USE OF BIOIMPEDANCE IN PREVENTION OF SARCOPENIA IN THE ELDERLY

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SUMMARY

Objectives: Physiological ageing is associated with major and progressive changes in body composition, particularly in the decline of fat-free mass, which puts older individuals at risk of geriatric syndromes such as sarcopenia and sarcopenic obesity. Bioimpedance analysis noninvasively allows the determination of body composition, thus being able to rapidly assess primary risk factors leading to sarcopenia prediction.

Methods: We conducted a study of 180 probands, 120 females (66.7%) with a mean age of 76.23 (SD = 9.29) years and 60 males (33.3%) with a mean age of 74.01 (SD = 8.99) years in cooperation with facilities for the elderly and with the inpatient department of the clinics of J.A. Reimann Hospital in Prešov. Body height, body weight, hip circumference, and waist circumference were determined by the anthropometric method, from which the values of the body mass index and waist-to-hip ratio were calculated. Active body mass, total body water, extracellular body water, intracellular body water, cell mass, body mass fat, body fat index, fat-free mass index, impedance at frequencies of 50 kHz, resistance, reactance, and phase angle were determined using the Quadscan 4000 Touch bioimpedance instrument. Appendicular skeletal muscle mass (ASMM) and muscle mass (ASMM/Ht2) were calculated. The data obtained from anthropometric and bioimpedance measurements were processed in MS Excel 2000 and STATISTICA ver. 12. The difference of means in the studied groups was tested by the t-test.

Results: Presarcopenia was diagnosed in 12 (6.66%) probands out of 180 probands, of which were 3 (5%) men and 9 women (7.5%). Phase angle, ASMM and ASMM/Ht2 values were significantly lower ($p < 0.001$) in men and women with presarcopenia.

Conclusion: By introducing bioimpedance measurements into practice, it is possible to obtain results in a non-invasive way revealing possible presarcopenia in the elderly.

Key words: phase angle, reactance, sarcopenia, bioimpedance, geriatrics

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INTRODUCTION

Ageing is a complex set of interacting and interdependent processes at the molecular, subcellular, cellular, organ, and overall levels. Sarcopenia represents a progressive, generalized loss of muscle mass, muscle strength, and muscle function. It accompanies the physiological process of ageing as well as several chronic diseases which negatively affect their course and prognosis. Due to its multifactorial pathogenesis, sarcopenia is considered a complex geriatric syndrome. Several age-related factors are involved in its development, such as neuromuscular degeneration, changes in muscle protein turnover, changes in hormone levels and sensitivity, chronic inflammation, oxidative stress, and behavioural or lifestyle factors (1). A distinction is made between primary sarcopenia, which is age-related, and secondary sarcopenia, which is accompanied by chronic disease, a condition associated with immobility or inadequate nutrient intake or digestion (2). One of the most studied mechanisms involved in the pathogenesis of sarcopenia is neuromuscular degeneration. It is characterized by atrophy of muscle fibres, especially type II fibres, reduced number of alpha motor units from the spinal cord, and accumulation of fat in the muscles. Neuromuscular junctions represent the synaptic interface between motor neuron branches and muscle cells involved in the transmission of muscle action potentials. They play a key role in the neuromuscular damage that occurs in aging. With age, both the area of the nerve-ending and the number of postsynaptic endings decrease, leading to a functional impairment of the postsynaptic response of the neuromuscular junction (3).

Sarcopenia is also characterised by a variable decline in several hormones, especially sex hormones such as testosterone and dehydroepiandrosterone, or growth hormone. Levels are often reduced in the elderly, leading to changes in body composition,

such as an increase in visceral fat and a decrease in muscle mass and bone mineral density (4). According to the European Working Group on Sarcopenia in Older People (EWGSOP) operational definition, a diagnosis of sarcopenia requires the presence of low muscle mass and low muscle function, which can be defined by low muscle strength or low physical performance (5).

Bioimpedance body composition sensing is a non-invasive powerful technique for assessing human physiological signals due to deep tissue penetration. The bioimpedance analysis (BIA) is based on the principle that the electric current flows at different rates through the body depending upon its composition. The body is composed mostly of water with ions, through which an electric current can flow. The water in the body is localized in two compartments: extra-cellular water (approx. 45%) and intracellular water (approx. 55%). On the other hand, the body also contains non-conducting materials – body fat that provide resistance to the flow of electric current. Adipose tissue is significantly less conductive than the muscles or bones. Hence, there is a direct relationship between the concentrations of ions and the electrical conductivity, and an indirect relationship exists between the ion concentration and the resistance of the solution (6). Of particular importance in assessing muscle quality is the phase angle (PhA) of the bioelectrical impedance, which is a measure of the phase shift between the voltage and current flowing through the tissue. The phase shift is a delay in current flow that is caused by the deposition of electrical charge in cell membranes. The value of the phase angle impedance depends on the capacitance of the cell membranes, thus indirectly on the number and size of cells with integral membranes (7). A higher value of phase angle is a good predictor of more intracellular water in the body fluid distribution and consequently a lower ratio of extracellular water to intracellular water (8). A decrease in the degree of cellular hydration can lead to muscle atrophy (9). The aim of our study was to assess the risk of sarcopenia in people over 70 years of age using the bioimpedance parameters PhA, appendicular skeletal muscle mass (ASMM), body fat (BF), and body mass index (BMI).

MATERIALS AND METHODS

The study population consisted of 180 probands (60 males and 120 females). The mean age was 74.01 (SD = 8.99 years) for males and 76.23 (SD = 9.29 years) for females. Anthropometric and bioimpedance measurements were performed in the facilities for the elderly and the inpatient Department of Internal Medicine at the J.A. Reimann Hospital in Prešov. The inclusion criteria for probands were age over 60 years and signed informed consent. None of the participants had a previous diagnosis of sarcopenia or its preclinical status. Exclusion criteria included limb amputation, malignant disease, and the presence of metal prosthetic devices (10). Anthropometric measurements consisted of body height (Ht), weight (Wt), waist circumference (WC), and hip circumference (HC). Measurements of body weight and height were performed with an accuracy of 0.05 kg and 0.1 cm on a mechanical scale with a SECA 700 meter (Seca GmbH and Co. KG., Germany). The BMI is calculated by dividing a person's weight by the square of their height. Waist-to-hip ratio (WHR) is calculated as the ratio between waist circumference and hip circumference (10).

Body composition was estimated by bioelectrical impedance analysis using a Bodystat Quadscan 4000 Touch multifrequency analyser (Bodystat, British Isles). For each participant total body water (TBW) (%), extra-cellular water (ECW) (%), intracellular water (ICW) (%), cell mass (BCM) (kg), body fat (BF) (%), BF (kg), active body mass (ATH) (%), ATH (kg), body fat index (BFMI) (kg/m^2), fat-free mass index (FFMI) (kg/m^2), impedance (IMP) (50 kHz), resistance (RESIST) (Ω), reactance (REAC) (Ω), phase angle (PhA) (°) were measured. The analyser measures IMP to an accuracy of 0.01 Ω and PhA to an accuracy of 0.01°. The RESIST, REAC, and PhA values were measured at frequency 50 kHz. Measurements were performed in the supine position with four electrodes (1 for each leg and 1 for each arm). Participants were asked not to eat, drink or perform any physical activity for at least three hours before the examination and to empty their bladder immediately before the measurement (11).

The appendicular skeletal muscle mass was calculated according to the prediction equation of Sergi et al. Muscle mass was low for ASMM/Ht2 values < 7.0 kg/m^2 for males and < 5.5 kg/m^2 for females (12).

$$ASMM\ (kg) = -3.964 + \left(0.227\ x \frac{Ht^2}{R}\right) + (0.095\ x\ weight)$$

$$+(1.384\ x\ sex) + (0.064\ x\ X_c)$$

ASMM – appendicular muscle mass; R – resistance (Ω); Ht – height (cm); Xc – reactance (Ω); Ht2/R – resistance index (cm^2/Ω); Wt – weight (kg); sex: male = 1, female = 0

Data obtained from anthropometric and bioimpedance measurements were processed in MS Excel 2000 and STATISTICA ver. 12. The Shapiro-Wilk test was used to test for normality. The non-parametric Kruskal-Wallis test was used to evaluate differences between and within sexes. Results were presented as mean ± standard deviation (SD), and 95% confidence intervals (95% CI) were calculated for the mean values. Statistical significance of the results was accepted at p-value < 0.05. The comparison was supplemented by determining the percentage occurrence of the values of the investigated parameters.

RESULTS

The descriptive characteristics of the subjects and the differences between them are presented in Table 1.

As expected, compared with women, men were characterized by greater body weight, height, BMI, WHR, and smaller waist and hip circumferences. Mean height in men was significantly higher ($p = 0.004$) than in women. Mean body weight was significantly higher in males than females ($p < 0.001$). The mean BMI was 28.98 kg/m^2 (SD = 9.67), corresponding to the overweight. In males, the mean BMI was 30.73 kg/m^2 (SD = 15.06) statistically significantly higher compared to the mean BMI of females of 28.35 kg/m^2 (SD = 4.99), ($p < 0.001$). In men, the mean hip circumference was statistically significantly lower compared to women ($p < 0.001$). In women, the mean waist circumference was significantly lower than in men ($p < 0.001$). The WHR index value was not significant between the sexes ($p = 0.540$).

Table 1. *Average values of selected anthropometric parameters in the analysed set*

Parameter	Men n = 60 Mean (SD)	Women n = 120 Mean (SD)	p-value
Age (years)	74.01 (8.99)	76.23 (9.29)	**0.003**
Body height (m)	1.72 (0.18)	1.60 (0.07)	**0.004**
Body weight (kg)	85.61 (16.51)	73.36 (13.81)	**< 0.001**
Body mass index (kg/m^2)	30.73 (15.06)	28.35 (4.99)	**< 0.001**
Waist circumference (cm)	99.22 (12.08)	96.38 (14.4)	**< 0.001**
Hip circumference (cm)	105.96 (9.77)	106.70 (10.57)	**< 0.001**
Waist-hip ratio	1.09 (0.14)	0.90 (0.10)	0.540

SD – standard deviation. Numbers in bold indicate statistically significant values.

The results of the bioimpedance analysis are shown in Table 2. Depending on age, gender, and body composition, the total body water accounts for 50–75% of body weight and intracellular water comprises 2/3 of total body water (100–13). The younger individuals have more total body water. In old age, the percentage of TBW decreases at the expense of an increase in the percentage of BF. Women had a higher percentage of TBW 50.17 (SD = 8.77%) compared to men 48.27 (SD = 10.23%). The decrease in ICW is generally related to osmotic factors. Whereas an increase in ECW is usually due to a shift from the intracellular space to the extracellular space (14). The proportion of ICW and ECW is lower in men compared to women, but the difference is not statistically significant (ECW, p = 0.071) (ICW, p = 0.069). There was also no significant difference (p = 0.638) in the mean BCM in men 41.18 kg (SD = 8.83) compared to women 29.26 kg (SD = 8.93).

In men, the mean BF values in kilograms were 26.20 kg (SD = 12.97). In women, the mean values were significantly higher (p = 0.002). BF was 30.10 kg (SD = 10.19) in females. ATH is metabolically active as opposed to adipose tissue, which is metabolically inactive. The mean values for the whole set indicate a significant representation of BF versus ATH. A significant difference was found in the mean ATH value comparing men and women (p < 0.001).

In men, the mean BFMI value was 10.81 kg/m^2 (SD = 13.07). In women was significantly higher 11.70 kg/m^2 (SD = 4.07) (p = 0.001). A statistically significant difference (p = 0.005) was found in the FFMI comparing men 20.89 kg/m^2 (SD = 3.84) and woman 16.63 kg/m^2 (SD = 3.37).

The difference in PhA value was statistically significant comparing sexes (p < 0.001). The mean PhA value in the analysed set of men was 10.11° (SD = 6.15) in women it was value of 7.43° (SD = 4.98).

The resistance value in the analysed set of men was 446.24 Ω (SD = 96.56) and of women 514.14 Ω (SD = 108.19). In males, these values were significantly lower compared to the female population (p = 0.005).

Table 2. *Average values of selected bioimpedance parameters in the analysed set*

Parameter	Men n = 60 Mean (SD)	Women n = 120 Mean (SD)	p-value
Total body water (%)	48.27 (10.23)	50.17 (8.77)	0.097
Extracellular water (%)	23.59 (4.47)	22.88 (3.00)	0.071
Intracellular water (%)	34.06 (5.71)	27.99 (5.86)	0.069
Cell mass (kg)	41.18 (8.83)	29.26 (8.93)	0.638
Body fat (%)	29.73 (12.02)	40.73 (9.19)	**< 0.001**
Body fat (kg)	26.2 1(2.97)	30.10 (10.19)	**0.002**
Active body mass (%)	70.59 (12.02)	59.27 (9.19)	**< 0.001**
Active body mass (kg)	60.39 (13.38)	43.26 (10.04)	**< 0.001**
Body fat mass index (kg/m^2)	10.81 (13.07)	11.70 (4.07)	**0.001**
Fat free mass index (kg/m^2)	20.89 (3.84)	16.63 (3.37)	**0.005**
Impedance 50 kHz	455.45 (101.79)	519.95 (107.97)	**0.007**
Resistance (Ω)	446.24 (96.56)	514.14 (108.19)	**0.005**
Reactance (Ω)	76.23 (61.59)	64.54 (42.85)	**0.008**
Phase angle (°)	10.11 (6.15)	7.43 (4.98)	**< 0.001**

SD – standard deviation. Numbers in bold indicate statistically significant values.

Table 3. *Descriptive characteristics of men with no sarcopenia and presarcopenia*

Parameter	Men (n = 60)		p-value
	No sarcopenia n = 57 Mean (SD)	Presarcopenia n = 3 Mean (SD)	
Age (years)	71.21 (7.44)	73.64 (5.41)	< 0.001
Height (m)	1.71 (7.41)	1.69 (3.46)	0.041
Weight (kg)	84.35 (6.73)	80.16 (3.66)	0.036
Body mass index (kg/m^2)	30.02 (1.56)	26.49 (1.36)	0.040
Body fat (%)	23.83 (1.71)	28.50 (2.84)	< 0.001
Reactance (Ω)	74.20 (5.69)	69.40 (4.61)	0.033
Phase angle (°)	10.01 (6.02)	6.09 (1.44)	< 0.001
Appendicular skeletal muscle mass (kg)	25.08 (3.45)	21.30 (2.26)	< 0.001
ASMM/height^2 (kg/m^2)	8.55 (0.97)	7.00 (0.87)	< 0.001

ASMM – appendicular skeletal muscle mass; SD – standard deviation

The reactance is related to cellularity, cell size and cell membrane integrity. Women had smaller mean values of 64.54 Ω (SD = 42.85) than men 76.23 Ω (SD = 61.59). A statistically significant difference was confirmed (p = 0.008).

The results of descriptive statistics to detect the prevalence of presarcopenia in the set of men and women are presented in Tables 3 and 4. The stage of presarcopenia was diagnosed in 12 patients (6.7%) of the total cohort. Among the diagnosed patients, there were 9 females with a mean age of 75.34 (SD = 6.11) years and 3 males with a mean age of 73.64 (SD = 5.41) years. Men in the cohort diagnosed with presarcopenia had significantly higher age (p < 0.001). A significant difference was found in the average Ht value of men with presarcopenia (p = 0.041). Men with presarcopenia showed a lower mean Ht of 1.69 m (SD = 3.46) compared to men without sarcopenia of 1.71 m (SD = 7.41). The average Wt in men with presarcopenia was 80.16 kg (SD = 3.66), in men without the disease it was 84.35 kg (SD = 6.73). A significant difference was confirmed (p = 0.036). A significant difference was found in the BMI value (p = 0.040). Men with presarcopenia reached a lower BMI value of 26.49 kg/m^2 (SD = 1.36) compared to non-sarcopenic men 30.02 kg/m^2 (SD = 1.56). The value of BF was significantly different (p < 0.001) comparing to non-sarcopenic men 23.83% (SD = 1.71) and presarcopenic 28.50% (SD = 2.84). The REAC value was significantly lower (p = 0.033) in men with presarcopenia 69.40 Ω (SD = 4.61) compared to non-sarcopenic men 74.20 Ω (SD = 5.69). The value of PhA in presarcopenic men was lower 6.09° (SD = 1.44) than in non-sarcopenic men 10.01° (SD = 6.02). Lower values were also found for ASMM parameter. In men with presarcopenia, the value of ASMM was 21.30 kg (SD = 2.26), in non-sarcopenic men it was 25.08 kg (SD = 3.45). The ASMM/Ht2 value was 7.00 kg/m^2 (SD = 0.87) in presarcopenic men compared to 8.55 kg/m^2 (SD = 0.97) in non-sarcopenic men. A statistically significant difference in all three monitored parameters PhA, ASMM and ASMM/Ht2 was confirmed (p < 0.001).

The average age of non-sarcopenic women was 71.58 years (SD = 9.14), the average age of presarcopenic women was 75.34 years (SD = 6.11). Women with presarcopenia were significantly older (p < 0.001) compared to non-sarcopenic women. No significant difference was found in the average Ht of women (p = 0.054). Women with presarcopenia reached a lower mean Ht of 1.57 m (SD = 4.11) compared to women without sarcopenia of 1.59 m (SD = 8.26). The average Wt in women with presarcopenia was 70.83

Table 4. *Descriptive characteristics of women with no sarcopenia and presarcopenia*

Parameter	Women (n = 120)		p-value
	No sarcopenia n = 111 Mean (SD)	Presarcopenia n = 9 Mean (SD)	
Age (years)	71.58 (9.14)	75.34 (6.11)	< 0.001
Height (m)	1.59 (8.26)	1.57 (4.11)	0.054
Weight (kg)	72.41 (6.12)	70.83 (4.94)	0.042
Body mass index (kg/m^2)	27.83 (3.64)	24.87 (3.44)	0.028
Body fat (%)	36.14 (0.74)	39.92 (1.43)	< 0.001
Reactance (Ω)	62.97 (6.49)	60.70 (4.05)	0.051
Phase angle (°)	7.03 (4.26)	4.81 (1.98)	< 0.001
ASMM (kg)	17.60 (2.68)	14.04 (1.08)	< 0.001
ASMM/height^2 (kg/m^2)	7.03 (0.94)	5.39 (0.27)	< 0.001

ASMM – appendicular skeletal muscle mass; SD – standard deviation

kg (SD = 4.94), in women without the disease it was 72.41 kg (SD = 6.12). The significant difference was confirmed (p = 0.042).

We also found a significant difference in the BMI value (p = 0.028). Women with pre-sarcopenia reached a lower BMI value of 24.87 kg/m^2 (SD = 3.44) compared to non-sarcopenic women of 27.83 kg/m^2 (SD = 3.64). The value of BF% was significantly different (p < 0.001) comparing non-sarcopenic women 36.14% (SD = 0.74) and presarcopenic women 39.92% (SD = 1.43). The value of REAC was not significantly different (p = 0.051) in women with presarcopenia 60.70 Ω (SD = 4.05) compared to non-sarcopenic women 62.97 Ω (SD = 6.49). The value of PhA in presarcopenic women was lower 4.81° (SD = 1.98) than in non-sarcopenic women 7.03° (SD = 4.26). Lower value was also found for ASMM. In women with presarcopenia, the value of ASMM was 14.04 kg (SD = 1.08), in non-sarcopenic women it was 17.60 kg (SD = 2.68). The value of ASMM/Ht2 was 5.39 kg/m^2 (SD = 0.27) in sarcopenic women compared to 7.03 kg/m^2 (SD = 0.94) in non-sarcopenic women. The statistically significant difference of the monitored parameters PhA, ASMM and ASMM/Ht2 was calculated (p < 0.001).

DISCUSSION

Body composition measurements are objective methods of nutritional assessment and are of interest to many disciplines (15). Body composition assessment provides insight into the nutritional status and functional capacity of the human body. The EWGSOP has identified bioelectrical impedance analysis as a good portable alternative. Due to its low cost and quick and easy use, bioimpedance has been proposed for systematic and repeated assessment of muscle mass in clinical practice (16). Sarcopenia is one of the geriatric syndromes. If left untreated over the years sarcopenia causes deterioration in basic activities of daily living, falls, cognitive impairment, and increased hospital admissions (17).

We observed a trend of the distribution curve towards a higher BMI in our studied population. In the male population, the BMI value was 30.73 kg/m^2 (SD = 15.06), this value is categorized as the first-degree obesity according to Weir and Jan (18). Mean BMI results in the female cohort were 28.35 kg/m^2 (SD = 4.99) and were categorized as overweight. BMI takes into account only body mass and not body composition. This fact may not be suitable for the elderly, and also for an understanding of optimal body composition with balanced fat and lean mass. Measures of body fat mass, including body fat percentage, are used in the elderly to diagnose obesity and estimate obesity-related disease risks (19). In our study, BF was significantly higher (p < 0.001) in presarcopenic men and women compared to non-sarcopenic men and women.

Water is the most important inorganic substance in the human body. It forms the main component of the internal environment, and it is essential part of every single cell and the building material of individual cellular substances (20). The mean TBW reached 48.27% (SD = 10.23) in men and 50.17% (SD = 8.77) in women. Fat tissue predominates in the body composition of obese individuals. In the analysed population, more than 80% of men and 76.67% of women were overweight or reached the third-degree obesity. The age composition of the population also contributed to the results of the measured values. The average age for men was 74.01 years (SD = 8.99) and for women 76.23 years (SD = 9.29). The amount of TBW depended on age. The younger the individual, the more TBW they have. In the higher age, the percentage of TBW decreases at the expense of an increase in the percentage of BF. Pérez-Morales et al. (21) set that an adult female has a TBW value of 50% and an adult male has a TBW value of 60%. Women have a higher proportion of fat and a lower proportion of muscle (21). The reported TBW values did not match to our study.

TBW consists of two components: ICW and ECW. A decrease in ICW is generally related to osmotic factors. Whereas an increase in ECW is usually due to a shift from the intracellular to the extracellular space. The percentage of ICW and ECW of the whole set is higher for ICW than ECW. Mean ICW and ECW values for both men and women are below the reference range. It is advisable to increase the daily fluid intake to prevent dehydration (22).

Park et al. (23) evaluated the association between sarcopenia and the ECW/TBW ratio. The high ECW/TBW ratio in the weak grip group was 1.63 times higher than in the strong grip group (p = 0.017). An ECW/TBW ratio greater than 0.39 was 2.17 times more likely in probands with sarcopenia. According to the study, the ECW/TBW ratio may be one of the valid research tools to assess strength and physical performance. The ECW/TBW ratio in our studied group reached 0.48 in men and 0.45 in women. The high ECW/TBW ratio can predict sarcopenia and also a weak grip according to the evaluated results of the observed ECW/TBW ratio (23).

The point of the study by McIntosh et al. (24) was to develop a predictive measurement tool to estimate, diagnose, and identify sarcopenia. Criteria for this tool were considered to make it comprehensive and accessible to primary caregivers in community settings for the elderly. Eighty-five older adult probands living in a community elderly centre participated in the study, with a mean proband age of 75.2 years (SD = 5.7). The value of FFM determined by bioelectrical impedance was normalized by height – FFMI. FFMI was significantly correlated with girth measurements, WHR and BMI index, maximal grip strength, and step time. Based on these measurements, they proposed a prediction equation that accounted for the greatest variability, in FFMI are included independent variables such as gender, BMI, and step time. The proposed linear regression model can successfully predict FFMI values with high accuracy in both men and women. With these values, physicians can predict sarcopenia, and plan and implement early interventions. This is why this instrument could serve as a tool to determine the prediction of sarcopenia by FFMI (24, 25).

According to the international diagnostic criteria for sarcopenia, appendicular muscle mass is used as an indicator of muscle mass. The evaluation of ASMM is essential for determining low muscle mass in sarcopenia. VanItallie et al. (26) proposed the FFMI concept, which classifies BMI into fat and other components as indicators of nutritional status. FFMI may act as a simple surrogate marker for screening for low muscle mass in the diagnosis of sarcopenia. It is easy and relatively inexpensive to evaluate FFMI in community settings, even using widely available BIA devices. Although ASMM, which excludes bone and organ mass, has long been used internationally as an indicator of skeletal muscle mass to diagnose sarcopenia. The literature has revealed that FFMI has a strong positive correlation with ASMI (ASMM/ht2) ($r \geq 0.87$). If FFMI can estimate ASMI without advanced equipment or devices, population-based screening of low

muscle mass using FFMI would be widely and easily available for primary healthcare and community-based preventive services, including regular health screenings and counselling, as well as epidemiological research (26).

Kawakami et al. (27) stated that the optimal BIA-measured ASMI cutoff values for screening low muscle mass defined by ASMI were 7.7 kg/m^2 (sensitivity 87%, specificity 83%) for men and 6.1 kg/m^2 (sensitivity 84%, specificity 80%) for women (27). In our study, the value of ASMM/Ht2 was significantly lower in presarcopenic men and women ($p < 0.001$) compared to non-sarcopenic men and women.

PhA describes the phase difference between voltage and current sinusoidal waveforms likely because of the presence of cell membranes and tissue interfaces. It is thought to be a proxy of water distribution (ratio between ECW/ICW) and body cell mass BCM. The high values of PhA suggest greater cellularity (more BCM relative to FFM), cellular integrity and cell functions. The variability in PhA values may be ascribed to factors such as age, gender, race, body composition, level of physical activity and adiposity (28). PhA is positively correlated with cell membrane integrity and cell function. With intact cell membranes, all cellular functions are preserved, which increases the value of PhA. When cell membranes are damaged, selective filtration function is reduced. Currently, PhA is used to predict clinical outcomes. In 2019 was proposed as a possible marker for the diagnosis of sarcopenia according to the EWGSOP (29). The reduced PhA value in the presarcopenia group may be due to fewer and smaller cells with integral membranes, which reduce the phase shift between the current flowing through the tissues and the voltage. The change in cell size is most often due to a decrease in their hydration and nutrition and a decrease in the lipid content of the cell membranes. The result is subsequent atrophy of muscle cells. Because of its sensitivity to changes in cell mass and the distribution of ICW and ECW, the phase angle is considered a qualitative measure of soft tissues. High PhA values have been suggested as a good marker of higher cellularity, cell membrane integrity and better cell function. In healthy individuals, the phase angle is usually between 5 and 7 and correlates with various indices of functional and nutritional status. PhA decreases with increasing age due to a decrease in reactance, which may represent an increase in resistance due to a decrease in body water at the expense of an increase in fat mass in advanced age (30). The phase angle value was significantly lower in women 4.81° (SD = 1.98) and men 6.09° (SD = 1.44 with presarcopenia compared with probands without the disease. The electrical properties of muscle tissue are affected by structural and chemical changes. Bioimpedance methods can facilitate the identification of changes in muscle quality.

Malnutrition is an important risk factor for the development of sarcopenia. Recently, PhA has become increasingly known as a marker of nutritional status and can be considered a good indicator to identify elderly patients at risk of sarcopenia. Kosoku et al. (31) investigated the prevalence of sarcopenia and the relationship between sarcopenia and PhA or BMI as nutritional factors. Authors evaluated the discriminative power of these nutritional factors for sarcopenia in kidney transplant recipients. The prevalence of sarcopenia was lower in kidney transplant recipients, possibly due to differences in definitions of sarcopenia and population demographics such as age, sex, race, and comorbidities. Both, PhA and BMI were negatively correlated with sarcopenia after adjustment for age, sex, time after transplantation, presence of diabetes mellitus, and other nutritional factors. Discriminant performance for PhA and BMI had sufficient power to detect sarcopenia. The results suggest that PhA and BMI can be used in clinical practice to predict sarcopenia in kidney transplant patients (31).

In their meta-analysis, Di Vincenzo et al. (28) evaluated the relationships between BIA-derived PhA and sarcopenia. Overall, evidence from the literature reasonably supports the notion that PhA is reduced in sarcopenic individuals/patients, and that the prevalence of sarcopenia increases when PhA is low. The results of the study by Matias et al. (32) show that higher PhA values are related to better physical function. Regardless of sex, age, and skeletal muscle mass, PhA predicts body strength, agility, and dynamic balance in healthy older adults.

CONCLUSION

An analysis of the patient's body composition is important to determine the general health status. BIA revealed the occurrence of presarcopenia in 7% of the probands in the analysed group. The proportion of body fat was significantly higher in presarcopenic men and women. Significantly lower values of PhA and ASMM/Ht2 were observed in presarcopenic probands compared to non-sarcopenic ones. We found sex-specific differences in body composition, body fluid volumes, and hydration parameters. The use of the prognostic potential of the BIA method could improve the identification of adverse changes in the state and function of the skeletal muscles in order to prevent sarcopenia.

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Conflicts of Interest

None declared

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