REFERÊNCIA

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Relation of functional capacity, strength and muscle mass in elderly women with osteopenia and osteoporosis

Relação da capacidade funcional, força e massa muscular de idosas com osteopenia e osteoporose

Relación entre la capacidad funcional, la fuerza y la masa muscular en personas mayores con osteopenia y osteoporosis

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ABSTRACT | This study aimed at analyzing the association among functional ability tests, performance of knee muscles, and body composition of elderly women with low bone densities. A transverse study with 48 elderly women (aged 70.62±5.95 years) was developed, and their functional abilities were evaluated (Timed Up and Go – TUG and Chair Stand – CST tests), as well as their knee muscle performance (isokinetic dynamometer), their muscle mass (skeletal muscle index with BIA), and their lean mass (skin folds). The majority of the sample was active or moderately active (95.8%), was found to be overweight (68.75%), was not found to have sarcopenia (62.5%), and had average performances of 7.7 seconds in TUG and 11.21 seconds in CST. The functional ability was found to have moderate and low negative correlations with the knee muscle performance variables. Their muscle mass was found to have a low positive correlation with the power of knee extensor muscles and it was found to have no correlation with the functional ability, which was only found to have an association with the muscle performance, which reinforces how unreliable it is to use muscle mass as the single measurement for the identification of sarcopenia.

Keywords | Elderly; Bone Density; Muscle Strength; Body Composition.

RESUMO | Este estudo buscou analisar a associação entre testes de capacidade funcional, desempenho dos músculos do joelho e composição corporal de idosas com baixa densidade óssea. Foi desenvolvido um estudo transversal com 48 idosas (70,62±5,95 anos). Avaliou-se a capacidade funcional (testes Timed Up and Go – TUG e levantar e sentar na cadeira – TLS), desempenho muscular de joelho (dinamômetro isocinético), massa muscular (índice muscular esquelético com BIA) e massa magra (dobras cutâneas). A maioria da amostra era ativa ou moderadamente ativa (95,8%), apresentou sobrepeso (68,75%), ausência de sarcopenia (62,5%) e desempenho médio de 7,7 segundos no TUG e de 11,21 segundos no TLS. Observaram-se correlações negativas moderadas e baixas da capacidade funcional com as variáveis de desempenho muscular de joelho. A massa muscular apresentou correlação positiva baixa com potência de extensores de joelho e não apresentou correlação com a capacidade funcional, a qual apresentou associação somente com o desempenho muscular, reforçando a fragilidade do uso da massa muscular como medida única na identificação de sarcopenia.

Descritores | Idoso; Densidade Óssea; Força Muscular; Composição Corporal.

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RESUMEN | En este estudio se analizó la relación entre pruebas de capacidad funcional, el rendimiento de los músculos de la rodilla y la composición corporal de adultos mayores con baja densidad ósea. Se desarrolló un estudio transversal con 48 adultos mayores (70,62±5,95 años) para que se evalúe la capacidad funcional (test de Timed Up and Go – TUG y el de Levantarse y Sentarse en la silla – TLS), el rendimiento muscular de la rodilla (dinamómetro isocinético), la masa muscular (índice del músculo esquelético con BIA) y la masa magra (pliegues cutáneos). La mayoría de la muestra era activa o moderadamente activa (un 95,8%), presentaba sobrepeso (un 68,75%) ausencia de sarcopenia (un 62,5%) y un rendimiento medio de 7,7 segundos en el TUG y de 11,21 segundos en el TLS. Se observó moderadas y bajas correlaciones negativas en cuanto a la capacidad funcional con las variables de rendimiento muscular de la rodilla. La masa muscular mostró una baja correlación positiva con la potencia de extensores de rodilla, en cambio, no señaló una correlación con la capacidad funcional, que había demostrado relación solamente con el rendimiento muscular, lo que refuerza la fragilidad de utilización de la masa muscular como única medida para que se identifique la sarcopenia.

Palabras clave | Adultos Mayores; Densidad Ósea; Fuerza Muscular; Composición Corporal

INTRODUCTION

Aging is characterized by a decline in body functions and by alterations in all body levels[1]. Among the body composition alterations, there are highlights to the gradual increase of fat mass[2] and the decreased bone and muscle mass, with a reduction in the number and size of type II muscle fibers[3]. From age 40 and on, 5% muscle mass is estimated to be lost with each decade, with a faster decline after age 65[4], particularly in the lower limbs; that quantitative loss of transverse muscle area has been observed to contribute to muscle weakness[5,6]. Those gradual mass and muscle strength losses define sarcopenia, a geriatric syndrome that is considered to be a determining factor for bone mineral density (BMD)[3], which is found to have a multifactorial etiology[7] and present individuals to adverse health situations, with functional losses, dependency, social restrictions, and increased health costs and mortality[8].

Most studies for the prevalence of sarcopenia have used the decrease in muscle mass as the only criterion for its identification[7]. However, the low muscle mass, on itself, may not be enough to recognize the risk of adverse functional results[9], and the functional ability investigation has been standing out among the findings regarding the association between the functional ability and the muscle performance of elderly people[4,10]. Studies have been identifying significant associations of muscle strength and muscle power of knee extensors and flexors with the ability to stand up from a chair[4,11] and with the walking speed[12]; and the associations of torque peaks of knee extensors and flexors and the muscle work of knee extensors with the abilities to stand up and walk[13,14] among elderly people. Considering that, the European Working Group on Sarcopenia in Older People has suggested the following criteria for the classification of sarcopenia: reduced muscle mass and strength, with hindered ability to perform a functional activity[15]. Those considerations point towards the possibility for the use of physical-functional evaluation tools, not only for identifying activity limitations, but also as a feasible, valid, and reproducible alternative to infer structural and functional disabilities, which allows identifying individuals who are at a clinical risk of having/developing sarcopenia[1].

Due to that, this study aimed at analyzing the association among functional ability tests, performance of the muscles which move the knee, and the body composition of elderly women with BMDs.

METHODOLOGY

The transverse study was conducted with the approval from the Ethics Committee of Universidade Federal de Minas Gerais, and with the consent from the participants.

Elderly women of 60 years or older who had been diagnosed (≅31 months before the study or at the beginning of it) with osteopenia or osteoporosis in the L1-L4 femur segments or in the femoral neck (*T-score* <–1,0 DP in the bone densitometry scan) were selected in a non-randomized way from health care programs targeted at elderly people in Brazil's Distrito Federal (Federal District). Elderly women who had found to be cognitively impaired through a Mini Mental State Examination[16] (<17), elderly women who had sequelae from neurological diseases, amputations, pain complaints, and history of recent fractures in lower limbs were excluded.

The adjusted activity score (AAS) and the Human Activity Profile (HAP) were used in order to assess the physical activity level, and they allowed classifying the elderly women as inactive (AAS<53), moderately active (AAS=53-54), or active (AAS>74)[17]. Mass (kg) and body height (m) were used in order to calculate the Body Mass Index - BMI (kg/m^2).

Functional ability was measured through clinical tests Timed Up and Go (TUG) and Chair Stand Test (CST). TUG has measured mobility and body balance through the time required to stand up from a chair, walk three meters as fast as possible, spin, go all the way back and sit down again[18]. CST evaluated the posture control and the muscle performance of lower limbs, through the evaluation of the time required to stand up and sit on a chair for five times, as fast as possible, with the arms folded on the chest[19]. Both tests were performed in sequence (with no intervals), and the times which were longer than 10 seconds in TUG[1818] and 12 seconds in CST[19] were considered as indicative of damaged functional ability.

The isokinetic muscle performance was evaluated through the following measurements: torque peak to body mass (Newton-meter/body mass); work to body mass (Joule/body mass) at 60°/s (5 maximum repetitions); average power (Watts) at 180°/s (15 maximum repetitions) of knee flexors and extensors in the dominant lower limb (preferred for kicking) through a Biodex System 4 Pro® isokinetic dynamometer, using concentric contractions. The backrest of the dynamometer was fixed at 85°, the rotational axis of the device was aligned with the lateral epicondyle of the femur, the lever pillow was fixed three centimeters above the lateral malleolus, and the range of motion was set to 85°. The tests were performed according to the manufacturer's specifications, also considering the familiarization at the day of the test with the isokinetic exercise in a maximum and two submaximum repetitions, with correction for gravity, and 120-second rest between test speeds[20].

Lean mass was estimated based on the averages of the three thickness measurements of biceps, triceps, subscapularis, midaxillary, pectoral, suprailiac, abdominal, thigh, and mid-calf skin fold sites[21], in the right hemibody, in order to calculate body fat percentage based on the prediction equation by Jackson et al.[22]. The lean mass percentage and its value in kilograms were calculated based on the body fat percentage. That lean mass measurement was collected from part of the sample (20 elderly women). The skeletal muscle mass index (SMMI) was obtained for the whole sample (48 elderly women) through Bioelectric Impedance (BIA) using the equation proposed by Janssen et al.[23], which calculates absolute skeletal muscle mass (kg) as divided by the squared height (m^2), which allows adjusting non-muscle components (bone, fat, and organs)[5]:

Muscle Mass: $[(h^2/r \times 0.401) + (s \times 3.825) + (i \times -0.071)] + 5.102$
h = height in cm; **r** = resistance in Ohm;
s = sex 0 for women; **a** = age in years.

That equation uses the resistance measurement from BIA, as collected through the tetrapolar body composition analyzer Maltron BF-900®, and it consists in the imperceptible passage of low-intensity (500-800μÄ) and high frequency (50kHz) electric current through the body. During the evaluation, the elderly women lay on their backs, with the red electrodes being placed under the articular lines of the wrist and ankle, and the black electrodes on the third metacarpal bone (hand) and on the second metatarsal bone (foot) of the right hemibody[6]. SMMI (kg/m^2) allowed the indication of severe (≤5.75), moderate (5.76–6.75), or absent sarcopenia (≥6.76)[15].

Firstly, the data regarding age, medications used, bone densitometry, and HAP were collected at volunteers' houses. In the same week, in the Movement Laboratory, the following order of evaluations was conducted, with one-minute resting periods between each: body mass and height measurements; functional tests; isokinetic evaluation; skin fold thickness; and BIA. The compliance with the recommendations regarding the body impedance test were not monitored (excessive water intake, alcohol and coffee consumption in the previous 24 hours, and emptying of the bladder 30 minutes before the test)[24].

The statistical analyses were processed in SPSS 16.0 software. The data distribution normality was confirmed through Kolmogorov-Smirnov test; Pearson product-moment correlation coefficient was used, and a 5% significance level was considered.

RESULTS

48 elderly women were evaluated (70.62±5.95 years), of which most were considered as active, moderately active (95.8%)[17], and overweight (68.75%) (WHO classification) (Table 1).

Table 1. Clinical and demographic characteristics of the sample (n = 48)

	Share (n)	Average±SD
Age (years)		70.62±5.95
≤ 75 years		-
>75 years		-
Metabolic bone diagnose		
Osteopenia/T-score	52.1% (25)	-1.74±0.43
Osteoporose/T-score	47.9% (23)	-3.21±0.64
Human Activity Profile (score)	-	73.37±9.03
Inactive	4.2% (2)	-
Moderately active	45.8% (22)	-
Active	50.0% (24)	-
Medications (number)	-	5.12±2.95
Body mass index (kg/m²)	-	27.93±4.99
WHO Obesity		
Classification	2.1% (1)	16.76
Moderate Thinness	29.2% (14)	22.31±1.76
Normal Range	35.4% (17)	28.22±1.50
Pre-Obese	29.2% (14)	32.54±1.32
Obese Class I	4.2% (2)	38.04±0.86
Obese Class III		

WHO - World Health Organization Kg = Kilogram. m = meter

Table 2. Functional ability, muscle performance and mass of the sample (n=48)

Variable	Share % (n)	Average± SD
Timed Up and Go Test (s)	-	7.70±1.95
≤10 s	95.8%	-
>10 s	(46)	-
	4.2% (2)	
Chair Stand Test (s)	-	11.21±3.18
≤12 s	77.1%	-
>12 s	(37)	-
	22.9%	
	(11)	
Torque peak of knee extensors (Nm/kg)	-	118.94±32.30
Torque peak of knee flexors (Nm/kg)	-	56.29±16.08
Work of knee extensors (J/kg)	-	117.45±30.98
Work of knee flexors (J/kg)	-	59.34±18.97
Power from knee extensors (W)	-	65.03±17.87
Power from knee flexors (W)	-	33.35±10.96
Lean mass (kg)	-	43.44±5.76
Skeletal muscle mass index (kg/m²)	-	7.21±1.00
Classification of sarcopenia	4.2% (2)	
Severe	33.3%	
Moderate	(16)	-
Non-sarcopenic	62.5%	
	(30)	

Nm/kg = Newton.meter/Kilogram; J/kg = Joule/Kilogram; W = Watts; kg/m2 = Kilogram/meter²

The characteristics related to functional ability, mass, and muscle performance are in Table 2. Most subjects were found to have good performances in TUG (95.8%; average of 7.7 seconds) and in the Chair Stand Test (77.1%, average of 11.21 seconds), and 62.5% of elderly women were found to have SMMIs higher or equal to 6.76kg/m².

In the correlation analyses (Table 3), TUG was found to have a high positive correlation with CST, moderate negative correlations with the work from knee extensors and with the level of physical activity; and low negative correlations with the remaining muscle performance variables. CST was found to have moderate negative correlations with the power from knee flexors and with the physical activity level, and low negative correlations with the remaining muscle performance variables. SMMI was found to have a low correlation, albeit positive, with the power from knee extensors. A moderate positive correlation (r=0.662; p=0.001) was found to exist between the two lean mass evaluation measurements, as well as low positive correlations between the physical activity level and all muscle performance variables.

Table 3. Correlation among studied variables

	IME	TUG	TLS	PAH
Skeletal muscle mass index (kg/m²)	-	-0.05	0.00	-0.147
TUG (s)	-	-	0.71**†	-0.551**†
Torque peak of knee extensors (Nm/kg)	-0.29*	-0.46**†	-0.41**†	0.463**†
Torque peak of knee flexors (Nm/kg)	-0.41**†	-0.42**†	-0.44**†	0.360**†
Work of knee extensors (J/kg)	-0.33*	-0.50**†	-0.45**†	0.471**†
Work of knee flexors (J/kg)	-0.45**†	-0.40**†	-0.43**†	0.362*†
Power from knee extensors (W)	0.29*	-0.42**†	-0.33*	0.286*†
Power from knee flexors (W)	0.04	-0.48†	-0.50†	0.372**†
Physical activity level (AAS/HAP)	-	-	-0.536**†	-

Pearson product-moment correlation coefficient (r). †Test power > 80%. *p < 0.05. **p < 0.01. TUG = Timed Up and Go Test. CST = Chair Stand Test. AAS – Adjusted Activity Score. HAP = Human Activity Profile. Nm/Kg = Newton.meter/Kilogram; J/kg = Joule/Kilogram; W = Watts; kg/m² = Kilogram/meter²

DISCUSSION

In this study, the three muscle performance parameters evaluated (torque peak, work, and muscle power) were found to have similar associations with standing up, sitting down, and fast walking activities, which corroborates findings in the literature[4,11,13,25]. Several studies have also evaluated the relationships among those variables in community elderly people, and found a strong correlation between the muscle performance in the lower limbs with the decreased mobility in walking activities[4,12,13,25,26], and in activities regarding going up and down stairs[8,26], with the reduced performance for standing up and sitting down[4,8,11,25] and the possibility of falling[27]. Pisciottano et al.[13] observed that the 1-unit increase in the torque peak of knee extensors was associated with a 0.01-second improvement in individual capacities in TUG. However, unlike this study, some others pointed out that muscle power explained, in a more consistent way than muscle strength, the variation in functional limitations in relatively more intense tasks[11,25], a fact which has been linked to reduced nerve impulses, to the fact that elderly people are not very familiarized with knee extension in isokinetic dynamometers[11], and to the more dynamic and dependent characteristics, regarding both the force production and the contraction speed in those daily activities[2525].

Muscle mass was not found to be correlated with functional ability, and it was found to have a low positive correlation with the average power of knee extensors and negative correlations with the remaining muscle performance variables in elderly women. Such results corroborate the results from Hairi et al.[4], who also found an association between the quadriceps muscle strength and functional limitation, and no relationship between the latter and muscle mass, which suggests that muscle strength would be the factor which could best determine the limitations in activities regarding walking, standing up, and sitting down. Conversely, some authors[5,6,28-31] pointed out that higher muscle mass influenced better physical performances[28] and that low lean mass was related to functional disability[5,6], dependency in daily activities,[31] and decreased mobility[30]. However, in the physiological aging process, decreased muscle mass may not play a significant role in the diminished functional ability and muscle performance, as that reduction in performance is due to multiple factors[9]. The decline in muscle strength may be more related to neural alterations, which are more characterized by the increased co-activation of antagonist muscles, and reduced recruitment speed and synchronization of motor unit activation than by the hypotrophy of muscle fibers, which may significantly contribute to functional alterations[11]. Those results reinforce the idea that the isolated use of muscle mass as a criterion to define sarcopenia may not be adequate for all age ranges, taking into account that, in the elderly, the relationship between muscle mass and physical-functional ability has not shown to be linear[13].

Other studies have mentioned that the absent correlation between mass and muscle performance in the elderly may be explained through the altered muscle quality[32], as defined by the functional application of muscle strength in relation to the muscle mass amount[33], with the decreased strength occurring first, and in a quicker fashion as compared to the decreased mass[10]. That phenomenon may have taken place in this study sample that comprised more active, younger, and non-sarcopenic elderly women, for whom the onset of the muscle performance physiological decline is not necessarily being accompanied by diminished muscle mass. Contributing to this analysis in this study, unlike the remaining main variables (functional ability and muscle strength), the muscle mass measurement was not related to the subjects' physical activity levels. Furthermore, the literature points towards a strong association between a lower muscle quality and higher functional limitations in daily activities[4], reduced walking speed, balance deficit[29], and decreased muscle performance[2,3]. Also, considering that most elderly women in this study were found to be overweight, the reduced muscle quality may also be a consequence of the altered body composition that arises from the increased fat-free mass[2,29] and through the infiltration of fat into the muscles[34].

The sample was not calculated in this study, nor was the intake of water, alcohol, or coffee was controlled, and the emptying of bladders were not supervised either before the body impedance tests were taken. Such limitations hinder the internal validity of the study; however, the findings regarding significant positive and moderate correlations among bioimpedance and lean mass measurements that were obtained through the thickness of skin folds showed how reliable the body impedance evaluation and the SMMI calculation were. In order to improve the robustness of results, future studies are recommended to separate samples by age ranges, before correlation analyses can be conducted.

Thus, taking into account that no linear relationships were found among muscle mass and applied functional tests, the muscle performance of knee extensors and flexors seems to have a more important role than muscle mass by itself[13] for the preservation of abilities regarding walking, standing up, or sitting down[4], for elderly women with low BMDs. Therefore, the muscle performance is suggested to be the parameter that is prioritized in the clinical practice for the investigation of functional limitations in elderly women, once the use of muscle mass as the only parameter may not be the most adequate way to define sarcopenia. Considering the correlation among the isokinetic variables and the TUG and CST tests, and the quicker, easier, and more inexpensive application of functional ability measurements may enable tracing the physical-functional risks that are related to sarcopenia.

CONCLUSION

In conclusion, the association between functional ability and muscle performance was the only one observed, and its relationship with muscle mass was not found to be true. The latter, in turn, was found to be inversely related to muscle strength. Those findings reinforce how unreliable it is to use muscle mass as the single measurement for the identification of sarcopenia.

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