demonstrated to be associated with body cell mass, underscoring its a significance as a vital indicator of health and nutritional status within a hospital setting.

RESUMO

Introdução: O ângulo de fase (AF) é reconhecido como um parâmetro importante na avaliação da saúde celular e da massa celular corporal em virtude de sua capacidade de mensurar propriedades teciduais como a integridade da membrana celular. O objetivo do trabalho foi analisar a relação entre o AF e a massa celular corporal em pacientes hospitalizados. **Método:** Esse foi um estudo transversal realizado com pacientes, de ambos os sexos, hospitalizados no município de Lagarto, SE, Brasil. Foram coletados dados sociodemográficos e de saúde. Os parâmetros nutricionais avaliados foram: índice de massa corporal, massa celular corporal, massa livre de gordura, percentual de gordura corporal, AF e índice de massa celular corporal. **Resultados:** A amostra foi composta por 117 participantes, sendo 62,4% do sexo feminino. Observou-se menor média do AF entre os idosos ($p<0,001$), em indivíduos com baixo peso ($p<0,001$), com baixa reserva muscular ($p=0,033$) e em risco nutricional ($p<0,001$). Indivíduos com baixo peso apresentaram valores médios inferiores de AF, massa celular corporal e massa livre de gordura, quando comparado com indivíduos com peso adequado e excesso de peso ($p<0,05$). Houve correlação positiva entre o AF, índice de massa corporal, massa livre de gordura, massa celular corporal e água corporal total ($p<0,05$). O modelo de regressão com massa livre de gordura e massa celular corporal foi capaz de explicar 53,7% da variabilidade do AF. **Conclusão:** O AF apresentou relação com a massa celular corporal, destacando a importância como indicador do estado de saúde e nutrição no contexto hospitalar.

Keywords:
Nutritional assessment. Body composition. Electrical bioimpedance. Phase angle. Inpatients.

Unitermos:
Avaliação nutricional. Composição corporal. Bioimpedância elétrica. Ângulo de fase. Pacientes internados.

Address for correspondence:
Carolina Cunha de Oliveira
Universidade Federal de Sergipe, Departamento de Nutrição - Av. Gov. Marcelo Déda, 13 - São José - Lagarto, SE, Brasil – CEP: 49400-000
E-mail: carol_cunh@academico.ufs.br

Submission:
October 27st, 2025

Accepted for publication:
January 6th, 2026

Date of publication:
January 22th, 2026

1. Universidade Federal de Sergipe, Lagarto, SE, Brasil.
2. Departamento de Nutrição, Universidade Federal de Sergipe, Lagarto, SE, Brasil.

INTRODUCTION

Body composition assessment enables the estimation of variables pertinent to patient care, including hydration status and body cell mass (BCM), which area significant indicators associated with physical function, morbidity, and mortality[1,2]. Bioelectrical impedance analysis (BIA) assesses the impedance to the passage of an electrical current applied to the body. This impedance is composed of resistance (R), which corresponds to the opposition to the flow of current through ionic solutions within and between cells, and reactance (Xc), which reflects the delay in electrical conduction due to the capacitance of cell membranes and tissue interfaces. The capacitance of the membranes is known to induce a phase shift, which consequently results in the phase angle (PhA)[3,4].

PhA is recognized as a critical parameter in assessing cellular health and body cell mass (BCM) due to its capacity to evaluate tissue properties such as cell membrane integrity and body fluid distribuition[3-5]. Thirdly, the PhA values are influenced by a number of biological factors, including cell count, membrane integrity, and cell fluid volumes. Consequently, factors that modify cell structure, including nutritional status, body composition, and age, exert an influence on the result. In this context, reduced PhA values are associated with decreased cell integrity and cell death[4].

Scientific literature has demonstrated the potential of PhA as a prognostic indicator for various diseases, including specific types of cancer, sepsis, sarcopenia, and in individuals with acquired immunodeficiency syndrome. In addition to its role as an individual indicator, PhA has been found to be superior to other predictors in certain contexts[3.] Thirdly, the PhA has been examined as a potential nutritional indicator due to its capacity to assess body composition at the molecular, cellular, and tissue levels, contingent upon the comparison method employed[3,6,7].

Conversely, BCM constitutes a pivotal metric in evaluating nutritional status, given that its components encompass fat mass (FM) and fat-free mass (FFM). FFM is a body composition parameter comprised of multiple compartments. Excluding extracellular water and bone mineral mass from FFM allows for the isolation of BCM, a compartment characterized by high metabolic activity[6.] Consequently, the determination of BCM serves as an indicator for the qualitative assessment of FFM.

Consequently, it is imperative to undertake research that substantiates the analysis and utilization of PhA as a marker of BCM, in addition to its function as a potential nutritional indicator in clinical practice. This contributes to the early identification of risk, the development of precise nutritional plans, and enhancements in the quality of care for hospitalized patients. The present study aims to analyze the relationship between PhA and BCM in hospitalized patients.

METHODS

Study Design and Sample

This was a cross-sectional study conducted from January to December 2022 at the University Hospital of Lagarto, SE, Brazil. The convenience sample of patients included in this study was selected from those admitted during the specified period, with patients admitted to. The inclusion criteria were as follows: individuals aged 19 years or older, of both sexes, who met the criteria for performing the BIA[8], exam and who did not present any physical-postural changes that would prevent anthropometric assessment. The following individuals were excluded from participation: children, adolescents, pregnant women, individuals using pacemakers, individuals with edema, individuals with ascites and/or visceromegaly, individuals who did not accept the consent form, and individuals in palliative care.

Collection Instruments and Procedures

The collection was conducted by a group of nutrition students and nutritionists from the residency program, under the supervision of the coordinating researcher. Initially, the patients were screened, and sociodemographic and clinical data were obtained. Subsequently, anthropometric assessment and BIA examination of the patients were performed.

For the anthropometric assessment, an electronic scale (Plena®) with a maximum capacity of up to 150 kg and an accuracy of 100 g was used to obtain the current weight. A manual stadiometer (Sanny®) with a maximum extension of 220 cm was used to measure height. Calf circumference (CC) was measured using a flexible, non-elastic tape measure. Measurements were taken according to the standard techniques proposed by Lohman et al.[8]. In cases where weight and height could not be measured, they were estimated using the equations proposed by Chumlea et al.[10,11].

Body mass index (BMI) was calculated and classified according to the cut-off points of the WHO (2000)[12] for adults and PAHO/SABE[13] for the elderly. WC was classified according to the cut-off points proposed by Barbosa-Silva et al.[14], being equal to or less than 34 cm for men and 33 cm for women as an indicator of muscle mass deficit.

Nutritional screening was performed using the Nutritional Risk Screening (NRS-2002) tool recommended by the European Society for Parenteral and Enteral Nutrition (ESPEN). The NRS-2002 classifies patients as being at nutritional risk if they have a total score ≥ 3 points, and not at nutritional risk if their total score is <3 points[15,16].

The Biodynamics Model 310e TBW® device was used to perform the BIA test, with an accuracy of 0.1% for resistance and 0.2% for reactance, an electrical current speed of 800 (microamperes), and a current frequency of 50 kHz (kilohertz). Participants were instructed before the test, according to ESPEN[8], being given recommendations and the BIA device instruction manual. To perform the test, it was necessary to rest for at least 10 minutes before the evaluation. Participants remained in the supine position, with their legs about 30 cm apart, their hands open and resting on the stretcher, barefoot and without jewelry.

Resistance, reactance, total body water (TBW), and BCM data were obtained using software provided by the BIA device. To identify FFM, the equation proposed by Gonzalez et al.[17] for Brazilian adults was used. FM was obtained by subtracting weight (kg) from LFM (kg). AF was calculated using the arc tangent (Xc/R) x 180°/π.[17] The body cell mass index (BCMI) was equql to BCM/height^2, as described by Talluri.[19]

Ethical Aspects

This study was approved by the Research Ethics Committee of the Federal University of Sergipe-Lagarto Campus, according to opinion No. 4,386,020, in accordance with Resolution No. 466/12. All participating individuals were informed about the objectives and processes addressed in the study, as well as the benefits and risks, as described in the Free and Informed Consent Form.

Statistical Analysis

The SPSS (Statistical Package for Social Sciences) program, version 20.0, was used for data analysis. Initially, a descriptive analysis of the variables was performed, expressed as mean and standard deviation for continuous variables and absolute and relative frequency for categorical variables. The normality of the variables was assessed using the Kolmogorov-Smirnov test.

The comparison of means between groups was performed using the Student's t-test or the one-way ANOVA test when the variable included three categories. When a statistically significant difference was identified, the Bonferroni post-test was applied for multiple comparisons between pairs of groups.

The correlation between continuous variables was assessed using Pearson's correlation test. To identify independent predictors of the dependent variable PhA, multiple linear regression was performed, including in the model variables with statistical significance ($p<0.20$) in the univariate analysis and those of previously established theoretical relevance. The results were expressed as regression coefficients (β) and 95% confidence intervals (95%CI). In all analyses, a significance level of 5% was adopted.

RESULTS

The sample consisted of 117 participants, of whom 62.4% were female. A lower mean PhA value was observed among the elderly ($p<0.001$), individuals with low weight ($p<0.001$), low muscle reserve ($p=0.033$), and nutritional risk ($p<0.001$) (Table 1).

Figure 1 shows the comparison of body composition variables and PhA according to BMI classification. It was observed that underweight individuals had significantly lower mean values for PhA, BCM, and FFM when compared to individuals of normal weight and overweight individuals. In addition, there was no significant difference in the mean PhA value between individuals classified as normal weight and overweight.

Table 1 – Sociodemographic, nutritional and morbidity profile of hospitalized patients.

Variables	N (%)	Phase angle	
		Mean (SD)	p
Sex			
Men	44 (37.6)	5.7 (1.5)	0.645
Women	73 (62.4)	5.7 (1.2)	
Age group			<0.001
Adult	59 (50.4)	6.4 (1.5)	
Elderly	58 (49.6)	5.1 (1.0)	
BMI classification			<0.001
Underweight	58 (49.6)	5.1 (1.1)	
Adequate	35 (29.9)	6.3 (1.7)**	
Overweight	24 (20.5)	6.6 (0.7)**	

Continuous Table 1 – Sociodemographic, nutritional and morbidity profile of hospitalized patients.

Variables	N (%)	Phase angle	
		Mean (SD)	p
CC Classification[a]			0.033
Adequate	44 (39.3)	6.1 (1.0)	
Depletion	68 (60.7)	5.6 (1.6)	
NRS-2002[b]			<0.001
No nutritional risk	61 (56.0)	6.4 (1.4)	
Nutritional risk	48 (44.0)	5.1 (1.1)	
Main reasons for hospitalization[c]			0.880
Cardiovascular	30 (26.1)	5.6 (1.0)	
Respiratory	15 (12.8)	6.0 (1.0)	
Gastrointestinal	22 (18.8)	5.9 (2.4)	
Metabolic/Renal	13 (11.1)	5.5 (0.9)	
Infectious	13 (11.1)	5.6 (1.2)	
Neurological	4 (3.4)	5.8 (0.8)	
Others	18 (15.4)	6.0 (1.4)	

SD = standard deviation; n = sample size; [a]n=109; [b]n=112; [c]n=115; ⁑ = there is no statistical difference between the BMI classification categories using the Bonferroni test.

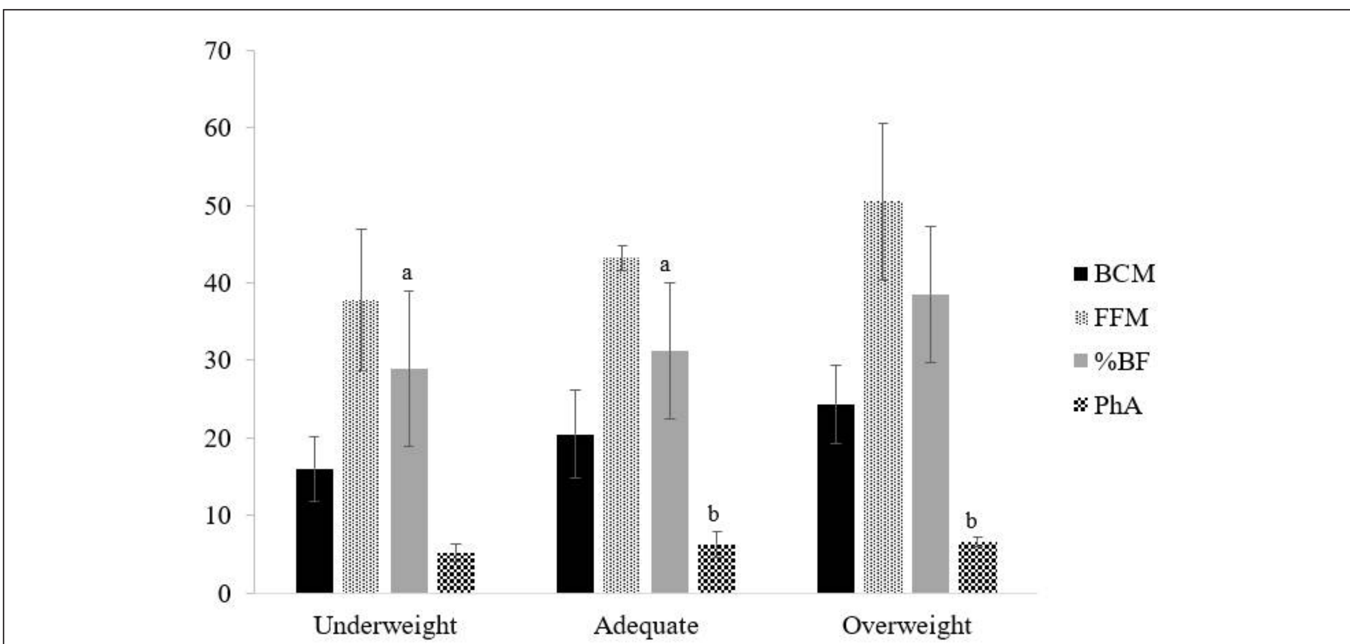

Figure 1 -Comparison between PhA, BCM and %BF between the BMI categories of the patients evaluated.
PhA = phase angle; BCM = body cell mass; FFM = fat-free mass; %BF = percentage of fat mass. Data are presented as mean ± SD. Equal letters demonstrate that there is no statistical difference between the BMI classification categories by the Bonferroni test.

Analyzing the correlation between PhA and the variables analyzed (Figure 2), a positive correlation was observed between PhA and BMI, FFM, BCM, TBW, and BCMI ($p<0.05$). In contrast, a negative correlation was found between PA and age ($r=0.47$; $p<0.01$).

In the multiple linear regression analysis (Table 2), it was found that the model, adjusted for age, with the variables FFM and BCM presented an R^2 of 53.7%. These variables were determined to best explain the variation in PhA, such that an increase of one unit of BCM is associated with an increase of 0.37° in the PhA value.

	PhA	Age	BMI	FFM	%BF	BMC	TBW	BCMI
PhA	1,00	-0,47	0,35	0,24	0,04	0,53	0,23	0,57
Age	-0,47	1,00	-0,22	-0,27	0,01	-0,45	-0,27	-0,39
BMI	0,35	-0,22	1,00	0,53	0,38	0,59	0,51	0,73
FFM	0,24	-0,27	0,53	1,00	-0,30	0,89	0,99	0,70
%BF	0,04	0,01	0,38	-0,30	1,00	-0,22	-0,30	-0,06
BMC	0,53	-0,45	0,59	0,89	-0,22	1,00	0,88	0,88
TBW	0,23	-0,27	0,51	0,99	-0,30	0,88	1,00	0,70
BCMI	0,57	-0,39	0,73	0,70	-0,06	0,88	0,70	1,00

Figure 2 - *Pearson correlation between PhA, age, BMI, FFM, %FM, BCM, TBW and BCMI of the patients evaluated.*
** = p<0.05; ** = p<0.01; TBW = total body water; PhA = phase angle; BMI = body mass index; BCMI = body cell mass index; BCM = body cell mass; FFM = fat-free mass; %BF = percentage of fat mass.*

Table 2 – Multiple linear regression model of the phase angle of the evaluated patients.

Variables	Phase angle		
	Beta	95%CI	Adjusted R^2 (%)
FFM	-0.15	-0,18 – -0,11	53.7
BCM	0.37	0.30 – 0.44	

95%CI = 95% confidence interval; FFM = lean body mass; BCM = cellular body mass.

DISCUSSION

The study observed a relationship between PhA and BCM in hospitalized patients, demonstrating that individuals with higher PhA had higher BCM. Other studies have shown that PhA has emerged as a promising tool in body composition assessment, as it reflects body cell mass, muscle quality, and the distribution of body water compartments[3,5,20,21].

The study by Cimmino et al.[5] sought to identify an association between BMI, PhA, BCM, and FM in adults admitted to a study and research clinic in Italy, revealing a positive relationship between BCM and PhA. This relationship between PhA and BCM was evidenced in the present study.

On the other hand, analyzing the relationship between PhA and nutritional and biochemical markers in hospitalized patients, Vasconcelos & Oliveira[22] found that PhA correlated with the thickness of the adductor pollicis muscle, appendicular muscle mass, appendicular muscle mass index, and hematocrit. These indicators are related to the individual's nutritional status. Bellido et al.[23] observed a reduction in PhA values in clinical conditions characterized by loss of body mass and changes in hydration status, as occurs in cases of malnutrition, sarcopenia, and cachexia. It is known that PhA values tend to decrease with advancing age, with the decline attributed to reduced reactance[3]. This reduction is associated with loss of muscle mass and a decline in body water, an essential component of muscle cells and present in greater proportions in healthy individuals[3,5].

PhA is recognized as a good indicator of nutritional status and a promising measure for the clinical prognosis of patients. Furthermore, it has been shown to be more efficient for nutritional assessment than the Subjective Global Assessment[24]. The study by Deeltar Giorno et al.[25] found that reduced levels of PhA are associated with longer hospital stays, increased readmissions, and hospital mortality in medical wards.

The studies available in the literature suggest that PhA may represent a relevant indicator of length of hospital stay, and its monitoring is essential for designing an appropriate therapeutic plan that reduces prolonged hospitalizations. This strategy is important, given the negative impact of prolonged hospitalization on healthcare costs and patient health. Studies show an association between PA and mortality, suggesting that it may be a useful indicator for identifying high-risk patients, regardless of their comorbidity[25,26]. In addition, PhA can also be used as a marker of malnutrition, since its values decrease significantly with the reduction of muscle mass[27].

Overall, studies show that PhA has prognostic value in various health and disease issues. However, further research is needed to determine how to translate scientific knowledge about PhA into clinical practice, taking into account the different contexts of diseases.

Given this, it is important to recognize that our study must be interpreted with caution, since the study design makes it impossible to monitor and analyze variables over time. The sample composed of hospitalized patients alone justifies the difficulty in interpreting the data and the more complex evaluation of PhA performance. In addition, the sample size may not be sufficient to represent the diversity of the hospitalized population, as well as the lack of stratification of the analyses by age group and gender, which impacts the interpretation of the results. Furthermore, it is recommended that new prospective studies be conducted, involving patient follow-up, as well as comparisons by gender, age group, and clinical condition, allowing for better identification of PhA performance according to individual characteristics.

CONCLUSION

This study presented the relationship between PhA and BCM, highlighting the importance of assessment in the hospital setting as parameters related to the health and nutritional status of individuals.

REFERENCES

1. Prado CM, Gonzalez MC, Norman K, Barazzoni R, Cederholm T, Compher C, et al. Methodological standards for body composition-an expert-endorsed guide for research and clinical applications: levels, models, and terminology. Am J Clin Nutr. 2025;122(2):384-91.
2. Lukaski HC, Talluri A. Phase angle as an index of physiological status: validating bioelectrical assessments of hydration and cell mass in health and disease. Rev Endocr Metab Disord. 2022;24:371–9.
3. Martins PC, Alves Junior CAS, Silva AM, Silva DAS. Phase angle and body composition: a scoping review. Clin Nutr ESPEN. 2023;56:237-50.
4. Silva BR, Orsso CE, Gonzalez MC, Sicchieri JMF, Mialich MS, Jordao AA, et al. Phase angle and cellular health: inflammation and oxidative damage. Rev Endocr Metab Disord. 2022(3):543–62.
5. Cimmion F, Petrella L, Cavaliere G, Ambrósio K, Trinchese G, Monda V, et al. A bioelectrical impedance analysis in adult subjects: the relationship between phase angle and body cell mass. J Funct Morphol Kinesiol. 2023;8(3):107.
6. Yamada Y, Yoshida T, Murakami H, Kawakami R, Gando Y, Ohno H, et al. Phase angle obtained via bioelectrical impedance analysis and objectively measured physical activity or exercise habits. Sci Rep. 2022;12(1):17274.
7. Norman K, Stabäus N, Pirlich M, Bosy-Westphal A. Bioelectrical phase angle and impedance vector analysis - clinical relevance and applicability of impedance parameters. Clin Nutr. 2012:31(6):854-61.
8. Kyle UG, Bosaeus I, Lorenzo AD, Deurenberg P, Elia M, Gómez JM, et al. Bioelectrical impedance analysis—part I: review of principles and methods. Clin Nutr. 2004;23(5):1226-43.
9. Lohman TG, Roche A, Martorell R. Anthropometric standardization reference manual. Champaign: Human Kinetics Books; 1988.
10. Chumlea WC, Guo S, Roche AF, Steinbaugh ML. Prediction of body weight for the nonambulatory elderly from anthropometry. J Am Diet Assoc.1985;88(5):564-8.
11. Chumlea WC, Steinbaugh ML, Roche AF, Mukherjee D, Gopalaswamy N. Nutritional anthropometric assessment in elderly persons 65 to 90 years of age. J Nutri Elder. 1985;4(4):39–52.
12. World Health Organization. Obesity: preventing and managing the global epidemic. Geneva: World Health Organization; 2000.
13. Organización Panamericana de la Salud. División de Promoción y Protección de la Salud (HPP). Encuesta multicéntrica: salud, bienestar y envejecimiento (SABE) en América Latina y el Caribe: informe preliminar. In: XXXVI Reunión del Comité Asesor de Investigaciones en Salud; 2001 Jun 9-11; Kingston, Jamaica. Washington (DC): Organización Panamericana de la Salud; 2002. Espanhol.
14. Barbosa-Silva,TG, Bielemann RM, Gonzalez MC, Menezes AM. Prevalence of sarcopenia among community-dwelling elderly of a medium-sized South American city: results of the COMO VAI? study. J Cachexia Sarcopenia Muscle. 2016;7(2):136-43.
15. 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(3):321-36.
16. Schiesser M, Müller S, Kirchhoff P, Breitenstein S, Schäfer M, Clavien PA. Assessment of a novel screening score for nutritional risk in predicting complications in gastro-intestinal surgery. Clin Nutr. 2008;27(4):565-70.
17. Gonzalez MC, Orlandi SP, Santos LP, Barros AJD. Body composition using bioelectrical impedance: Development and validation of a predictive equation for fat-free mass in a middle-income country. Clin Nutr. 2019;38(5):2175-9.

18. Azevedo ZMA, Silva DA, Dutra MVP, Elsas MIG, Barbosa-Silva MCG, Fonseca VM. Association between phase angle, PRISM I and sepsis severity. Rev Bras Ter Intensiva. 2007;19(3):297-303.
19. Talluri T. Qualitative human body composition analysis assessed with bioelectrical impedance. Coll Antropol. 1998;22(2): 427-32.
20. Vincenzo OV, Marra M, Gregorio AD, Pasanisi F, Scalfi L. Bioelectrical impedance analysis (BIA) - derived phase angle in sarcopenia: a systematic review. Clin Nutr. 2021;40(5): 3052-61.
21. Pereira JPC, Rebouças AS, Prado CM, Gonzalez MC, Cabral PC, Diniz AS, et al. Phase angle as a marker of muscle quality: a systematic review and meta-analysis. Clin Nutr. 2024;43(12): 308-26.
22. Vasconcelos ACH, Oliveira CC. Concordância entre ângulo de fase e marcadores nutricionais e bioquímicos em pacientes hospitalizados. BRASPEN J. 2025;40(2):e202440216. Portuguese.
23. Bellido D, García-Gracía C, Talluri A, Lukaski CH, García-Almeida JM. Future lines of research on phase angle: strengths and limitations. Rev Endocr Metab Disord. 2023;24(3): 563-83.
24. Plauth M, Sulz I, Viertel M, Höfer V, Witt M, Raddatz F, et al. Phase angle is a stronger predictor of hospital outcome than subjective global assessment - results from the prospective Dessau Hospital Malnutrition Study. Nutrients. 2022;14(9):1780.
25. Giorno RD, Quarenghi M, Stefanelli K, Rigamonti A, Stanglini C, Vecchi VD, et al. Phase angle is associated with length of hospital stay, readmissions, mortality, and falls in patients hospitalized in internal-medicine wards: a retrospective cohort study. Nutrition. 2021;85:111068.
26. Wilhelm-Leen ER, Hall YN, Horwitz RI, Chertow GM. Phase angle, frailty and mortality in older adults. J Gen Intern Med. 2014;29(1):147-54.
27. Stobäus N, Pirlich M, Valentini L, Schulzke JD, Norman K. Determinants of bioelectrical phase angle in disease. Br J Nutr. 2012;107(8):1217-20.

Study location: Lagarto University Hospital, SE, Brazil.

Conflict of interest: The authors declare there are none.