Phase angle can predict bone indicators in older adults: A cross-sectional study

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Introduction

- Aging is the process that involves **quantitative and qualitative changes in skeletal muscle structure and function and several changes in bone health**, which increase the risk of fractures and loss of independence and autonomy;

- **Osteoporosis** is considered a worldwide public health concern, which is characterized by **low bone mass and microarchitectural changes in the bone** being a risk factor for fractures in older adults.

(Consensus, 1993; Edwards et al., 2015)

- **Phase angle from BIA** has been described as a **global health marker**, as muscle index and can predict several health outcomes in older adults, such as physical and muscle function.

(Germano et al., 2021; Matias et al., 2020; Norman et al., 2012; Nunes et al., 2019; Wilhelm-Leen et al., 2014; Yamada et al., 2019)

Introduction

- **The concept of PhA** relies on changes in **resistance and reactance** as alternating current passes through evaluated tissues. A phase shift occurs as **part of the current is stored in the resistive compartments of cellular membranes.**

(Antunes et al., 2020)

- A **lower PhA** value indicates poorer **cell health** and loss of **cell membrane integrity.**

(Toso et al., 2003)

- This study aimed to verify a **relationship between phase angle (PhA) with bone indicators**. We also intended to analyse the **ability of PhA to predict bone indicators** after adjusting for potential confounders.

Materials and Methods

- This cross-sectional study enrolled a total of **56 older adults of both sexes** (mean ± standard deviation (SD); age, 73.50 ± 6.47 years; height, 155.45 ± 8.27 cm; weight, 70.43 ± 11.71 kg; fat mass, 26.87 ± 6.47; and body mass index (BMI), 28.09 ± 4.37 kg/m^2);

- Participants who are at least **65 years old and able to walk independently and perform the tasks of daily living** were considered eligible for the present study. However, participants who reported having diabetes, cardiac diseases, being submitted to surgery in the last 6 months, or having active oncology disease were excluded from the study;

- All procedures were approved by the ethics committee of the University of Evora (**approval no. 22030**).

Materials and Methods

Phase Angle

In Body S10® (Model JMW140, Seoul, Korea)

- Phase Angle at 50 Khz.

Bone Indicators

DXA (Hologic, Inc., Bedford, MA, USA)

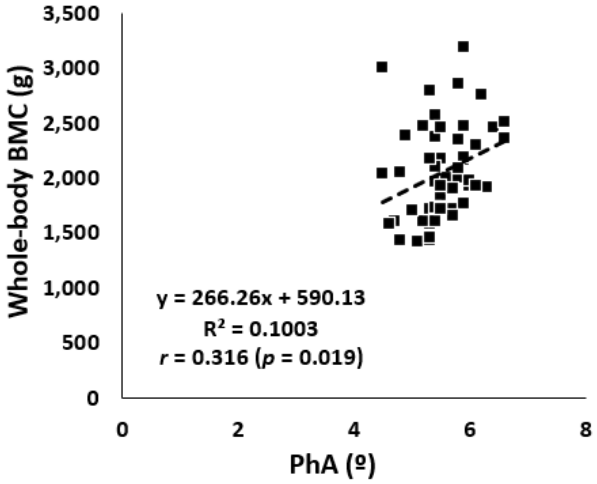
- Whole body BMC (g);
- Whole body BMD (g);
- Femoral neck BMC (g);
- Femoral neck BMD (g/cm²).

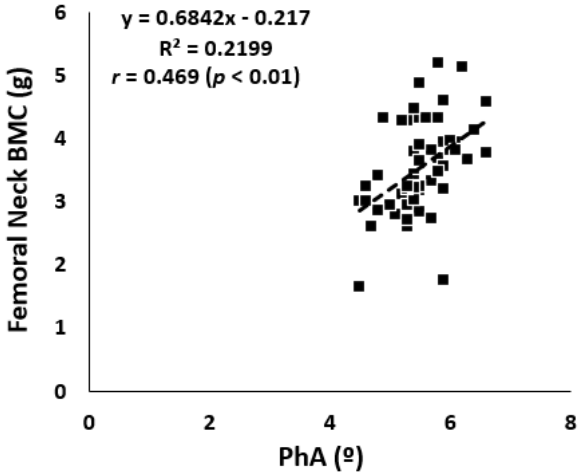
Results

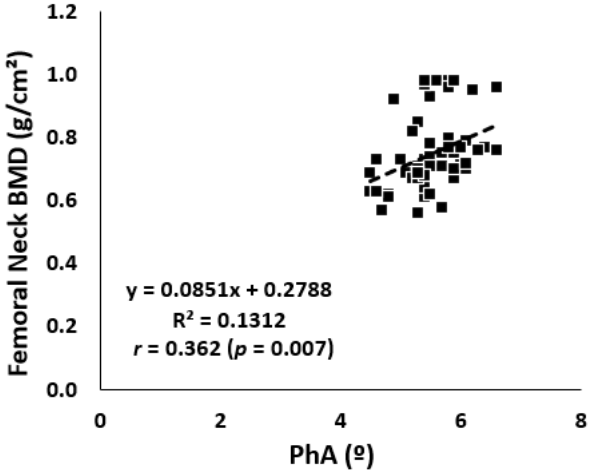
Measures	Mean ± SD	Phase Angle		
		r	p-value	Effect
Whole body BMC (g)	2060.72 ± 419.67	0.316	**0.019**	Moderate
Whole body BMD (g/cm^2)	1.08 ± 0.17	0.128	0.352	Small
Femoral neck BMC (g)	3.56 ± 0.73	0.469	**<0.01**	Moderate
Femoral neck BMD (g/cm^2)	0.75 ± 0.12	0.365	**0.007**	Moderate

Correlations ($p \leq 0.05$) are highlighted in bold. Abbreviations: **BMC**, bone mineral content; **BMD**, bone mineral density; **g**, grams; **SD**, standard deviation.

Results


Whole-body BMC (g)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0
2
4
6
8
PhA (º)
y = 266.26x + 590.13
R² = 0.1003
r = 0.316 (p = 0.019)


Femoral Neck BMC (g)
6
5
4
3
2
1
0
0
2
4
6
8
PhA (º)
y = 0.6842x - 0.217
R² = 0.2199
r = 0.469 (p < 0.01)


Femoral Neck BMD (g/cm²)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
2
4
6
8
PhA (º)
y = 0.0851x + 0.2788
R² = 0.1312
r = 0.362 (p = 0.007)

Results

Models	β (CI 95%)	R	Adjusted R^2	p-value
Whole body BMC				
Phase Angle	590.132 (-616.575 to 1796.840)	0.317	0.084	**0.017**
Model 1	-427.625 (-3158.601 to 2303.352)	0.335	0.078	**0.043**
Model 2	27.838 (-1961.142 to 2016.817)	0.735	0.514	< **0.01**
Model 3	1605.657 (-1061.330 to 4272.644)	0.752	0.532	< **0.01**
Model 4	1803.659 (-1944.795 to 5552.113)	0.753	0.523	< **0.01**
Whole body BMD				
Phase Angle	0.843 (0.345 to 1.341)	0.129	-0.002	0.342
Model 1	0.584 (-0.547 to 1.716)	0.147	-0.015	0.562
Model 2	0.664 (-0.431 to 1.759)	0.324	0.053	0.121
Model 3	0.935 (-0.572 to 2.443)	0.331	0.040	0.195
Model 4	1.383 (-0.728 to 3.494)	0.341	0.028	0.271

Significant differences ($p \leq 0.05$) are highlighted in bold. Abbreviations: **BMC**, bone mineral content; **BMD**, bone mineral density;

Note: **Model 1**, phase angle adjusted for age**; Model 2**, phase angle adjusted for age and lean mass; **Model 3,** phase angle adjusted for age, lean mass and total body fat in percent; **Model 4,** phase angle adjusted for age, lean mass, total body fat in percent and body mass index.

Results

Models	β (CI 95%)	R	Adjusted R^2	p-value
Femoral neck BMC				
Phase Angle	-0.218 (-2.167 to 1.731)	0.469	0.206	**< 0.01**
Model 1	-1.568 (-5.988 to 2.852)	0.476	0.198	**0.001**
Model 2	-1.367 (-5.761 to 3.027)	0.504	0.212	**0.001**
Model 3	-0.507 (-6.561 to 5.547)	0.507	0.199	**0.004**
Model 4	-1.384 (-9.888 to 7.120)	0.508	0.184	**0.009**
Femoral neck BMD				
Phase Angle	0.273 (-0.060 to 0.605)	0.365	0.117	**0.006**
Model 1	0.144 (-0.613 to 0.901)	0.368	0.103	**0.021**
Model 2	0.179 (-0.572 to 0.931)	0.410	0.120	**0.022**
Model 3	0.114 (-0.923 to 1.150)	0.411	0.104	**0.047**
Model 4	0.050 (-1.407 to 1.507)	0.411	0.086	0.089

Significant differences ($p \leq 0.05$) are highlighted in bold. Abbreviations: **BMC**, bone mineral content; **BMD**, bone mineral density;

Note: **Model 1**, phase angle adjusted for age; **Model 2,** phase angle adjusted for age and lean mass; **Model 3,** phase angle adjusted for age, lean mass and total body fat in percent; **Model 4,** phase angle adjusted for age, lean mass, total body fat in percent and body mass index.

Discussion and Conclusions

- To our knowledge, **only one previous study investigated the relationship between PhA and BMD in older adults** (Antunes et al., 2020). Although the authors had included in their study the BMD values for whole-body, femur, neck, and forearm regions, did not include the BMC values;

- Even though it is not possible to establish causality about these associations, we justify that these relationships could be related to the fact that there is a **relationship between muscle mass with PhA** (Basile et al., 2014; Kilic et al., 2017) **and with bone density** (Sharifi et al., 2022).

Discussion and Conclusions

- In this sense, **we believe** that on biomechanical level, **the force produced by muscles affects the bone density** (Frost, 1996). Additionally, some studies (Binder & Kohrt, 2000; Wang et al., 2022) claimed that greater **muscle strength leads to better muscle contraction which that stimulated bone cells that are anatomically related to these muscles.**

- **We concluded** that **good levels of bone indicators**, particularly femoral neck BMD and BMC are related with **higher cellularity, cell membrane integrity and better cell function**, expressed by PhA. We also conclude that the PhA can be used as a marker of bone quality.

References

Antunes, M., Cyrino, E. S., Silva, D. R. P., Tomeleri, C. M., Nabuco, H. C. G., Cavalcante, E. F., Cunha, P. M., Cyrino, L. T., Dos Santos, L., Silva, A. M., & Sardinha, L. B. (2020). Total and regional bone mineral density are associated with cellular health in older men and women. Archives of Gerontology and Geriatrics, 90, 104156. https://doi.org/10.1016/j.archger.2020.104156

Basile, C., Della-Morte, D., Cacciatore, F., Gargiulo, G., Galizia, G., Roselli, M., Curcio, F., Bonaduce, D., & Abete, P. (2014). Phase angle as bioelectrical marker to identify elderly patients at risk of sarcopenia. Experimental Gerontology, 58, 43–46. https://doi.org/10.1016/j.exger.2014.07.009

Binder, E. F., & Kohrt, W. M. (2000). Relationships between body composition and bone mineral content and density in older women and men. Clin Exerc Physiol., 2, 84–91.

Consensus, A. (1993). Consensus development conference: Diagnosis, prophylaxis, and treatment of osteoporosis. The American Journal of Medicine, 94(6), 646–650. https://doi.org/10.1016/0002-9343(93)90218-e

Edwards, M. H., Dennison, E. M., Aihie Sayer, A., Fielding, R., & Cooper, C. (2015). Osteoporosis and sarcopenia in older age. Bone, 80, 126–130. https://doi.org/10.1016/j.bone.2015.04.016

Frost, H. M. (1996). Perspectives: A proposed general model of the «mechanostat» (suggestions from a new skeletal-biologic paradigm). The Anatomical Record, 244(2), 139–147. https://doi.org/10.1002/(SICI)1097-0185(199602)244:2<139::AID-AR1>3.0.CO;2-X

Germano, M. L., Dos Santos Gomes, C., Azevedo, I. G., Fernandes, J., de Medeiros Freitas, R. V., & Guerra, R. O. (2021). Relationship between phase angle and physical performance measures in community-dwelling older adults. Experimental Gerontology, 152, 111466. https://doi.org/10.1016/j.exger.2021.111466

Kilic, M. K., Kizilarslanoglu, M. C., Arik, G., Bolayir, B., Kara, O., Dogan Varan, H., Sumer, F., Kuyumcu, M. E., Halil, M., & Ulger, Z. (2017). Association of Bioelectrical Impedance Analysis–Derived Phase Angle and Sarcopenia in Older Adults. Nutrition in Clinical Practice, 32(1), 103–109. https://doi.org/10.1177/0884533616664503

Matias, C. N., Nunes, C. L., Francisco, S., Tomeleri, C. M., Cyrino, E. S., Sardinha, L. B., & Silva, A. M. (2020). Phase angle predicts physical function in older adults. Archives of Gerontology and Geriatrics, 90, 104151. https://doi.org/10.1016/j.archger.2020.104151

References

Norman, K., Stobäus, N., Pirlich, M., & Bosy-Westphal, A. (2012). Bioelectrical phase angle and impedance vector analysis – Clinical relevance and applicability of impedance parameters. Clinical Nutrition, 31(6), 854–861. https://doi.org/10.1016/j.clnu.2012.05.008

Nunes, J. P., Ribeiro, A. S., Silva, A. M., Schoenfeld, B. J., Dos Santos, L., Cunha, P. M., Nascimento, M. A., Tomeleri, C. M., Nabuco, H. C. G., Antunes, M., Cyrino, L. T., & Cyrino, E. S. (2019). Improvements in Phase Angle Are Related With Muscle Quality Index After Resistance Training in Older Women. Journal of Aging and Physical Activity, 27(4), 515–520. https://doi.org/10.1123/japa.2018-0259

Sharifi, R., Kordi, S., Noravesh, F., Aghababaei, Y., Ramezani, M., & Maghbooli, Z. (2022). Bone mineral density and muscle mass in adults with developmental skeletal discrepancies. BMC Musculoskeletal Disorders, 23(1), 593. https://doi.org/10.1186/s12891-022-05538-9

Toso, S., Piccoli, A., Gusella, M., Menon, D., Crepaldi, G., Bononi, A., & Ferrazzi, E. (2003). Bioimpedance vector pattern in cancer patients without disease versus locally advanced or disseminated disease. Nutrition, 19(6), 510–514. https://doi.org/10.1016/S0899-9007(02)01084-5

Wang, Y., Wang, S., Chen, Z., & Ran, Z. (2022). The Relationship between Body Composition and Bone Mineral Density of Female Workers in A Unit of Tai'an. Computational and Mathematical Methods in Medicine, 2022, 1011768. https://doi.org/10.1155/2022/1011768

Wilhelm-Leen, E. R., Hall, Y. N., Horwitz, R. I., & Chertow, G. M. (2014). Phase angle, frailty and mortality in older adults. Journal of General Internal Medicine, 29(1), 147–154. https://doi.org/10.1007/s11606-013-2585-z

Yamada, M., Kimura, Y., Ishiyama, D., Nishio, N., Otobe, Y., Tanaka, T., Ohji, S., Koyama, S., Sato, A., Suzuki, M., Ogawa, H., Ichikawa, T., Ito, D., & Arai, H. (2019). Phase Angle is a Useful indicator for Muscle Function in Older Adults. The Journal of Nutrition, Health & Aging, 23(3), 251–255. https://doi.org/10.1007/s12603-018-1151-0

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