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Danielle Cristina Guimarães da Silva[1]
Rafael da Silva Eufrásio[2]
Fabrícia Geralda Ferreira[3]

[1] Universidade Federal de Ouro Preto, Departamento de Nutrição Clínica e Social. Ouro Preto, MG, Brasil.

[2] Universidade Federal do Oeste da Bahia, Centro das Ciências Biológicas e da Saúde. Barreiras, BA, Brasil.

[3] Universidade da Força Aérea, Escola Preparatória de Cadetes do Ar. Barbacena, MG, Brasil.

Corresponde
Danielle Cristina Guimarães da Silva
daniellenut@hotmail.com

Assistant Editor
Barbara Perez Vogt

Phase angle and associated factors in patients with chronic kidney disease on hemodialysis treatment

Ângulo de fase e fatores associados em pacientes com doença renal crônica em tratamento hemodialítico

Abstract

Introduction: Phase angle (PA) is a measurement derived from bioelectrical impedance that is used to assess patient prognosis as it is closely related to the patient's nutritional status. ***Objective***: To verify the association between PA and sociodemographic, clinical, biochemical and anthropometric characteristics in patients undergoing hemodialysis treatment. ***Methods**:* Cross-sectional study conducted between 2018 and 2019 at a hemodialysis unit. Sociodemographic data were collected and anthropometric measurements (dry weight, height, handgrip strength, triciptal and subscapular skinfold thickness), body composition, and clinical data were obtained from the patients' medical records. Linear regression was used to determine the association between independent variables and PA. ***Results**:* The study sample consisted of 122 patients. There was a predominance of males, individuals who were married or with a partner, and individuals in the age group between 35 and 59. A negative association was found between age and PA (p = 0.018). A higher dry weight was associated with a higher PA (p = 0.047) and higher handgrip strength (p = 0.016). ***Conclusion**:* PA was found to be negatively associated with age and positively associated with weight and handgrip strength.

Keywords: Nutrition. Hemodialysis. Chronic kidney disease. Bioimpedance.

Resumo

Introdução: O ângulo de fase (AF) é uma medida derivada da bioimpedância elétrica utilizada para avaliar o prognóstico do paciente, pois está intimamente relacionada ao estado nutricional do mesmo. ***Objetivo***: Verificar a associação entre AF e características sociodemográficas, clínicas, bioquímicas e antropométricas em pacientes em tratamento hemodialítico. *Métodos:* Estudo transversal realizado entre 2018 e 2019 em uma unidade de hemodiálise. Os dados sociodemográficos foram coletados e as medidas antropométricas (peso seco, altura, força de preensão manual, pregas cutâneas triciptal e subescapular), composição corporal e dados clínicos foram obtidos dos prontuários dos pacientes. A análise de regressão linear foi utilizada para verificar a associação entre as variáveis independentes e AF. *Resultados:* A amostra do estudo foi composta por 122 pacientes. Houve

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predomínio do sexo masculino, de indivíduos casados ou com companheiro e de indivíduos na faixa etária entre 35 e 59 anos. Foi encontrada associação negativa entre idade e AF (p = 0,018). Maior peso seco foi associado a uma maior atividade física (p = 0,047) e maior força de preensão manual (p = 0,016). ***Conclusão:*** A atividade física foi negativamente associada à idade e positivamente associada ao peso e à força de preensão manual.

Palavras-chave: Hemodiálise. Doença renal crônica. Bioimpedância.

INTRODUCTION

The incidence of people diagnosed with chronic kidney disease (CKD) has risen over the years, making it a public health problem.[1-3] According to World Kidney Day, 10% of the world's population has CKD,[1] requiring early preventive and therapeutic measures to reduce and delay adverse clinical outcomes.[4-7]

Patients with CKD are prone to various complications, such as pulmonary congestion, metabolic acidosis, hypocalcemia, hyperphosphatemia, and especially malnutrition.[3,5-7] It is important to highlight that the prevalence of malnutrition in kidney patients on hemodialysis can vary between 11 and 54%.[8] Malnutrition in hemodialysis patients can develop due to low food intake as a result of severe restrictions, nausea, queasiness, frequent blood sampling, and nutrient and blood loss in the dialysate.[3,5-7]

Malnourished patients are more likely to be hospitalized and have an increased risk of infection and mortality, because the body does not respond adequately to treatment, intense catabolism and inflammatory cytokine production are common, and the immune system is weakened.[3,5-7] Therefore, they should be routinely monitored and assessed nutritionally. For renal patients, various methods are used in clinical practice, such as anthropometry, ultrasound, food intake questionnaires, and bioelectrical impedance analysis (BIA), among others.[9]

Phase angle (PA) is a measure derived from BIA that is used to assess patient prognosis.[9-11] Some studies suggest a close relationship between PA and nutritional status.[9-11] Malnourished patients with CKD suffer from changes in body composition, such as a reduction in muscle mass, which leads to a loss of strength and consequent reduction in PA.[9-11]

A systematic review and meta-analysis by Martins et al.[12] showed a direct association between PA, muscle strength and aerobic fitness in patients with cancer, Crohn's disease, sarcopenia, kidney transplants, and in hemodialysis therapy. In addition, a reduced PA is associated with a greater risk of mortality and may be associated with a greater likelihood of hospitalization with regression of the clinical condition.[10-12] However, few studies have analyzed PA together with other aspects in this populationto verify the possible relationship. In this context, this study aimed to determine if there was an association between PA and sociodemographic, clinical, biochemical and anthropometric characteristics in patients undergoing hemodialysis treatment.

METHOD

Study design

This is a cross-sectional study conducted at a hemodialysis clinic located in the municipality of Barreiras, in the state of Bahia, Brazil.

Population and sample

The study was conducted in a convenience sample of 122 patients of both sexes undergoing conventional hemodialysis treatment with a session duration of approximately 4 hours. All patients who met the inclusion criteria were invited to participate in the study.

The inclusion criteria were being over 18 years old, undergoing hemodialysis treatment at the health unit for at least one month, and signing the Free and Informed Consent Form. Patients who were unable to answer the survey or who had not undergone anthropometry and pregnant women were excluded from the study. The project was approved by the Research Ethics Committee of the Federal University of Oeste da Bahia under protocol no. 83803418.3.0000.8060.

Procedures

Data collection took place between July 2018 and November 2019 and consisted of the application of a structured questionnaire, the collection of anthropometric measurements, the analysis of body composition, and the gathering of clinical data from the patients' medical records. All the collection stages were carried out by previously trained interviewers to ensure the reliability of the data obtained.

Sociodemographic information was collected, such as sex, age, education, marital status, and socioeconomic status according to the Brazilian Association of Research Companies (ABEP).[13] Clinical and biochemical data (albumin, hemoglobin and time on hemodialysis) were obtained from the patients' medical records.

The following data were collected: dry weight, height, handgrip strength, triciptal skinfold (TSF), and subscapular skinfold (SSF). The body composition data analyzed by bioimpedance were PA, lean mass and fat mass. Anthropometric measurements and body composition analysis were performed after the hemodialysis session.

Dry weight was measured using a SECA® electronic scale (model SECA-665®, USA - 2016), with a maximum capacity of 300 kg and sensitivity of 100 g. Height was measured using a WISO® (Brazil) fixed-rod stadiometer. Handgrip strength was measured in duplicate, after the hemodialysis session, using a SAEHAN® hydraulic dynamometer (Saehan Corporation - SH5001). The non-fistulated arm was used for measurement. The participants were seated with the arm without the catheter adducted and the elbow flexed to 90º. The maximum strength obtained by the patient was used for analysis.[14]

A CESCORF® adipometer (clinical model) was used to measure the folds (TSF and SSF). The measurement was performed on the limb opposite the dominant arm and the arm with vascular access.[15]

Bioelectrical impedance (A-310 Biodynamics Corporation USA) was used to determine the patient's PA, lean mass (LM), and fat mass (FM). For the bioimpedance test, the participants were informed about the necessary prerequisites, such as no alcohol consumption or strenuous exercise in the 24 hours prior to the test.[15] After the hemodialysis session, the participants were asked to remove any metal objects from their bodies, then they were positioned horizontally, and with the help of four plethysmograph electrodes, a low-intensity electric current detected the patients' body composition.[16]

Descriptive statistics

The data were analyzed using Stata 13.1 software. The normality of the variables was assessed using the Shapiro-Wilk test. Variables that were not normally distributed were log-transformed for statistical analysis. Data were expressed as mean ± standard deviation or median (quartiles), according to the variable distribution. The association between the independent variables and PA was verified using linear regression models. In the multiple model, variables with $p<0.20$ in the bivariate analysis were considered, and only those with $p<0.05$ remained in the model.

RESULTS

The hemodialysis unit had 156 registered patients, of whom140 were eligible for the study. After the analysis of discharges and deaths, the sample size for this study was 122 patients. Of these, 63.1% (n = 77) were male, 63.1% (n = 77) were married or had a partner, 59% (n = 72) were aged between 35 and 59, 86.1% (n = 105) had elementary school as education level, and 49.2% (n = 60) classified as to the low socioeconomic level, as shown in Table 1.

Table 1. Sociodemographic characteristics of patients treated at a hemodialysis center in Oeste da Bahia. Barreiras-BA, 2018-2019.

VARIABLES	N	%
Sex		
Male	77	63.1
Female	45	36.9
Marital Status		
Married/partnered	77	63.1
Single/separated/widowed	45	36.9
Age Group (Years)		
<35	26	21.3
≥35-59	72	59.0
≥60	24	19.7
Education		
Non-literate	11	9.0
Elementary school	105	86.1
High school/vocational school/higher education	44	4.9
Socioeconomic Level		
High (A and B)	11	9.0
Intermediate (C)	51	41.8
Low (D and E)	60	49.2

The mean values for the study population were as follows: height: 165.33 cm (SD=9.37); dry weight: 66.1 kg (SD=14.44); TSF: 14.83 mm (SD=8.61); SSF: 16.18 mm (SD=8.25); lean mass: 49.2 kg (SD=11.67); fat mass: 17. 19 kg (SD=9.25); PA: 6.89º (SD=1.95), handgrip strength: 28.86 kgf (SD=18.62); time on hemodialysis: 27.2 months (SD=39.34); albumin: 3.53 mg/dL (SD=0.56); and hemoglobin: 9.50 mg/dL (SD=3.49). The biochemical information for serum albumin and serum hemoglobin showed mean values of 3.53 mg/dL (SD=0.56) and 9.50 g/dL (SD=3.49), respectively (Table 2).

Table 2. Anthropometric, body composition, clinical and biochemical characteristics of patients with chronic renal failure on hemodialysis in Oeste da Bahia. Barreiras-BA, 2018-2019.

Anthropometric variables	Mean	Standard Deviation (SD)	25th percentile; 75th percentile
Height (cm)	165.33	9.37	159; 172
Dry weight (kg)	66.10	14.44	57.3; 73.3
Tricipital skinfold thickness (mm)	14.83	8.61	9; 20
Subscapular skinfold thickness (mm)	16.18	8.25	10; 20
Lean mass (kg)	49.20	11.67	41.5; 55.4
Fat mass (kg)	17.19	9.25	10.8; 22.7
Phase angle (°)	6.89	1.95	5.8; 7.6
Handgrip strength(kgf)	28.86	18.62	16; 40
Time on hemodialysis(months)	27.2	39.34	6; 34.5
Albumin (mg/dL)	3.53	0.56	3.25; 3.91
Hemoglobin (g/dL)	9.50	3.49	7.9; 10.5

Table 3 shows the determinants of PA by simple and multiple analyses in a linear regression. Negative associations were found between age and PA. A higher dry weight was associated with a higher PA and higher handgrip strength. There were no statistically significant associations with biochemical or clinical factors.

Table 3. Coefficients of simple and multiple linear regressions, confidence intervals and p-values for phase angleinpatients with chronic renal failure on hemodialysis in Oeste da Bahia. Barreiras-BA, 2018-2019.

Variables	β	CI (95%)	p-value	ßAj	CI (95%)	p-value
Sex	-0.089	-0.181; 0.002	0.056			
Marital status	-0.016	-0.110; 0.076	0.724			
Age	-0.003	-0.006; -0.001	0.030	-0.080	-0.146; -0.014	0.018
Education	0.043	-0.078; 0.164	0.483			
Socioeconomic level	-0.030	-0.101; 0.040	0.403			
Height (cm)	0.004	-0.001; 0.009	0.057			
Dry weight (kg)	0.003	0.001; 0.007	0.011	0.003	0.001; 0.058	0.047
Tricipital skinfold thickness (mm)	0.001	-0.004; 0.006	0.744			
Subscapular skinfold thickness (mm)	0.001	-0.005; 0.006	0.939			
Lean mass (kg)	0.003	0.001; 0.007	0.042			
Fat mass (kg)	0.002	-0.002; 0.007	0.325			
Handgrip strength (kgf)	0.003	0.001; 0.006	0.001	0.002	0.001; 0.005	0.016
Time on hemodialysis (months)	-0.001	-0.001; 0.002	0.452			
Albumin (mg/dL)	0.054	-0.031; 0.139	0.213			
Hemoglobin (g/dL)	0.005	-0.007; 0.019	0.403			

CI (95%): 95% confidence interval; ß: ß value for simple linear regression; ßAj: ß value adjusted for covariates; p-value: multiple linear regression,assuming significance at $p<0.05$; the variables were adjusted for each other for the final model.

DISCUSSION

This study investigated whether PA is associated with sociodemographic, anthropometric, body composition, clinical and biochemical factors in patients undergoing hemodialysis therapy at a health service. A negative association was found between age and PA, i.e., older individuals had lower values for this variable. It was also observed that higher dry weight and handgrip strength were positively associated with PA.

Like the data found in our study, a negative relationship between PA and age was observed in the study by Soares et al.[10] when comparing the body composition of 29 hemodialysis patients with healthy individuals living in Goiânia (GO). With advancing age, some cells lose their functionality and the individual's functional status decreases, which is indicated by reduced PA values.[10,11] In addition, the physiological changes associated with aging, together with the prolongation of hemodialysis therapy, can contribute to the worsening of the physical/functional incapacity of dialysis patients.[17,18] Elderly individuals undergoing hemodialysis treatment are susceptible to loss of lean mass, malnutrition, anemia, osteoporosis, frailty, sarcopenia and other alterations due to their inflammatory state, increased catabolism, low food intake, low vitamin D levels, reduced erythropoietin, nutrient and blood losses in the dialysate, and intensive blood sampling.[17,18]

A study of 126 adults (52 on peritoneal dialysis and 74 on hemodialysis) showed that malnourished patients had lower PA values and were older than those without malnutrition.[19] Kim and Don-Jin[20] analyzed the nutritional status of 76 hemodialysis patients and found a negative association between PA and both age and female sex. Changes in membrane selective permeability and cell death occur throughout life, but these mechanisms are accelerated with age, resulting in a decrease in cell integrity.[10,11,19] Therefore, an adequate diet throughout life (based on fresh and minimally processed foods, as well as low consumption of processed and ultra-processed foods) is necessary as it contains important nutrients such as antioxidants, which act on cell health and structure, preventing lipid peroxidation and free radical attack.[10,11,19] In addition, fresh foods are rich in fiber, minerals, and important vitamins at this stage of life, such as vitamin D, calcium, iron, and others that affect muscle health and the immune system.[10,11,19] In this context, it should be noted that the elderly suffer from important dietary changes, such as reduced food intake and low water consumption, which negatively affect the health, strength, muscle mass and consequently the PA of this group.[17,18]

We found that dry weight was positively associated with PA. When controlled, an increase in dry weight can have a positive impact, especially in dialysis patients, who are prone to malnutrition.[21] Thus, weight gain may result in positive changes in body composition and nutritional status in malnourished dialysis patients, and consequently increase PA.[21] Pimentel et al.[9] found no relationship between PA and dry weight in chronic kidney disease patients before and after hemodialysis. These differences may be related to population variability and also to the water changes present in these patients.[9]

Our results on the positive relationship between PA and handgrip strength contradict the studies by Pimentel et al.[9] and Beberashvili et al.,[22] among 57 and 250 adult and elderly hemodialysis patients. These parameters may indicate the general health of the patients, i.e., high PA and strength values are associated with better functional and nutritional integrity in patients with CKD.[23,24]

A recent study by Kang et al.,[23] which sought to verify the correlation between PA and muscle mass, strength and quality of life in 83 adult and elderly patients who had been on hemodialysis therapy for more than 6 months, found a positive relationship between PA, muscle mass, physical performance and especially muscle strength. Shin et al.[24] used PA as a marker of muscle health and quality of life in 149 adult patients with CKD and found that as PA decreased, handgrip strength also decreased. According to Ding et al.,[25] the loss of muscle mass can cause a decrease in intracellular water, which reduces resistance and consequently PA.

Individuals undergoing hemodialysis are exposed to numerous factors that contribute to the loss of muscle mass and consequently loss of strength, such as the chronic inflammatory process leading to hypoalbuminemia, loss of protein for dialysis, muscle hypercatabolism, hormonal disorders, and especially dietary changes.[17,18] As a result, quality of life is compromised and mortality is higher in this population.[24] In this context, early and continuous nutritional intervention is needed to reduce the effects of muscle catabolism and various other metabolic changes present in these patients, especially malnutrition.[20]

The use of PA as a predictor of patient functional and nutritional status is widespread, especially in clinical practice.[9-11] However, more studies with a diverse population and larger sample size are needed, as different population characteristics can influence the results and clinical outcomes.[25] In addition, PA should not be assessed in isolation, so other measurements (calf circumference, abdominal circumference) and their combination with other methods (performance tests) and nutritional parameters, such as imaging tests (computed tomography, magnetic resonance imaging) and food consumption questionnaires (food frequency questionnaire, 24-hour recall, food diary)[4,25,26] are essential in future research on PA.

A limitation of this study is the use of some data from medical records that were not obtained directly by trained researchers, but other studies cited in this research have used the same methodology. Data collected by untrained people compromise the quality of the information and may not be consistent with the patients' real information. However, the hospital where the research was conducted has a rigorous system for recording and monitoring the data entered into medical records.

As a positive point, it is worth highlighting the size of the sample, which, although not very large, represented 78.2% of the total number of patients registered at the unit and was representative of the group. The sample in this study was mostly male, adult/elderly, married, with primary education and an intermediate socioeconomic level, but these characteristics may not represent most patients undergoing hemodialysis treatment, i.e., the results obtained should not be generalized to the entire hemodialysis population and possible selection bias must be considered.

CONCLUSION

It is concluded that PA is negatively associated with the sociodemographic factor age and positively associated with dry weight and handgrip strength in hemodialysis patients. It is therefore necessary for this population to be routinely assessed by multi-professional teams to reduce adverse clinical outcomes.

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Contributors

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