Association between physical fitness and phase angle in older adults: A pilot study

Asociación entre condición física y fase angular en el adulto mayor: Un estudio piloto

Associação entre condição física e fase angular em idosos: Um estudo piloto

Iván Toledo Rebolledo [1], Cristina Frerk Ubilla [2], Felipe Morales Gómez [3], Raúl Muñoz Agostini [4], Ricardo Martínez-Flores [5] & Fernando Rodríguez-Rodríguez [6]

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ABSTRACT

The diagnosis by bioimpedance (BIA) and the phase angle (PhA) are indicators, that allow monitoring of the physical health and nutritional status of older adults. The objective of this study was to establish the relationship between physical fitness and phase angle values by bioimpedance in a group of sedentary older adults. 24 elderly sedentary volunteers participated (21 women and 3 men). Each participant underwent bioimpedance, manual dynamometry, and the 6-minute Senior Fitness Test (SFT). Subsequently, the results were analyzed, making a correlation between PhA and cardiorespiratory physical condition, another between PhA and cardiorespiratory physical condition according to sex and finally an association between PhA and handgrip strength. R71% presented a PhA mean below the reference (4.5° ± 0.4), specifically 67% of men and 62% of women. The correlation between PhA and cardiorespiratory fitness showed a value of R^2= 0.50; p<0.0001. The association between PhA and handgrip strength was R^2=0.35; p=0.0023. A significant relationship was found between a cardiorespiratory fitness test and PhA and between handgrip strength and PhA. It is of clinical importance to include objective cellular assessment parameters in older adults such as PhA.

Key words: Bioimpedance; Elderly; Physical activity, Handgrip strength.

[1] Licenciado en Educación Física y Salud. Programa de Pedagogía en Educación Física, Pontificia Universidad Católica de Valparaíso. Valparaíso, Chile. https://orcid.org/0009-0004-9455-6807 | ivantoledor@gmail.com

[2] Licenciada en Educación Física y Salud. Programa de Pedagogía en Educación Física, Pontificia Universidad Católica de Valparaíso. Valparaíso, Chile. https://orcid.org/0009-0009-0010-0873 | cfrerku1@gmail.com

[3] Licenciado en Educación Física y Salud. Programa de Pedagogía en Educación Física, Pontificia Universidad Católica de Valparaíso. Valparaíso, Chile. https://orcid.org/0009-0005-8608-275X | mgomez.felipe@gmail.com

[4] Licenciado en Educación Física y Salud. Programa de Pedagogía en Educación Física, Pontificia Universidad Católica de Valparaíso. Valparaíso, Chile. https://orcid.org/0009-0004-9420-6989 | raul.andre.munoz@gmail.com

[5] Licenciado en Educación Física y Salud. Grupo de investigación IRyS, Escuela de Educación Física, Pontificia Universidad Católica de Valparaíso. Valparaíso, Chile. https://orcid.org/0000-0002-8435-2710 | ricardo.antonio.martinezf@gmail.com

[6] Doctor en Biomedicina. Grupo de investigación IRyS, Escuela de Educación Física, Pontificia Universidad Católica de Valparaíso. Valparaíso, Chile. https://orcid.org/0000-0002-4999-4857 | fernando.rodriguez@pucv.cl

RESUMEN

El diagnóstico por bioimpedancia (BIA) y el ángulo de fase (AnF), como indicador, permiten monitorear el estado físico, de salud y nutricional en adultos mayores. El objetivo de este estudio fue establecer la relación entre la condición física y valores de fase angular por bioimpedancia en un grupo de adultos mayores sedentarios. Participaron voluntariamente 24 adultos mayores sedentarios (21 mujeres y 3 hombres). A cada participante se les midió bioimpedancia, fuerza de presión manual y test de 6 minutos del Senior Fitness Test (SFT). Posteriormente se analizaron los resultados, correlacionando el ángulo de fase (AnF) y condición física cardiorrespiratoria según sexo y el AnF con la fuerza de presión manual. El 71% presentó una media de AnF por debajo de la referencia (4,5° ± 0,4), específicamente, el 67% de los hombres y el 62% de las mujeres. La correlación entre AnF y capacidad física cardiorrespiratoria arrojó un valor de R^2= 0,50; p<0,0001. La asociación entre AnF y fuerza de presión manual fue de R^2=0,35; p=0,0023. Se encontró una relación significativa entre una prueba de condición física cardiorrespiratoria y AnF y entre la fuerza de presión manual y AnF. Es de importancia clínica incluir parámetros objetivos de valoración celular en adultos mayores como el AnF.

Palabras clave: Bioimpedancia; Mayores; Actividad Física; Fuerza de presión manual.

RESUMO

O diagnóstico por bioimpedância (BIA) e ângulo de fase (AnF), como indicador, permitem monitorar o estado físico, de saúde e nutricional de idosos. O objetivo deste estudo foi estabelecer a relação entre a condição física e os valores da fase angular por bioimpedância em um grupo de idosos sedentários. Participaram voluntariamente 24 idosos sedentários (21 mulheres e 3 homens). Cada participante foi medido bioimpedância, força de pressão manual e teste de 6 minutos do Senior Fitness Test (SFT). Posteriormente, os resultados foram analisados, correlacionando o ângulo de fase (AnF) e a condição física cardiorrespiratória de acordo com o sexo e o AnF com a força de pressão manual. 71% apresentaram média do LAn abaixo da referência (4,5° ± 0,4), sendo 67% dos homens e 62% das mulheres. A correlação entre o LAn e a aptidão cardiorrespiratória deu um valor de R^2= 0,50; p<0,0001. A associação entre LAn e força de pressão manual foi R^2=0,35; p=0,0023. Encontrou-se relação significativa entre teste de aptidão cardiorrespiratória e NF e entre força de pressão manual e NF. É de importância clínica incluir parâmetros objetivos de avaliação celular em adultos mais velhos, como AnF.

Palavras chave: Bioimpedância; Idosos; Atividade física, Força de pressão manual.

INTRODUCTION

Currently, 22% of the world's population belongs to the older adult group and in Chile, 19% is in this same group (Arnold et al., 2021), estimating that this value will increase to 33% by 2050 (Arnold et al., 2017). Aging produces various systemic alterations, decreasing the activity of most organs and tissues (Landinez et al., 2012). Lack of exercise, physical activity and immobility are aggravating factors (Chávez et al., 2004). In this sense, changes appear that affect body mass, the size and function of cells and muscles, VO2max, the skeletal system, the cardiopulmonary system, among others. On the other hand, it is necessary to mention that the speed of the functional decline of the organism varies enormously from person to person, and from organ to organ within the same individual (Landinez et al., 2012). Physical exercise has a direct and positive influence on the health of older adults, helping to maintain their motor independence, prevent different diseases, and provide psychological, social, and emotional benefits of physical activity (Ramakrishnan et al., 2021).

In this sense, diagnostic tools such as bioimpedance (BIA) and phase angle (PhA) emerge as indicators that allow monitoring the physical and nutritional status of older adults (Cheung et al., 2021).

BIA is a method that estimates total body water, fat mass, and fat-free mass, which allows identifying the early association between excess or deficiency of these and the risk of some chronic diseases (Pratt et al., 2019).

On the other hand, we can define PhA as the ratio between reactance (Xc) and electrical resistance (R), understanding resistance as the pure opposition of a biological conductor to the flow of an alternating electric current, while reactance is the effect of resistance to electricity due to the storage of electric charge in a capacitor (Llames et al., 2013). In practice, both are indicators of the quality of soft tissue mass, in addition to cell membrane permeability and hydration. Consequently, PhA is quantified as a tangential arc with the formula (Xc/R) x (180°/π) (Lukaski, 2013). Previous studies have pointed out PhA as a predictor of sarcopenia and its association with cancer, malnutrition, and mortality risk in older adults (Ji et al., 2021; Kwon et al., 2023; Lukaski et al., 2017). Likewise, a robust body of evidence indicates that PhA is associated with the quantity and quality of muscle mass, as well as with nutritional status and muscular and aerobic fitness (Akamatsu et al., 2022; Martins et al., 2022; Geng et al., 2022; Sato et al., 2022).

According to the above, physical activity causes an increase in PhA, resulting in better cell membrane integrity and functionality, changes in intracellular composition, and improved tissue capacity (Mundstock et al., 2019). Furthermore, it has been used in different populations as an objective indicator of cellular health (Ribeiro et al., 2017). Accordingly, PhA is identified as a new biomarker of frailty. A low PhA score (<4.6 in women and <5.0 in men) can predict mortality and morbidity in severe pathologies, such as in patients with cardiac surgery (Mullie et al., 2018). In this sense and due to all the above and the aging of the population worldwide (Arnold et al., 2021), it is necessary to investigate measures that allow us to evaluate the physical condition of older adults and its relationship with cellular health (Faria et al., 2018; Saad et al., 2018).

Therefore, the objective of this study was to establish the relationship between physical condition and PhA values by bioimpedance in a group of sedentary older adults.

METHODS

This exploratory, non-probabilistic, cross-sectional study was conducted on 24 older adults (3 men and 21 women) belonging to the Circle of Retired Armed Forces. The average age was 78.8 years. The subjects were selected in a non-probabilistic manner and had to be over 65 years old. They should not have problems moving independently or suffer from any mental disorder such as dementia or Alzheimer's.

Instruments

Height was measured with a portable stadiometer brand Seca 213 (Hamburg, Germany) with a precision of 0.1 cm. To obtain the weight record, a digital scale Omron HN-289 (Illinois, USA) with a precision of 100 g was used. For the evaluation of body composition, an octopolar bioelectrical impedance analyzer model InBody s10 (Seoul, Korea) with six measurement frequencies (1 kHz, 5 kHz, 50 kHz, 250 kHz, 500 kHz, 1 MHz) was used. The exclusion criteria for the application of this instrument were: not wearing a metallic prosthesis and not having a pacemaker (Espinoza et al., 2019), since these conditions change the bioelectrical characteristics of the

tissues. A BASELINE manual dynamometer, digital model SMEDLEY 12-0286 (New York, USA) was also used. The reason why this instrument has been chosen is because it is easy to transport and, in addition, it measures maximum static muscle strength by means of hand grip, being able to estimate the physical condition and nutritional status of the subject with just one measurement (Zhang et al., 2017). From the battery of tests of the Senior Fitness Test (SFT), the 6-minute walking test was used, for which cones, measuring tapes to mark distances and standard stopwatches for measuring time were needed.

Procedures

The SFT 6-minute cardiorespiratory walking test, a manual dynamometry strength test, and a BIA assessment were administered. Data on the variables (physical condition and angular phase) were collected from the group of older adults at a single, specific time, analyzing the possible relationships that could be obtained (Hernández-Sampieri et al., 2014).

Before measuring by BIA, the subjects' body weight and height were recorded. For the BIA, the individuals had to lie supine with their arms relaxed at their sides. The tactile electrodes were placed on the thumb and middle finger; for the lower extremities, they were placed in the area below the malleoli. The PhA was determined at a frequency of 50 kHz and was calculated according to the following formula: (Xc/R) x (180°/π) (Lukaski, 2013).

To ensure the validity and reliability of the research, all the prerequisites for implementing electrical bioimpedance were taken into account (Buckinx et al., 2015). Participants were informed a week in advance of the precautions they should take to ensure that the measurement was performed optimally: not to perform intense exercise 12 hours before the evaluation, not to consume alcohol 48 hours before, not to eat food in the 4 hours prior to the test, to urinate 30 minutes before the test and to remove metal items from the body, such as earrings, bracelets, rings, among others (Alvero et al., 2009).

A manual dynamometer was used to determine static muscle strength. The dynamometric force was adjusted to the size of the hand, according to the BASELINE dynamometer manual. The subject was instructed to stand with the arm extended parallel to the trunk, holding the device and exerting maximum manual pressure force. This procedure was repeated twice alternating right and left hand, recording as a valid measure the best of the two attempts made with each limb (García et al., 2017).

To assess cardiorespiratory fitness, the SFT 6-minute walk was performed. This consists of walking the greatest distance possible in 6 minutes. Originally the test requires people to walk in a rectangular circuit, but recent versions use only a straight line (Langhammer & Stanghelle, 2015). In this case, it was performed around a court, walking in groups of 3-5 subjects. To calculate the total distance traveled, the number of laps was counted and then multiplied by the distance established in the circuit.

Statistical analysis

The results were analyzed using GraphPad Prism software (GraphPad, San Diego, CA, USA). The data were analyzed to explore their normality. However, the distribution was not parametric, therefore, Spearman's correlation between cardiorespiratory fitness and PhA, and between muscle strength and PhA was used. To perform the analyses with the PhA values, a cut-off point of 5.62° was considered in men aged 70-80 years and 5.32° in men >80 years, and 5.14° in women aged 70-80 years and 5.47° in women >80 years (Mattiello et al., 2020). A significant correlation was considered with a $p<0.05$.

Ethical aspects

Prior to the start of the study, the subjects were informed about the respective procedures to be performed and signed an informed consent regarding the characteristics of the study. This project respected the ethical standards based on the Declaration of Helsinki, updated in 2013 and approved by the Bioethics Committee of the Pontifical Catholic University of Valparaíso (Code: BIOEPUCV-H154-2018).

RESULTAS

Table 1 shows body composition by sex, as well as hand dynamometry and distance covered in the 6-minute test of the study participants.

It can be seen that both men and women are in the overweight BMI category. Although it is not an objective of the study, important differences in physical condition can be seen between men and women; statistical differences can be seen by sex between body weight, height, fat mass and strength by hand dynamometry in the right hand.

Table 1

Mean values and standard deviation of body composition and physical condition of the study participants.

Variables	Total Mean ± SD	Male (N=3) Mean ± SD	Female (N=21) Mean ± SD	p
Age	78.8 ± 5.6	77.0 ± 3.6	79.0 ± 5.8	0.525
Body composition				
Weight (kg)	66.4 ± 9.9	82.7 ± 10.9	64.1 ± 7.5	*0.011
Height (cm)	153.9 ± 9.7	176.7 ± 2.1	150.6 ± 4.3	*<0.001
BMI (kg/m2)	28.0 ± 3.1	26.5 ± 3.9	28.2 ± 3.0	0.457
Fat mass (%)	43.7 ± 6.7	30.0 ± 6.0	45.7 ± 4.0	*<0.001
Physical condition				
Mean dynam. (kg)	21.9 ± 9.4	34.2 ± 14.7	20.2 ± 7.2	0.082
Right dynam. (kg)	23.9 ± 10.6	35.4 ± 15.4	22.5 ± 9.3	*0.039
Left dynam. (kg)	22.6 ± 10.8	32.9 ± 16.1	21.3 ± 9.7	0.169
6 minutes test (m)	354.3 ± 109.9	448 ± 93.35	340 ± 107.28	0.126

SD: Standard Deviation. m: meters traveled. *Statistical significance of p<0.05.

Table 2 shows the PhA values of both groups according to the BIA evaluation, being slightly higher in men than in women, but without presenting significant differences.

Table 2

Means and standard deviations of the phase angle values.

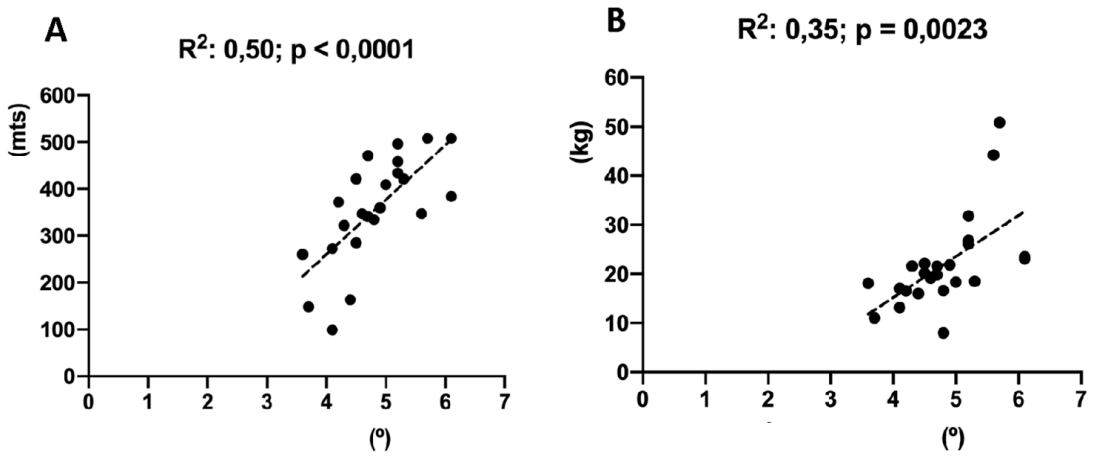
PhA	Total Mean ± SD	Male Mean ± SD	Female Mean ± SD	p
Phase angle (°)	4.8 ± 0.7	5.2 ± 0.5	4.7 ± 0.7	0.207

PhA: Phase angle. Ref: Reference 4.6° in women; 5.0° in men.

In Figure 1A, the correlation (R2) between the distance covered in the 6-minute test and the PhA of the total group can be seen. In addition, in Figure 1B, the correlation between strength by manual dynamometry and PhA can be observed.

Figure 1

Correlation between distance covered in the 6-minute test and PhA and between manual dynamometry and PhA.



In both tests, correlations were significant with PhA ($p<0.05$). In addition, a moderate correlation strength was present in the cardiorespiratory endurance test (6-minute test) (0.50), and a low correlation strength was present in the hand grip strength (0.35).

DISCUSSION

The aim of this study was to establish the relationship between physical condition and angular phase values by bioimpedance in a group of sedentary older adults.

Previous studies have indicated that an accelerated decrease in PhA occurs when reaching 80–89 years of age (Buffa et al., 2003). In addition, women tend to have a lower PhA value than men (Santomauro et al., 2008). This could be due to the differences in body composition present in both sexes (greater muscle mass in men and greater fat mass in women).

Of the participants in this study, 71% had an average PhA below the reference (4.5° ± 0.4). Of the reference by sex, 62% of women were below, while in the case of men it was 67%. This represents a deterioration in cellular health in this group, which could be expressed in sarcopenia, dynapenia and frailty.

Phase angle and cardiorespiratory fitness

In this exploratory study, a linear relationship between a cardiorespiratory test of older adults and PhA (R2= 0.50) has been identified. However, the direct relationship between PhA and cardiorespiratory fitness has not been clearly established, however, it has been shown to be directly associated with cellular quality (Dittmar et al., 2015), which are metabolically the most active component and can provide more energy and physical performance (Martins et al., 2022). Previous evidence indicates that PhA is associated with high levels of physical activity in non-institutionalized older adults (Dittmar et al., 2015), as well as with the Barthel index for activities of daily living (Norman et al., 2007). However, the available literature on this relationship comes mainly from studies that include children and adolescents (Martins et al., 2022; Langer et al., 2020; Martins et al., 2019, 2020) or obese adults (Streb et al., 2020).

Several studies claim that more research is needed to validate, for example, the association between PhA and cardiorespiratory disorders such as ejection heart failure and cardiorespiratory risk (Faria et al., 2018; Saad et al., 2018). This also accounts for a lack of studies involving adults and older adults without a diagnosis of deterioration or disease that would confirm these results.

If a relationship between PhA and cardiorespiratory condition is validated, the application of PhA as a predictor of cardiorespiratory health in the older adult population could be enabled. Along these lines, this study provides evidence supporting the relationship between cardiorespiratory fitness and PhA.

Phase angle and muscle strength

Studies indicate that a low PhA value is associated with a lower functional capacity of the muscle in older adult patients with cancer (Norman et al., 2015). In accordance with this, our study showed that there is a relationship (r2=0.35) between PhA and muscle strength. This linear statistical relationship between both variables would allow defining, through the force by manual dynamometry, the cellular quality of adults taking into account the PhA values.

In this sense, studies based on the SPPB scale (Short Physical Performance Battery), affirm that a low PhA is associated with a high index of physical fragility, as well as a low muscle mass and muscle strength (Mullie et al., 2018). Likewise, studies indicate that healthy older adult women with higher PhA have better muscle quality and function, independent of age and body composition (Tomeleri et al., 2018). A strong inverse association has also been found between PhA and sarcopenia (Player et al., 2019). A recent systematic review has identified that 93.7% of the evidence points to a direct relationship between PhA and muscle strength (Martins et al., 2022).

Given the overwhelming evidence, the importance of carrying out motor stimulation programs in adults is highlighted. In this regard, various studies mention that adult women who perform suspension strength training obtain an increase in PhA and static dynamometry values (Campa et al., 2018). Along the same lines, it has been pointed out that strength-resistance training in adult women can improve the PhA value, body water components, and muscle quality (Cunha et al., 2018). In addition, studies show that eight weeks of strength-resistance training improves the cellular parameter of PhA in obese adult women (Ribeiro et al., 2020). On the other hand, changes in muscle quality are positively correlated with a significant PhA value.

Including a PhA diagnosis prior to training programs in older adults would help to have a clear idea of the effectiveness of the programs.

To date, there are few studies that specify the implications of PhA associated with muscle strength specifically in the elderly population in Chile. There is a lack of studies that validate PhA as a parameter associated with muscle strength.

CONCLUSION

A significant linear relationship has been found between a cardiorespiratory fitness test for older adults and the phase angle. Likewise, a significant correlation has been found between the hand grip strength by dynamometry and the phase angle values. This indicates, on the one hand, that both a test to assess cardiorespiratory fitness, as well as a strength test, could provide us with parameters that are associated with cell quality and health.

On the other hand, it highlights the importance of including objective parameters for cellular assessment of the effects of exercise and training programs in older adults, such as PhA. It is important to incorporate BIA into the health diagnosis of older adults, which allows adults to be referred to public and private intervention programs, in order to improve the health and quality of life of the elderly.

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Addres for correspondence

Fernando Rodríguez-Rodríguez
Doctor en Biomedicina.
Grupo de investigación IRyS, Escuela de Educación Física,
Pontificia Universidad Católica de Valparaíso.
Valparaíso, Chile

ORCID: https://orcid.org/0000-0002-4999-4857
Contact: fernando.rodriguez@pucv.cl

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