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Association between handgrip strength and body composition, physical fitness, and biomarkers in postmenopausal women with metabolic syndrome

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SUMMARY

OBJECTIVES: This study examined the association between handgrip strength and body composition, physical fitness, and biomarkers in postmenopausal women with metabolic syndrome.

METHODS: A total of 75 postmenopausal women were diagnosed with metabolic syndrome participated in this study. Muscle strength was assessed via a hydraulic grip strength dynamometer; physical fitness tests included a timed-up-and-go, arm curl test, and 30-s chair stand. Body composition was assessed via bioelectrical impedance, from which estimates of fat mass, body fat percentage, fat-free mass, and visceral fat area were determined. Fasting plasma glucose and glycated hemoglobin were measured via blood sample analyses. Multiple linear regression analyses were conducted using handgrip strength as the dependent variable and using body composition, physical fitness, and biomarkers as independent variables.

RESULTS: The results revealed that 52% of the total sample were classified as obese, 37.3% as overweight, and only 10.7% as normal weight. Significant correlations were present between handgrip strength and fat-free mass ($p=0.002$; $R=0.590$), mean blood pressure ($p=0.002$; $R=0.450$), and arm curl ($p=0.001$; $R=0.795$).

CONCLUSION: This study showed that handgrip strength was predictive of fat-free mass, blood pressure, and upper limb strength performance.
KEYWORDS: Metabolic syndrome. Blood pressure. Body weight. Muscle strength. Physical fitness.

INTRODUCTION

Metabolic syndrome is a physiopathology with high worldwide prevalence and is characterized by multifactorial and progressive risk factors[1]. Generally, metabolic syndrome is diagnosed when the individual has four of the following conditions: dyslipidemia, presenting high low-density lipoprotein (LDL) and triglycerides, and low high-density lipoprotein (HDL); overweight and obesity, especially with abdominal fat concentration; elevated blood pressure (BP); and insulin resistance, with high levels of fasting glucose[2]. Metabolic syndrome increases cardiovascular morbidity, with progressive development of atherosclerosis and coronary artery disease (CAD), hypertension, and increased risk of stroke[3].

Prospective studies have found that physical fitness is inversely related to the prevalence of metabolic syndrome[4]. This can be attributed to sedentary behavior, with high amounts of sitting and reduced physical activity, which may increase cardiometabolic risk[5]. Since cardiorespiratory fitness is generally used as an indicator of functional capacity, it is an independent predictive factor of improved cardiometabolic risk profile, associated with a higher HDL concentration, lower waist circumference, and fasting glucose[6]. Bentes et al.[7] reported in a previous study, with 40 postmenopausal women, that muscle strength was associated with the reduced serum glucose concentrations and might be a key indicator of metabolic health. Moreover, postmenopausal women exhibit an increase in visceral adipose tissue and proinflammatory cytokines increasing cardiovascular risk[8,9].

Since grip strength is generally used as an index of general muscle strength and frailty, it has been used in clinical trials and considered a simple approach to evaluate muscle function[7]. Studies that assessed grip strength found it to be

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associated with body composition parameters and physical fitness performance[7,10]. This is important to consider since previous studies reported associations between changes in body composition, especially the increases in body fat and metabolic syndrome[11]. Other studies revealed associations between handgrip strength and other chronic diseases, such as type 2 diabetes, hypertension, and depression[12,13]. Therefore, the purpose of this study was to examine the association between handgrip strength and body composition, physical fitness, and biomarkers in postmenopausal women with metabolic syndrome.

METHODS

Research Design

Subjects were advised for fasting for 12 h and refrained from drinking water for 2 h before testing. Subjects were asked not to engage in any physical activity for 24 h before testing. Upon arrival, BP, fasting blood glucose, glycated hemoglobin (HbA1c), anthropometrics, and body composition via electrical bio-impedance were first measured. Then, all physical tests were performed in a randomized order as follows: handgrip strength (dominant arm), timed-up-and-go (TUG), 30-s chair stand, arm curl, and sit-to-stand.

Patients

A total of 75 postmenopausal women with metabolic syndrome participated in this study (Table 1). The National Cholesterol Education Program criteria were used to diagnose metabolic syndrome[14]. During the experimental procedures, patients remained on their typical diet, avoiding any nutritional supplementation. All subjects read and signed an informed consent in accordance with the Declaration of Helsinki. Patients who had any functional limitations or medical conditions that could be aggravated by the tests were excluded. The study protocol was approved by the local ethics committee (CAE: 23081213.6.0000.5269).

Anthropometry and body composition

Body composition was measured via octopolar electrical impedance (InBody 720, Biospace, Seoul, South Korea), previously validated[15,16]. Body mass (BM), fat mass (FM), lean body mass, fat percentage, fat-free mass (FFM), and visceral fat area (VFA) were measured. Body height was measured with a stadiometer (Stadiometer Seca 208 Bodymeter), and waist, iliac, abdominal, and hip circumferences were measured with an anthropometric tape.

Table 1. Patient characteristics (mean ± SD).

	Mean ± SD	95% Confidence Interval	
		Lower	Upper
Age (years)	57.9 ± 11.14	55.3	60.4
Height (cm)	157.6 ± 6.79	156.0	159.1
Body mass (kg)	76.7 ± 15.17	73.2	80.2
Abdominal circumference (cm)	96.4 ± 11.90	93.7	99.1
Waist-hip ratio	0.9 ± 0.08	0.9	0.9
Lean body mass (kg)	23.7 ± 4.00	22.8	24.6
Fat mass (kg)	33.8 ± 10.33	31.5	36.2
Visceral fat area (cm^2)	126.4 ± 31.30	119.2	133.6
Resting metabolic rate	1304.6 ± 134.21	1273.7	1335.5
Systolic blood pressure (mmHg)	131.3 ± 23.68	125.9	136.8
Diastolic blood pressure (mmHg)	82.9 ± 12.33	80.1	85.7
Mean arterial pressure	99.1 ± 14.79	95.6	102.5
Handgrip strength	24.3 ± 6.61	22.8	25.8
Relative force	0.3 ± 0.10	0.3	0.3
Arm curl	13.2 ± 3.66	12.4	14.1
Timed-up-and-go	11.2 ± 2.22	10.7	11.8
30-s chair stand	11.0 ± 4.06	10.1	11.9
Sit and reach (cm)	19.0 ± 4.61	17.9	20.1
Glycated hemoglobin (HbA1c)	7.1 ± 1.78	6.7	7.5
Fasting glucose (mg/dl)	147.0 ± 56.51	134.0	160.0

SD: Standard deviation.

Handgrip strength

To determine muscle strength, a hydraulic grip strength dynamometer (Jamar Hydraulic Hand Dynamometer Model J00105, Lafayette Instrument Company, Inc., IN, United States) was used. During the test, each subject had three attempts with a 1-min rest interval, and the highest value was recorded. The handgrip test was performed in a seated position, with the dominant arm, with the shoulder adducted, neutrally rotated, and elbow flexed at 90°. Moreover, relative strength was calculated with the equation: handgrip strength (kg) ÷ body mass (kg).

Physical fitness test

To determine functional capacity, the TUG test was used. A previous study reported that this test could predict fall risk in older adults[17]. This test involves the time taken to rise from a chair, walk 3 m, turn around a marker, walk back to the chair, and sit down[17].

To determine upper limb strength, an arm curl test was utilized, consisting of maximal repetitions performed in 30 s[18]. During this test, subjects were seated without bending the trunk forward, and dumbbells weighing 2.3 kg were used[18]. To determine lower limb strength, a 30-s chair stand test was utilized, consisting of the maximal number of rises from a chair that could be done in 30 s. During this test, the arms were folded across the chest, and the total number of rises was recorded[19].

Blood sample analysis

Blood samples were collected after fasting for 12 h to determine fasting plasma glucose and HbA1c. Serum HbA1c concentrations were assessed by high-performance liquid chromatography, and fasting glucose was measured by using the enzymatic colorimetric method.

Statistical analysis

A series of three multiple linear regression analyses were conducted with handgrip strength as the dependent variable. The independent variables included in analyses were clinical and body composition variables (e.g., age, BM, abdominal circumferences, waist-hip ratio, body mass index [BMI], muscle mass, FM, VFA, resting metabolic rate [RMR], systolic BP [SBP], diastolic BP [DBP], mean arterial pressure [MAP]), physical fitness variables (e.g., handgrip strength, arm curl repetitions, TUG, 30-s chair stand), and biomarkers (glucose and HbA1c). The level of significance was set at $p<0.05$ for all comparisons. All statistical analyses were performed using SPSS statistical software package version 20.0 (SPSS Inc., Chicago, IL, United States).

RESULTS

Descriptive results and comparisons between body mass index classifications

The sample was stratified by BMI classification as outlined by the WHO[20]. The results of the frequency analysis showed that out of the 75 patients in the total sample, 52% (39) were classified as obese, 37.3% (28) as overweight, and 10.7% (8) as normal weight.

Relationship between handgrip strength and body composition variables, blood pressure, functional capacity, and serum glycated hemoglobin

For the first multiple linear regression analysis, handgrip strength was the dependent variable with the following independent variables: body composition, waist–hip ratio, FM, VFM, and FFM; SBP, DBP, and mean BP; and age. According to the study by Pestana and Gageiro[21], this model revealed a significant variance of $p=0.002$ and a moderate correlation of $R=0.59$[21]. The coefficient of determination ($R^2=0.35$) showed that 35% of handgrip strength variability could be explained by the independent variables. Then, the stepwise method revealed that mean BP and FFM showed the greatest regression coefficient, coefficient of determination, and significance (ANOVA; $F=9.138$ and $p=0.002$, and the regression values are $R=0.450$ and $R^2=0.202$, respectively; see Figure 1).

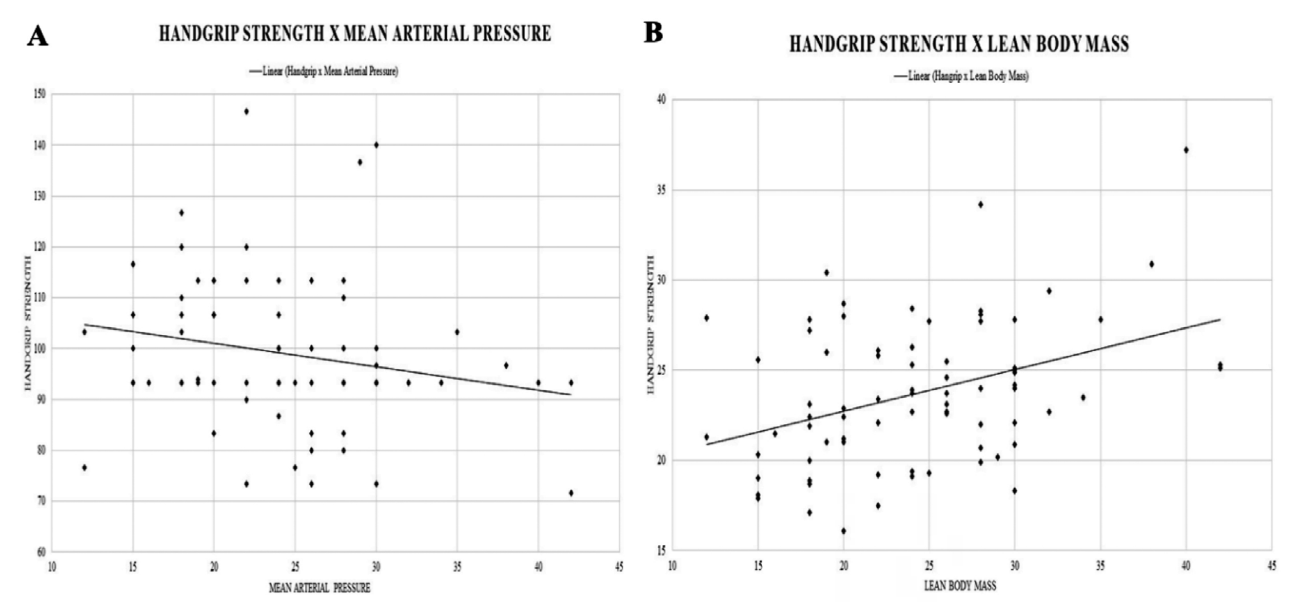
In the second multiple linear regression analysis, handgrip strength was the dependent variable with the following independent variables: relative handgrip strength, arm curl repetitions, TUG, and 30-s chair stand. According to the study by Pestana and Gageiro[21], this model revealed a significant variance of $p=0.001$ and a strong correlation of $R=0.80$. The coefficient of determination ($R^2=0.65$) showed that 65% of the handgrip strength variability could be explained by the independent variables. Then, the stepwise method revealed that arm curl repetitions showed the greatest regression coefficient, coefficient of determination, and significance (ANOVA; $F=61.938$ and $p=0.001$, and the regression values are $R=0.795$ and $R^2=0.632$, respectively; see Figure 2).

In the third multiple linear regression analysis, handgrip strength was the dependent variable with the following independent variables: handgrip strength and HbA1c and fasting glucose. According to the study by Pestana and Gageiro[21], no significant results were observed ($p=0.978$) with a weak correlation ($R=0.02$).

DISCUSSION

The key findings of the present study showed that 52% of the total sample could be classified as obese, 37.3% as overweight, and 10.7% as normal weight. In addition, based on linear regression analysis, handgrip strength was predictive of the following variables: muscle mass, MAP, and arm curl repetitions.

Steffl et al.[22] examined the association between handgrip strength, muscle mass, and physical performance in 69 community-dwelling elderly women. The results showed a high association between variables and concluded that muscle mass and handgrip strength were more predictive of sarcopenia than physical fitness status. In the present study, the first linear regression showed that handgrip strength was predictive of FFM. In a literature review, Bohannon[23] concluded that handgrip strength was associated with the presence of metabolic syndrome and



A: Handgrip strength and lean body mass; B: Handgrip strength and mean arterial pressure.

Figure 1. The regression results between variables.

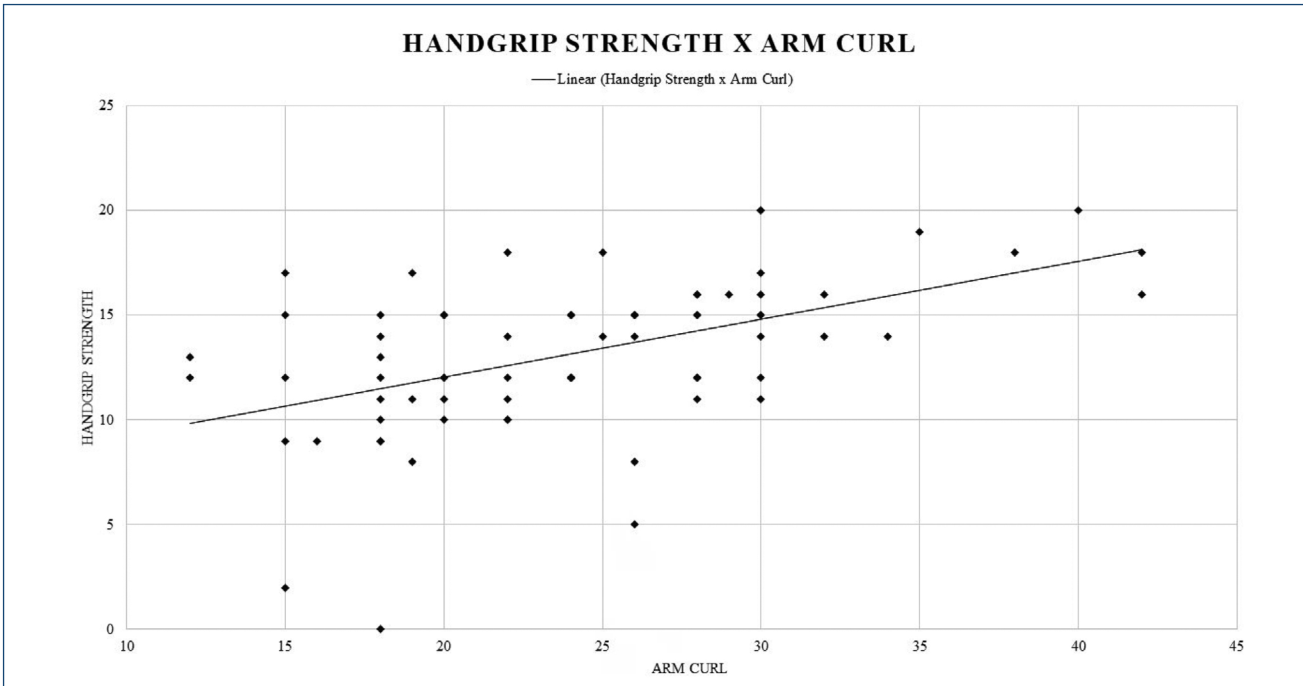


Figure 2. Handgrip strength and arm curl regression results.

was predictive of mobility and mortality. The mechanism to explain these associations might be connected to adipose tissue-releasing adipocytokines that promote chronic systemic and regional inflammation, related to poorer functional capacity, and reduce muscle strength[24].

Furthermore, in the present study, mean BP showed an inverse association with the handgrip strength based on the first linear regression analysis. Mainous et al.[25] studied the association between handgrip strength, diabetes, and hypertension. The results showed that patients with hypertension had lower levels of handgrip strength when compared to healthy patients. Our results showed an inverse association between mean BP and handgrip strength; this result has clinical relevance for controlling high BP. Besides that, general strength training is a key strategy to prevent hypertension, including isometric handgrip training as reported in the literature[26].

In the second linear regression analysis, only one independent variable, the arm curl test, was associated with handgrip strength. Jeoung and Lee[27] studied the association between frailty and physical performance in 114 elderly women. The results showed that functional and physical fitness tests, mainly the handgrip strength test, in elderly women could be used to predict the risk of weakness. As the handgrip strength test is easy to administer, it can easily be applied in clinical settings in an elderly population. In the third linear regression analysis, there was no significant association between HbA1c and fasting glucose with the handgrip strength.

In this study, body composition was evaluated based on BMI, which can be considered a methodological limitation and future studies should use dual-energy X-ray absorptiometry or other assessments to determine overweight and obese subjects. However, for a large sample, BMI is a good and easy strategy to determine body composition and the strength of this method is the practical application. Moreover, supplementary studies are essential to improve workout intervention programs and approaches to avoid the elderly from becoming frail and to promote their health.

In conclusion, this study showed that handgrip strength could predict lean body mass, uncontrolled BP, and upper limb strength. The handgrip strength is easy to assess and could be applied to prevent early weakness and diseases like metabolic syndrome, diabetes, and hypertension.

AUTHOR'S CONTRIBUTIONS

HM: Conceptualization, Project administration, Visualization, Methodology, Writing – review & editing. **CB:** Conceptualization, Project administration, Visualization, Data curation, Formal Analysis, Methodology, Writing – review & editing. **MR:** Conceptualization, Funding acquisition, Supervision, and Visualization. **CCN:** Conceptualization, Funding acquisition, Supervision, and Visualization. **IN:** Visualization, Writing– review & editing. **JW:** Visualization, Writing– review & editing. **LM:** Conceptualization, Funding acquisition, Supervision, and Visualization.

REFERENCES

1. Carr DB, Utzschneider KM, Hull RL, Kodama K, Retzlaff BM, Brunzell JD, et al. Intra-abdominal fat is a major determinant of the National Cholesterol Education Program Adult Treatment Panel III criteria for the metabolic syndrome. Diabetes. 2004;53(8):2087-94. https://doi.org/10.2337/diabetes.53.8.2087
2. Roberts CK, Hevener AL, Barnard RJ. Metabolic syndrome and insulin resistance: underlying causes and modification by exercise training. Compr Physiol. 2013;3:1-58. https://doi.org/10.1002/cphy.c110062
3. Wewege MA, Thom MJ, Rye KA, Parmenter BJ. Aerobic, resistance or combined training: a systematic review and meta-analysis of exercise to reduce cardiovascular risk in adults with metabolic syndrome. Atherosclerosis. 2018;274:162-71. https://doi.org/10.1016/j.atherosclerosis.2018.05.002
4. Ekblom O, Ekblom-Bak E, Rosengren A, Hallsten M, Bergstrom G, Borjesson M. Cardiorespiratory Fitness, Sedentary Behaviour and Physical Activity Are Independently Associated with the Metabolic Syndrome, Results from the SCAPIS Pilot Study. PLoS One. 2015;10(6):e0131586. https://doi.org/10.1371/journal.pone.0131586
5. Edwards MK, Loprinzi PD. High amounts of sitting, low cardiorespiratory fitness, and low physical activity levels: 3 key ingredients in the recipe for influencing metabolic syndrome prevalence. Am J Health Promot. 2018;32(3):587-94. https://doi.org/10.1177/0890117116684889
6. Knaeps S, Bourgois JG, Charlier R, Mertens E, Lefevre J, Wijndaele K. Ten-year change in sedentary behaviour, moderate-to-vigorous physical activity, cardiorespiratory fitness and cardiometabolic risk: independent associations and mediation analysis. Br J Sports Med. 2018;52(16):1063-68. https://doi.org/10.1136/bjsports-2016-096083
7. Bentes CM, Costa PB, Resende M, Miranda HL, Silva CMV, Netto CC, et al. Association between muscle function and body composition, vitamin D status, and blood glucose in postmenopausal women with type 2 diabetes. Diabetes Metab Syndr. 2017;11(Suppl. 2):S679-84. https://doi.org/10.1016/j.dsx.2017.04.025
8. Sorpreso ICE, Júnior JMS, da Fonseca AM, Baracat EC. Female Aging. Rev Assoc Med Bras. 2015;61(6):553-6. https://doi.org/10.1590/1806-9282.61.06.553
9. Galhardo CL, Júnior JMS, SImões RS, Haidar MA, de Lima GR, Baracat EC. Estrogen effects on the vaginal pH, flora and cytology in late postmenopause after a long period without hormone therapy. Clin Exp Obstet Gynecol. 2006;33(2):85-9. PMID: 16903243
10. Lad UP, Satyanarayana P, Shisode-Lad S, Siri CHC, Kumari NR. A Study on the Correlation Between the Body Mass Index (BMI), the Body Fat Percentage, the Handgrip Strength and the Handgrip Endurance in Underweight, Normal Weight and Overweight Adolescents. J Clin Diagn Res. 2013;7(1):51-4. https://doi.org/10.7860/JCDR/2012/5026.2668
11. Fung MD, Canning KL, Mirdamadi P, Ardern CI, Kuk JL. Lifestyle and weight predictors of a healthy overweight profile over a 20-year follow up. Obesity. 2015;23(6):1320-5. https://doi.org/10.1002/oby.21087

12. Kim KN, Lee MR, Choi YH, Lee BE, Hong YC. Associations of Blood Cadmium Levels With Depression and Lower Handgrip Strength in a Community-Dwelling Elderly Population: A Repeated-Measures Panel Study. J Gerontol Ser Biol Sci Med Sci. 2016;71(11):1525-30. https://doi.org/10.1093/gerona/glw119

13. Hamasaki H. Association of handgrip strength with B-type natriuretic peptide levels and cardiovascular events in patients with type 2 diabetes. Diabetes Metab. 2017;45(2):209-11. https://doi.org/10.1016/j.diabet.2017.07.001

14. Royer M, Castelo-Branco C, Blumel JE, Chedraui PA, Danckers L, Bencosme A, et al. The US National Cholesterol Education Programme Adult Treatment Panel III (NCEP ATP III): prevalence of the metabolic syndrome in postmenopausal Latin American women. Climacteric. 2017;10(2):164-70. https://doi.org/10.1080/13697130701258895

15. Finn KJ, Saint-Maurice PF, Karsai I, Ihasz F, Csanyi T. Agreement Between Omron 306 and Biospace InBody 720 Bioelectrical Impedance Analyzers (BIA) in Children and Adolescents. Res Q Exerc Sport. 2015;86(Suppl. 1):S58-65. https://doi.org/10.1080/02701367.2015.1042998

16. Ogawa H, Fujitani K, Tsujinaka T, Imanishi K, Shirakata H, Kantani A, et al. InBody 720 as a new method of evaluating visceral obesity. Hepatogastroenterology. 2011;58(105):42-4. PMID: 21510284

17. Porciuncula FS, Rao AK, McIsaac TL. Aging-related decrements during specific phases of the dual-task Timed Up-and-Go test. Aging Clin Exp Res. 2016;28:121-30. https://doi.org/10.1007/s40520-015-0372-x

18. Singh DK, Manaf ZA, Yusoff NAM, Muhammad NA, Phan MF, Shahar S. Correlation between nutritional status and comprehensive physical performance measures among older adults with undernourishment in residential institutions. Clin Interv Aging. 2014;9:1415-23. https://doi.org/10.2147/CIA.S64997

19. Telenius EW, Engedal K, Bergland A. Inter-rater reliability of the Berg Balance Scale, 30 s chair stand test and 6 m walking test, and construct validity of the Berg Balance Scale in nursing home residents with mild-to-moderate dementia. BMJ Open 2015;5(9):e008321. https://doi.org/10.1136/bmjopen-2015-008321

20. Sellen D. Physical status: the use of and interpretation of anthropometry, Report of a WHO Expert Committee. World Health Organ Tech Rep Ser. 1995;854:1-452. PMID: 8594834

21. Pestana MH, Gageiro JN. Análise de dados para ciências sociais: a complementaridade do SPSS. 6th ed. Lisboa: Edições Sílabos; 2014.

22. Steffl M, Bohannon RW, Houdova V, Musalek M, Prajerova K, �esák P, et al. Association between clinical measures of sarcopenia in a sample of community-dwelling women. Isokinet Exerc Sci. 2015;23:41-4. https://doi.org/10.3233/IES-140562

23. Bohannon RW. Muscle strength: clinical and prognostic value of hand-grip dynamometry. Curr Opin Clin Nutr Metab Care. 2015;18(5):465-70. https://doi.org/10.1097/MCO.0000000000000202

24. Lim JP, Chong MS, Tay L, Yang YX, Leung BP, Yeo A, et al. Inter-muscular adipose tissue is associated with adipose tissue inflammation and poorer functional performance in central adiposity. Arch Gerontol Geriatr. 2018;13:1-7. https://doi.org/10.1016/j.archger.2018.11.006

25. Mainous AG, Tanner RJ, Anton SD, Jo A. Grip Strength as a Marker of Hypertension and Diabetes in Healthy Weight Adults. Am J Prev Med. 2015;49(6):850-8. https://doi.org/10.1016/j.amepre.2015.05.025

26. Bentley DC, Nguyen CH, Thomas SG. Resting blood pressure reductions following isometric handgrip exercise training and the impact of age and sex: protocol for a systematic review. Syst Rev. 2015;4:176. https://doi.org/10.1186/s13643-015-0164-6

27. Jeoung BJ, Lee YC. A Study of relationship between frailty and physical performance in elderly women. J Exerc Rehabil. 2015;11(4):215-9. https://doi.org/10.12965/jer.150223