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Association between phase angle of bioelectrical impedance analysis and nutritional parameters in older adults

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ABSTRACT

Introduction: Phase angle (PhA) is a Bioelectrical impedance analysis (BIA) parameter representing an indicator of cellular health and has been suggested as a biomarker of nutritional status. **Objective:** To evaluate the association between PhA and nutritional parameters in older adults. **Methods:** A cross-sectional study was conducted with community-dwelling older adults. Body mass index (BMI), arm muscle circumference (AMC), calf circumference (CC), body fat percentage (BF%), appendicular skeletal muscle mass (ASMM), serum albumin, mini-nutritional assessment (MNA), and PhA were assessed. Kolmogorov–Smirnov test, Spearman's correlation coefficient, chi-square test, and Poisson regression models were performed. **Results:** 144 participants were included in the study, and most of them were female, aged ≥80 years, and underweight. Most older adults with lower PhA were women, aged range 80–89 years, and with reduced ASMM ($p<0.05$). PhA presented a significant correlation with age ($r=-0.417$; $p<0.001$), ASMM ($r=0.427$; $p<0.001$), AMC ($r=0.195$; $p=0.019$) and BF% ($r=-0.223$; $p=0.007$). Older adults with lower PhA present reduced ASMM (PR: 1.25; 95%CI: 1.04–1.50), and hypoalbuminemia (PR: 1.50; 95%CI: 1.11–2.03). **Conclusion:** PhA is related to commonly nutritional indicators used in clinical practice and could be an important biomarker of muscle mass reserves in community-living older adults of both sexes.

Keywords: electric impedance; analytical methods; aged, 80 and over; nutritional assessment; nutritional status.

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INTRODUCTION

Bioelectrical impedance analysis (BIA) is a technique commonly used in clinical practice for assessing body composition and estimating fat and lean body mass[1]. Additionally, BIA provides the value of the phase angle (PhA), an indicator that has been widely considered a marker of cellular integrity, and health[2]. Also, PhA presents some advantages compared to traditional nutritional indicators since it is independent of confounding variables such as weight, height, age, and predictive equations[1].

Evidence shows that PhA is associated with muscle mass, strength, and body fat[1,3]. It has also been suggested to be useful in diagnosing sarcopenia and osteoporosis, as well as a prognostic marker of morbidity, survival, and mortality in various chronic and inflammatory diseases (cancer, sarcopenia, osteoporosis, malnutrition, and Alzheimer's disease)[2,4-7].

As a noninvasive tool, PhA is considered a highly versatile and objective biomarker for evaluating older adults' nutritional status and identifying patients at nutritional risk[3]. However, to date, few studies have been conducted to evaluate the relationship of PhA with traditional nutritional parameters, and even fewer assess the relationship between PhA and muscle quality among older adults[2,6,8]. Therefore, it is important to analyze the performance of PhA with other traditional methods used in the nutritional assessment of older adults.

Thus, this study evaluated the association between PhA and nutritional parameters commonly used in clinical practice, to assist in the identification of the nutritional status of older adults.

METHODS

Study design and participants

A cross-sectional study was conducted at a general geriatric clinic from a public medical center in the municipality of Lagarto, Sergipe, Brazil.

Study participants were individuals of both sexes, aged 60 years or older, without any restrictions to realize the BIA, and who also attended the geriatric clinic between August 2018 and December 2018. The clinic attended 10 older people once a week, which generates, on average, 480 geriatric clinical care per year. Once a week, eight of 10 patients previously listed in the medical record were selected at random to participate in our study, using their registered code.

Older adults with any type of physical and/or postural limitation that would not allow us to assess anthropometric measurements, with cognitive limitations, edema, ascites, and/or visceromegaly, and also, with a pacemaker, identified by medical screening, were excluded.

Measurements

Nutritional assessment

Body mass index (BMI: weight/height²), arm muscle circumference (AMC), calf circumference (CC), body fat percentage (BF%), and appendicular skeletal muscle mass (ASMM) were carried out by a group of nutrition graduates after supervised training. All anthropometric measurements were taken using the standardized techniques proposed by Lohman et al.[9].

BMI was classified as proposed by the Pan American Health Organization (PAHO)[10]: i) underweight (BMI <23.00 kg/m²); ii) normal weight (BMI between 23 and 28 kg/m²); and overweight (BMI ≥28 kg/m²). AMC was obtained from an equation proposed by Frisancho[11], using arm circumference and tricipital skinfold thickness measurements, and classified according to NHANES III[12], with values lower than the 25th percentile classified as a reduced muscle mass reserve. For CC, values lower than 33 cm for women and 34 cm for men were classified as reduced muscle mass[13].

Nutritional risk was assessed using the Mini-Nutritional Assessment (MNA), which comprises 18 questions aggregated into four domains: anthropometry, general health, dietary assessment, and health and nutrition self-perception. Older adults were classified as well-nourished (>23.5 points) or as at nutritional risk/malnourished (≤23.5 points), according to the cut-off point proposed by Guigoz[14].

The bromocresol green method was used to assess the serum albumin levels, and the samples were analyzed in the same laboratory by a trained technician. Values equal to or higher than 3.5 g/dl were classified as normal serum albumin[15].

Bioelectrical impedance analysis

BIA was performed using a Biodynamics Model 310e analyzer, with 0.1% and 0.2% of resistance (R) and reactance (Xc) accuracy, respectively, based on an alternate current of 800 µA at 50 kHz. The entire procedure was conducted according to guidelines proposed by Kyle et al.[16]. Based on the R and Xc, PhA was calculated using the following formula [$PhA\ (°) = arctangent\ (Xc/R) \times (180°/\pi)$], and values below five degrees were classified as lower PhA[17,18].

Fat-free mass (FFM) was obtained from the equation proposed by Gonzalez et al.[19]. Body fat (BF) was calculated considering the total body weight (TBW) minus FFM, both in kilograms (BF = weight – FFM). Then, BF% was estimated, considering the proportion of TBW that it represents. The BF% was classified according to the cut-off points proposed by Morrow Junior et al.[20].

Appendicular skeletal muscle mass

ASMM was estimated using the equation proposed by Sergi et al.[21]: $ASMM\ (Kg) = [-3.964 + (0.227 \times Ht/R) + (0.095 \times Wt) + (1.384 \times sex) + (0.064 \times Xc)]$, where Ht: height in cm²; R: resistance in ohms; Wt: weight in kg; sex: men = 1 and women=0; Xc: reactance in ohms. Also, ASMM was classified as reduced when <20 kg for men and <15 kg for women[22].

Statistical analysis

Participant characteristics are shown using descriptive statistics, according to PhA classification. Data distribution was assessed with the Kolmogorov–Smirnov test. The Chi-square test was used to compare individuals with normal and lower PhA. Spearman's correlation coefficients (*r*) were calculated to assess the link and degree of relation between PhA and nutritional parameters.

Crude and adjusted Poisson regression models with robust variance and confidence intervals at 95% examined the association between PhA and nutritional parameters. All analysis was adjusted for age and sex. A p-value of p<0.05 was considered statistically significant. SPSS software version 20.0 was used for all analyses.

Ethical approval

The Federal University of Sergipe Research Ethics Committee approved the study (Approval number: 25414314.2.0000.5546). Informed consent was obtained from the participants before data collection, and all participants were offered the opportunity to refuse to participate in the study.

RESULTS

During the period, 144 older adults were included in our study. Most of them were female (77.1%), aged ≥80 years (60.0%), underweight (54.9%), and presented impaired muscle mass, according to the AMC (61.5%), CC (57.3%) and ASMM (75.0%) assessment. Also, considering the MNA classification, 60.4% of older adults were at nutritional risk/malnourished. Besides, from those with lower PhA, most were women (88.8%; p<0.001), aged range from 80–89 years (50.0%; p<0.001), and with reduced ASMM (82.5%; p=0.020). (Table 1).

PhA presented an inverse correlation with age (r= −0.417; p<0.001) and BF% (r=−0.223; p=0.007), while it presented a positive correlation with AMC (r=0.195; p=0.019) and ASMM (r=0.427; p<0.001). When stratified the results by sex, a statistically significant positive correlation between PhA and AMC (r=0.478; p=0.005) was observed only for men (Figure 1).

A statistically significant association between reduced ASMM, hypoalbuminemia and lower PhA was found (p≤0.05). In the adjusted regression model, older adults with reduced ASMM (PR: 1.25; 95%CI: 1.04–1.50), and hypoalbuminemia (PR: 1.50; 95%CI: 1.11–2.03) presented lower PhA compared to those with normal PhA (Table 2).

DISCUSSION

In this study, PhA was associated with nutritional parameters related to muscle mass reserves, which suggests the possibility of using PhA as a biomarker of muscle mass, in particular, for older adults. Also, PhA presented an inverse correlation with age, BF%, AMC, and ASMM. Similar to our results, Barbosa-Silva et al.[18] observed a reduction in the PhA values with increasing age, as well as a lower PhA among women.

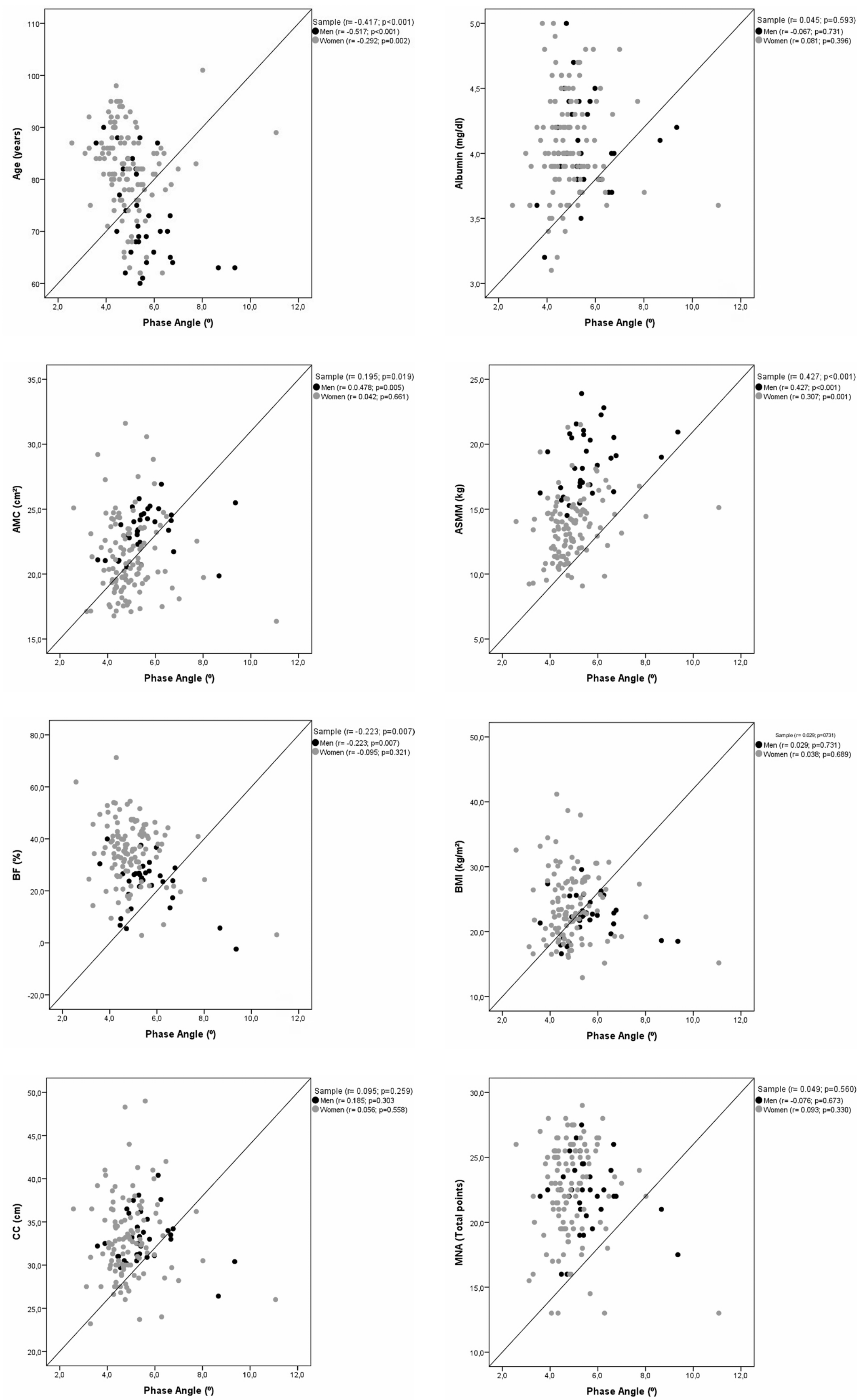
Scheunemann et al.[23] observed a concordance among standardized PhA with Subjective Global Assessment (SGA), Nutritional Risk Screening (NRS-2002), and BMI, highlighting the relationship between PhA and different nutritional parameters commonly used in clinical practice. Kilic et al.[6], in a study with community-dwelling and hospitalized older adults, reported that advanced age, low weight, BMI, CC, serum albumin level, handgrip strength, and skeletal muscle mass and index were associated with lower PhA.

Decreased cellular integrity associated with the aging process could explain, in part, those results. Also, chemical and anatomical changes in the quality and quantity of skeletal muscle mass contribute to lower PhA in older adults, regardless

Table 1: Participant characteristics according to the phase angle classification.

Characteristics	Sample	Phase Angle		p-value
		Lower	Normal	
	n (%)	n (%)	n (%)	
Sex				
Men	33 (22.9)	9 (11.2)	24 (37.5)	<0.001
Women	111 (77.1)	71 (88.8)	40 (62.5)	
Age Range				
60–69 years	24 (16.6)	5 (6.2)	19 (29.7)	<0.001
70–79 years	34 (23.4)	15 (18.8)	19 (29.7)	
80–89 years	63 (43.4)	40 (50.0)	22 (34.4)	
≥90 years	24 (16.6)	20 (25.0)	4 (6.2)	
BMI				
Underweight	79 (54.9)	46 (57.5)	33 (51.6)	0.756
Normal weight	41 (28.5)	21 (26.2)	20 (31.2)	
Overweight	24 (16.7)	13 (16.2)	11 (17.2)	
AMC				
Adequate	55 (38.5)	30 (38.0)	25 (39.1)	0.894
Reduced	88 (61.5)	49 (62.0)	39 (60.9)	
CC				
Adequate	61 (42.7)	31 (39.2)	30 (46.9)	0.359
Reduced	82 (57.3)	48 (60.8)	34 (53.1)	
BF%				
Adequate	114 (79.2)	64 (80.0)	50 (78.1)	0.783
Reduced	30 (20.8)	16 (20.0)	14 (21.9)	
ASMM				
Adequate	36 (25.0)	14 (17.5)	22 (34.4)	0.020
Reduced	108 (75.0)	66 (82.5)	42 (65.6)	
Albumin				
Adequate	139 (96.5)	75 (93.8)	64 (100.0)	0.066
Reduced	5 (3.5)	5 (6.2)	-	
MNA				
Adequate	57 (39.6)	29 (36.2)	27 (42.2)	0.495
Nutritional risk/ malnourished	87 (60.4)	51 (63.8)	37 (57.8)	

AMC: arm muscle circumference; ASMM: appendicular skeletal muscle mass; BF%: body fat percentage; BMI: body mass index; CC: calf circumference; MNA: Mini-Nutritional Assessment.
Chi-square test. A level of significance of p-value <0.05 was adopted



AMC: arm muscle circumference; ASMM: appendicular skeletal muscle mass; BF%: body fat percentage; BMI: body mass index; CC: calf circumference; MNA: Mini-Nutritional Assessment.

Figure 1: Spearman's correlation of phase angle with age and nutritional indicators.

of body composition. Therefore, these changes contribute to progressive reductions in muscle power and functionality[3]. Furthermore, older adults experience body redistribution of fatty tissue, and homeostasis, defined as the infiltration of fat tissue in muscle mass, which could decrease muscle conductivity and capacitive reactance, resulting in lower PhA, as mentioned in previous studies[24-27].

This, reinforce the proposal of PhA as a promising evaluation tool, and an alternative approach to identifying the nutritional and health condition of older adults[25]. Moreover, PhA is a safe tool and does not require specialized skills or experience in the examiner[28].

This study conducted with older adults without serious chronic diseases collaborates toward a better understanding of PhA as a nutritional assessment tool, particularly, related to evaluating muscle mass reserves. However, some limitations should be highlighted. The absence of reference values of PhA for Brazilian older adults might affect our results since the literature suggests that PhA values change across the population, despite the adoption of the cut-off point widely used in the literature to classify lower and normal PhA[17,18]. Also, our sample did not allow us to do a generalization for the Brazilian population. Instead, our results could help to screen older adults with muscle mass impairments in clinical practice through a noninvasive and non-expensive biomarker. Future work should focus on the evaluation of PhA in large samples, considering the influence of sex and age strata in PhA, as well as account for the nutritional and hydration status of participants.

Table 2: Prevalence and prevalence ratio for phase angle with nutritional indicators.

Nutritional indicators	Lower PhA Prevalence (%)	PR (95%CI) ⁱ	p-value
BMI <23.00 kg/m²	58.2	1.16 (0.88 – 1.54)	0.278
Reduced AMC	55.7	1.14 (0.86 – 1.51)	0.348
Reduced CC	58.5	1.08 (0.92 – 1.27)	0.358
Reduced BF%	53.3	0.97 (0.79 – 1.19)	0.784
Reduced ASMM	61.6	1.25 (1.04 – 1.50)	0.018
Albumin <3.5 mg/dl	100.0	1.50 (1.11 – 2.03)	0.009
MNA ≤23.5 points	58.0	1.12 (0.82 – 1.52)	0.475

AMC: arm muscle circumference; ASMM: appendicular skeletal muscle mass; BF%: body fat percentage; BMI: body mass index; CC: calf circumference; CI 95%: confidence interval 95%; MNA: Mini-Nutritional Assessment; PhA: phase angle; PR: prevalence ratio.
ⁱ Poisson regression model adjusted for age and sex.

In conclusion, our results support the use of PhA in daily clinical practice, as it can be regularly performed using a portable BIA device, and it can be easily interpreted as a marker of muscle mass reserves in community-dwelling older adults. Moreover, it is necessary to improve the investigation of PhA in clinical practice since it is a simple parameter that could be used to monitor changes in body composition and fluid balance, in an early stage, and, therefore, contribute to the screening and identification of changes in nutritional conditions in older adults, especially those related to muscle mass.

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