



## Isokinetic performance of knee flexor and extensor muscles in community-dwelling elderly women

*Desempenho dos músculos flexores e extensores de joelho de idosas da comunidade no dinamômetro isocinético*

Diogo C. Felício<sup>[a]</sup>, Daniele S. Pereira<sup>[b]</sup>, Bárbara Z. de Queiroz<sup>[c]</sup>, Alexandra M. Assumpção<sup>[c]</sup>, João M. D. Dias<sup>[c]</sup>, Leani S. M. Pereira<sup>[c]\*</sup>

<sup>[a]</sup> Universidade Federal de Juiz de Fora, Juiz de Fora, MG, Brazil

<sup>[b]</sup> Universidade Federal de Alfenas (Unifal), Alfenas, MG, Brazil

<sup>[c]</sup> Universidade Federal de Minas Gerais (UFMG), Belo Horizonte, MG, Brazil

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### Abstract

**Introduction:** The isokinetic dynamometer enables accurate assessment of muscle function. In Brazil, few studies have assessed the isokinetic muscle performance in older adults making interpretation and comparison of results with other studies. **Objectives:** To conduct a descriptive analysis of the performance of the muscle flexor and extensor muscles of the knee joint in elderly community and compare the performance between the age groups 65-74 years and 75 years or more. **Methods:** This is a cross sectional observational study with a convenience sample of 229 elderly community. For the analysis of muscle performance was used isokinetic dynamometer (Biodex System 3 Pro™) in the angular velocities of 60 °/s and 180 °/s. The variables evaluated

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\* DCF: MSc, e-mail: [diogofelicio@yahoo.com.br](mailto:diogofelicio@yahoo.com.br)  
DSP: PhD, e-mail: [daniele.sirineu@gmail.com](mailto:daniele.sirineu@gmail.com)  
BZQ: MSc, e-mail: [babzille@gmail.com](mailto:babzille@gmail.com)  
AMA: MSc, e-mail: [alexandram.fisio@gmail.com](mailto:alexandram.fisio@gmail.com)  
JMDD: PhD, e-mail: [jmdd@eefito.ufmg.br](mailto:jmdd@eefito.ufmg.br)  
LSMP: PhD, e-mail: [leanismp.bh@terra.com.br](mailto:leanismp.bh@terra.com.br)

were peak torque, peak torque normalized by body weight, total work normalized by body mass, total work, average power and agonist/antagonist ratio. Descriptive analysis was used to characterize the sample. For comparison between age groups was used Student's t-test with  $\alpha = 0.05$ . **Results:** The elderly women with older age showed a statistically significant decrease in most of the variables ( $p < 0.05$ ) except for the agonist and antagonist knee ( $p = 0.398$ ). **Conclusions:** The isokinetic was a sensitive tool to characterize the modifications caused by aging on muscle function. Elderly with results below the lower limits of the confidence intervals for all variables certainly has a decreased strength for the age group evaluated and must be addressed therapeutically. The results can be used as a benchmark in clinical practice and future research.

**Keywords:** Elderly women. Muscle performance. Isokinetic dynamometer.

### Resumo

**Introdução:** O dinamômetro isocinético possibilita a avaliação acurada da função muscular. No Brasil, poucos estudos avaliaram o desempenho muscular isocinético em idosos, dificultando a interpretação e comparação dos resultados com outros estudos. **Objetivos:** Realizar uma análise descritiva do desempenho muscular dos músculos flexores e extensores da articulação do joelho de idosas da comunidade e comparar o desempenho entre as faixas etárias de 65 a 74 anos e 75 anos ou mais. **Métodos:** Trata-se de um estudo observacional transversal, com uma amostra de conveniência com 229 idosas da comunidade. Para a análise do desempenho muscular foi utilizado o dinamômetro isocinético (Biodex System 3 Pro®) nas velocidades angulares de 60 °/s e 180 °/s. As variáveis avaliadas foram o pico torque, pico de torque normalizado pela massa corporal, trabalho normalizado pela massa corporal, trabalho total, potência e a relação agonista/antagonista. Foi utilizada análise descritiva para caracterização da amostra. Para comparação entre as faixas etárias foi usado o teste-t de Student considerando  $\alpha = 0,05$ . **Resultados:** As idosas com idade mais avançada apresentaram um decréscimo estatisticamente significativo na maioria das variáveis analisadas ( $p < 0,05$ ) com exceção da relação agonista e antagonista do joelho ( $p = 0,398$ ). **Conclusão:** O dinamômetro isocinético foi um instrumento sensível para caracterizar as modificações ocasionadas pelo envelhecimento na função muscular. Idosas com resultados abaixo dos limites inferiores dos intervalos de confiança para as variáveis pesquisadas apresentam uma força diminuída para a faixa etária avaliada e devem ser abordadas terapeuticamente. Os resultados podem ser utilizados como parâmetro de comparação na prática clínica e em futuras pesquisas.

**Palavras-chave:** Idosas. Desempenho muscular. Dinamômetro isocinético.

## Introduction

Population aging occurs significantly in Brazil and worldwide. In recent decades in Brazil has seen a progressive decline in mortality and fertility which culminates with an increase in the elderly quota (1). In line with the reality of other countries, in Brazil we can see a female predominance among the elderly (55%) (2). It is the old age feminization that makes research in gerontology have interest in this genre. Aging is accompanied by an increase in the prevalence of chronic diseases reflected in decreased muscle strength (3).

In 1989, Rosenberg (4) proposed the term sarcopenia to describe the involuntary loss of skeletal

muscle mass related to age. In an attempt to operationalize the term, Cruz-Jentoft et al. (5) proposed by a European consensus that sarcopenia is a geriatric syndrome characterized by loss of muscle mass and function. There is evidence linking the loss of muscle strength of the lower limbs to greater difficulty of elderly in performing functional activities such as climbing stairs, sitting and rising from a chair, decrease in walking speed, balance changes and increased risk of falls (6, 7).

The isokinetic dynamometer is often used to evaluate muscle function. This is an electromechanical instrument controlled by computer, which allows to obtain objective measures, reliable and valid in muscle performance. Currently, this tool is

characterized as the most accurate method available for the evaluation of neuromuscular function. The isokinetic dynamometer offers an accommodative resistance and predetermined and constant angular speed throughout the range of motion, allowing the muscle to exert its maximum capacity throughout the range (8).

In Brazil, we do not know studies evaluating the isokinetic muscle performance of the flexor muscles and community elderly knee extensors, stratified by age group, making the interpretation and comparison of results with national and international data.

Thus, the aim of this study was to perform a descriptive analysis of the flexor muscle performance and community elderly of knee joint extensors and compare the performance between different age groups.

## Methods

### Study design and ethical aspects

This was designed as a cross-sectional study. The research protocol was approved by the Federal University of Minas Gerais ethics committee (ETIC 038/2010). All participants were informed of the study characteristics and signed an informed consent form.

### Sample

Sample selection was carried out by convenience. The study included women from the community aged 65 years and older. Exclusion criteria were cognitive dysfunction detectable by the Mini-Mental State Examination score (9), which was considered to indicate the presence of cognitive impairment with a score less than 18 for illiterate participants and a score of 24 for participants with one or more years of study; fractures or a history of osteosynthesis of lower and/or upper limbs; severe visual or hearing losses; presence of neurological deficits self-report; a history of cancer within 5 years before data collection and pain complaint in the knee joint. To compare the performance between different age groups. The participants were divided into two groups: age group 65–74 years and aged 75 years or older.

## Instruments and procedures

### Sociodemographic and clinical characterization

Information on sample characteristics with respect to sociodemographic data, and information on the clinical conditions of the elderly, such as education, age, number of comorbidities and body mass index (BMI), were obtained using a standardized multidimensional questionnaire developed by the researchers.

### Muscle performance of knee extensors and flexors

For the evaluation of muscular performance were selected the knee joint muscles (quadriceps and hamstring muscle groups) due to its functional importance. We used the isokinetic dynamometer Biodex System 3 Pro™ (Biodex Medical Systems Inc., Shirley, NY, USA).

Participants carried out a 5-min lower limb warm up by means of walking on a flat surface. After warm up, they were positioned in the dynamometer chair. The dynamometer's rotation axis was aligned to the lateral epicondyle of the femur. The range of movement in performing the test was 90°, starting from 90° of knee flexion. Prior to testing conducted a familiarization training with three submaximal repetitions. Verbal feedback was given during the trials in order to encourage participants to move the dynamometer lever as fast and as vigorously as possible (8).

Data analysis was carried out using only the results obtained from the dominant lower limb, which was determined by the answer to the question, "If you were about to kick a ball, with which leg would you kick it?" (10). Angular velocities selected were 60 °/s with five repetitions and 180 °/s with 15 repetitions. Concentric-concentric mode was selected for assessment. The angular velocities of 60 °/s and 180 °/s were chosen because most of the functional activities are related to the ability to generate power at low speeds (11). The following isokinetic variables were chosen for analysis: peak torque, peak torque/body mass, total work, total work/body mass, average power, and agonist/antagonist (8, 12). Among the tests conducted was a two-minute rest period.

## Statistics

Sample characterization was provided using descriptive statistics. For isokinetic variables we calculated the confidence interval at 95%. The distribution of data normality was determined using the Kolmogorov-Smirnov normality test. For comparison between the age groups we used the Student's t-test for independent groups for quantitative variables. For all analyses, we used a significance level of 0.05. Statistical analyses were carried out using the Statistical Package for Social Sciences (PASW Data Collection, version 15.0; SPSS, Chicago, IL, USA).

## Results

The study included 229 elderly volunteers with a mean age of  $70.9 \pm 4.8$  years and a low level of education  $6.0 \pm 4.1$  years, however, without cognitive impairment MMSE  $25.9 \pm 2.9$ . The data relating to clinical elderly demonstrated a mean BMI  $29.2 \pm 4.8$  kg/m<sup>2</sup>, so participants was in overweight. According to self-reported comorbidities, the most prevalent diseases were hypertension with 69.8%. Comparing the groups, it was found that the older age group had a statistically significant decrease ( $p < 0.05$ ) in most

parameters assessed, except for the ratio of agonist muscles and antagonist knee ( $p = 0.398$ ). The socio-demographic and clinical characteristics of the sample are presented in Table 1. Tables 2 and 3 are data about the isokinetic evaluation.

## Discussion

This study aimed to carry out a descriptive analysis and compare muscle performance in isokinetic dynamometer flexor muscles and community elderly extenders with different age groups. The results could be used as a parameter for comparison in clinical practice and future research, given that were presented stratified by age, gender and the sample independent living in the community. In addition, we found that older age group had a statistically significant decrease in most of the evaluated parameters ( $p < 0.05$ ), except for the ratio of agonist muscles and antagonist knee ( $p = 0.398$ ). These results showed that the progressive process of muscle aging in community elderly with functional independence was detectable by the isokinetic dynamometer. Manual muscle testing can not always determine muscle minor changes caused by aging, which have indicated the need for physical therapy interventions.

**Table 1** - Demographic and clinical sample characteristics (n = 221)

Variables	Age group 65–74 years (n = 183)	Aged 75 years or older (n = 46)	Total (n = 229) Mean ± Standard deviation
	Mean ± Standard deviation	Mean ± Standard deviation	
Age (years)	69.0 ± 2.9	78.6 ± 3.3	70.9 ± 4.8
Weight (kg)	70.4 ± 12.5	68.8 ± 11.6	70.0 ± 12.3
Height (m)	1.55 ± 0.3	1.54 ± 0.5	1.54 ± 0.5
BMI	29.2 ± 4.8	28.9 ± 4.6	29.2 ± 4.8
Education (years)	6.3 ± 4.1	5.1 ± 3.9	6.0 ± 4.1
MMSE	26.0 ± 2.9	25.4 ± 2.9	25.9 ± 2.9
Comorbidities n (%)			
SH	132 (72.1%)	31 (67.4%)	163 (71.2%)
Arthritis	80 (43.7%)	19 (41.3%)	99 (43.2%)
Osteoporosis	36 (19.7%)	17 (37%)	53 (23.1%)

Note: The variables age, weight, height, BMI, education, MMSE values expressed as mean ± standard deviation; comorbidities in frequency and percentage. BMI = body mass index; MMSE = Mini-Mental State Examination, SH = hypertension.

**Table 2** - Values of the isokinetic variables for the extensors and flexors of the knee angular velocity of 60 °/s according to age group (n = 221)

Isokinetic variables	Age group 65–74 years (n = 183)	Aged 75 years or older (n = 46)	p Value
	Mean ± Standard deviation (CI 95%)	Mean ± Standard deviation (CI 95%)	
Peak torque ext. (Nm)	86.1 ± 20.2 (82.4-88.2)	76.6 ± 16.0 (72.9-85.0)	0.003*
Peak torque flex. (Nm)	35.3 ± 11.4 (33.1-36.5)	30.1 ± 9.3 (28.6-34.9)	0.006*
Peak torque/body weight ext. (%)	123.8 ± 31.6 (119.8-129.0)	113.1 ± 24.5 (102.1-118.3)	0.027*
Peak torque/body weight flex. (%)	50.7 ± 16.4 (48.3-53.3)	44.3 ± 13.6 (39.9-47.7)	0.015*
Total work/body weight ext. (%)	122.6 ± 32.8 (118.9-128.6)	111.8 ± 26.4 (99.8-114.2)	0.031*
Total work/body weight flex. (%)	56.8 ± 20.6 (53.8-60.1)	47.4 ± 18.9 (41.5-51.2)	0.005*
Total work ext. (J)	393.6 ± 94.1 (376.5-404.3)	345.0 ± 81.5 (327.7-383.0)	0.001*
Total work flex. (J)	176.6 ± 66.0 (163.1-183.5)	134.0 ± 57.8 (127.5-161.2)	< 0.001*
Average power ext. (W)	48.7 ± 11.8 (46.5-50.0)	42.7 ± 10.1 (40.8-48.0)	0.001*
Average power flex. (W)	20.7 ± 8.0 (19.1-21.6)	15.9 ± 6.8 (15.1-19.1)	< 0.001*
Agonist/antagonist ratio (%)	41.4 ± 11.0 (39.5-42.6)	39.7 ± 11.1 (36.8-45.2)	0.398

Note: ext = extension; flex = flexion; \* = statistical difference between the groups.

**Table 3** - Values of the isokinetic variables for the extensors and flexors of the knee angular velocity of 180 °/s according to age group (n = 221)

Isokinetic variables	Age group 65–74 years (n = 183)	Aged 75 years or older (n = 46)	p Value
	Mean ± Standard deviation (CI 95%)	Mean ± Standard deviation (CI 95%)	
Peak torque ext. (Nm)	55.9 ± 13.2 (53.2-57.2)	49.2 ± 10.6 (47.7-55.3)	0.002*
Peak torque flex. (Nm)	28.0 ± 8.7 (26.0-28.8)	24.3 ± 10.2 (22.9-28.4)	0.018*
Peak torque/body weight ext. (%)	80.7 ± 20.49 (77.6-83.8)	72.9 ± 17.3 (68.0-77.6)	0.017*
Peak torque/body weight flex. (%)	40.0 ± 12.4 (37.8-41.8)	35.6 ± 14.9 (31.9-38.6)	0.047*
Total work/body weight ext. (%)	84.6 ± 22.6 (81.3-88.2)	76.2 ± 20.1 (69.3-80.0)	0.020*
Total work/body weight flex. (%)	40.4 ± 14.7 (37.8-42.6)	33.2 ± 18.0 (29.3-37.5)	0.005*
Total work ext. (J)	733.7 ± 185.2 (691.5-747.4)	640.2 ± 165.2 (628.7-736.0)	0.002*
Total work flex. (J)	321.3 ± 137.9 (289.9-334.8)	242.4 ± 162.1 (230.7-310.1)	0.001*
Average power ext. (W)	76.5 ± 20.4 (71.8-78.0)	66.9 ± 18.5 (65.8-77.9)	0.004*
Average power flex. (W)	31.2 ± 14.1 (28.1-32.7)	23.6 ± 16.4 (22.3-30.1)	0.002*
Agonist/antagonist ratio (%)	50.4 ± 14.7 (47.6-52.0)	48.5 ± 16.6 (44.6-55.1)	0.489

Note: ext. = extension; flex. = flexion; \* = statistical difference between the groups.

The isokinetic variables evaluated were: peak torque, peak torque normalized by body weight, work, work normalized by body weight, power and agonist/antagonist relationship, important variables to perform the daily activities of the elderly. The variable peak torque is maximum strength at a specific point of the range of motion (ROM) (12). It was found in this study, a significant reduction in peak torque of knee extensors and flexors in the two predetermined angular velocities among elderly women groups. Furthermore, the results were speed-dependent, i.e., the smaller the larger the angular velocity values were found which confirms other studies (13, 14).

Comparing with data from literature Ordway et al. (15) evaluated 17 elderly women with a mean age of 72 years in the angular speed of 60 °/s met peak torque of  $82 \pm 21$  Nm for knee extensors and  $35 \pm 10$  Nm for the flexors which corroborates the results of the youngest participants of this study. Aquino et al. (16) evaluated 26 elderly women with a mean age of 77.8 years in the angular speed of 600 / s and found peak torque of  $76.9 \pm 13.9$  Nm for knee extensors and  $42.4 \pm 9.09$  nm for flexor. The findings of the previous study are not in agreement with the results found in this study, when compared with the values for the knee flexors older elderly group in this study. Please note that the search Aquino et al. (16) the dynamometer used was from another manufacturer which according Walmsley and Dias (17) can interfere with the results obtained.

The methodological variability and the variables chosen for evaluation by the isokinetic difficult to compare our results with other studies. Symons et al. (18) used the angular velocity of 90 °/s, Hartmann et al. (13) used a different dynamometer of this research, Zacaron et al. (19) did not include the variable peak torque and Danneskiold-Samsoe et al. (14) divided the groups in different age groups 60–69 and 70–79 years. Moreover, none of the above studies included only elderly.

The analysis of the variable muscle work normalized by body weight provides more extensive information muscle performance peak torque, as is the ability to generate muscle force throughout the range of motion (ROM) (12). A statistically significant reduction in muscle work among elderly women groups was checked. Ordway et al. (15) to evaluate elderly women with a mean age of 72 years found work  $106.00 \pm 27$  J for knee extensors and  $47 \pm 14$  J flexor in angular velocity of 60 °/s. The values are

lower compared to the age group of 65 to 74 years of this study. However, in the above study, the test was done with the non-dominant leg which differs from the methodology of our study.

As for the muscle power, the data from this study demonstrated a statistically significant decline in the elderly aged 75 years or more in the angular velocities of 60 °/s and 180 °/s. The muscle power parameter is the speed at which the muscles are able to generate work as an important factor for mobility and ambulatory elderly. It is involved in activities such as crossing a street, stop a car up off the floor and regain balance after a situation that promotes the imbalance (11, 20).

Some studies show that power is isokinetic variable that most relates to the performance of elderly people in daily activities (21). Skelton et al. (22), in 2002, showed in a cross-sectional study statistically significant differences in muscle strength of the flexors and knee extensors when comparing fallers ( $n = 20$  mean age  $74.5 \pm 5.7$ ) and non-fallers ( $n = 15$  mean age  $74.0 \pm 6.3$ ) and found no significant differences in peak torque. Muscle strength decreases 1 to 2% per year and that for most muscle groups, women are 1.5 to 2 times fainter than men (14). Muscle power in the elderly presents a decline 3–4% per year. Published data suggest that the decrease in power is a major factor in the decline of functional capacity of the elderly (13). The loss in peak production capacity of torque, work and power of the elderly population observed in the study is related to sarcopenia process that occurs with aging, especially related to the loss of muscle fiber type II (23). However, reduction of power has a considerable impact on functional activity in the elderly and in itself is the main predictor of adverse outcome (22).

Another variable was assessed isokinetic agonist/antagonist relationship. Values below 40% indicate the predominance of the extensor musculature or deficit in the flexor muscles, which can represent a muscle imbalance in the knee joint. Muscle imbalance can predispose the joint or the weakest muscle group to be injured (24). As a result of aging, there is a predominance of the flexor groups for extenders. This compensatory mechanism is the flexion of the hips and knees and increase the support base. It is often carried out by the elderly, and presents an attempt to lower the center of gravity and provide a greater postural stability and facilitate walking (25). The values of the agonist/antagonist obtained are below the reference values of the Biodex System 3

Pro™ software. However, agreed with the study by Dias et al. (24) also observed an increase in agonist/antagonist with increasing angular velocity.

No statistically significant differences were found in mean values of agonist/antagonist relationship (quadriceps and hamstrings) among the surveyed elderly groups, this way, the present study was not observed change in muscle balance of the knee. Although the group of elderly with the highest age group show losses at peak production capacity of torque, work and power, this loss occurred in proportion to the extensors and knee flexors, because it did not affect the muscular balance.

Changes in the levels after repeated isokinetic measures may be due to systematic or random error (26). Random errors occur due to equipment problems, errors by the researcher or volunteer search. Systematic errors include learning effect, fatigue and other (12, 27). To minimize errors in the present study, the parameters to use an isokinetic were strictly adhered to as calibration, positioning, stabilization, gravity correction, familiarization, guidance, verbal encouragement and preheating.

Among the limitations of the study include the sample disproportion between the groups and the BMI of the volunteers. The overweight could influence the performance of elderly women. Thus, we do not know the results obtained regarding the performance of elderly in the isokinetic evaluation may be underestimated when compared with a eutrophic elderly population.

## Conclusion

The results of our study can be used as benchmark in clinical practice and future research. The isokinetic was a sensitive tool to characterize the changes caused by aging on muscle function. Elderly with results below the lower limits of the confidence intervals for the variables studied have a decreased force for the age range studied and should be addressed therapeutically.

## References

1. Chaimowicz FA. Saúde dos idosos brasileiros às vésperas do século XXI: problemas, projeções e alternativas. *Rev Saúde Pública*. 1997;31(2):184-200.
2. Organização mundial da saúde. *Envelhecimento ativo: uma política de saúde*. Brasília: OMS; 2005.
3. Chang YM, Tsao LI, Huang MH. Experiences of coexisting with chronic illnesses among elderly women in communities. *Health Care Women Int*. 2014;35(11-12):1137-51.
4. Rosenberg IH. Summary comments: epidemiological and methodological problems in determining nutritional status of older persons. *Am J Clin Nutr*. 1989;50(5 Suppl):1231-3.
5. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, et al. Sarcopenia: European consensus on definition and diagnosis. *Age Ageing*. 2010;39(4):412-23.
6. Pamukoff DN, Haakonssen EC, Zaccaria JA, Madigan ML, Miller ME, Marsh AP. The effects of strength and power training on single-step balance recovery in older adults: a preliminary study. *Clin Interv Aging*. 2014;9:697-704.
7. Marmon AR, Milcarek BI, Snyder-Mackler L. Associations between knee extensor power and functional performance in patients after total knee arthroplasty and normal controls without knee pain. *Int J Sports Phys Ther*. 2014;9(2):168-78.
8. Perrin DH. *Isokinetic exercise and assessment*. Champaign: Human Kinetics Publishers; 1993.
9. Bertolucci PHF, Brucki SMD, Campacci SR, Juliano Y. O Mini-Exame do Estado Mental em uma população geral. *Arq Neuro-Psiquiatr*. 1994;52(1):1-7.
10. Dean JC, Kuo AD, Alexander NB. Age-related changes in maximal hip strength and movement speed. *J Gerontol A Biol Sci Med Sci*. 2004;59(3):286-92.
11. Ferri A, Scaglioni G, Pousson M, Capodaglio P, van Hoecke J, Narici MV. Strength and power changes of the human plantar flexors and knee extensors in response to resistance training in old age. *Acta Physiol Scand*. 2003;177(1):69-78.
12. Dvir Z. *Isokinetics: muscle testing, interpretation and clinical applications*. Edinburgh: Churchill Livingstone; 2004.
13. Hartmann A, Knols R, Murer K, de Bruin ED. Reproducibility of an isokinetic strength-testing protocol of the knee and ankle in older adults. *Gerontology*. 2009;55(3):259-68.

14. Danneskiold-Samsøe B, Bartels EM, Bülow PM, Lund H, Stockmarr A, Holm CC, et al. Isokinetic and isometric muscle strength in a healthy population with special reference to age and gender. *Acta Physiol.* 2009; 197(Suppl. 673):1-68.
15. Ordway NR, Hand N, Briggs G, Ploutz-Snyder LL. Reliability of knee and ankle Strength measures in an older adult population. *J Strength Cond Res.* 2006; 20(1):82-7.
16. Aquino MA, Leme LEG, Amatuzzi MM, Greve JMA, Terrieri ASAP, Andrusaitis FR, et al. Isokinetic assessment of knee flexor/extensor muscular strength in elderly women. *Rev Hosp Clin.* 2002;57(4):131-4.
17. Walmsley RP, Dias JM. Intermachine reliability of isokinetic concentric measurements of shoulder internal and external peak torque. *Isokinet Exerc Sci.* 1995; 5(2):75-80.
18. Symons TB, Vandervoort AA, Rice CL, Overend TJ, Marsh GD. Reliability of a single-session isokinetic and isometric strength measurement protocol in older men. *J Gerontol A Biol Sci Med Sci.* 2005;60(1):114-9.
19. Zacaron KAM, Dias JMD, Abreu NS, Dias RC. Nível de atividade física, dor e edema e suas relações com a disfunção muscular do joelho de idosos com osteoartrite. *Rev Bras Fisioter.* 2006;10(3):279-84.
20. Reid KF, Martin KI, Doros G, Clark DJ, Hau C, Patten C, et al. Comparative effects of light or heavy resistance power training for improving lower extremity power and physical performance in mobility-limited older adults. *J Gerontol A Biol Sci Med Sci.* 2015;70(3):374-80. doi: 10.1093/gerona/glu156.
21. Bassey EJ, Fiatarone MA, O'Neill EF, Kelly M, Evans WJ, Lipsitz LA. Leg extensor power and functional performance in very old men and women. *Clin Sci (Lond).* 1992;82(3):321-7.
22. Skelton DA, Kennedy J, Rutherford OM. Explosive power and asymmetry in leg muscle function in frequent fallers and non-fallers aged over 65. *Age Ageing.* 2002;31(2):119-25.
23. Walker S, Peltonen H, Sautel J, Scaramella C, Kraemer WJ, Avela J, et al. Neuromuscular adaptations to constant vs. variable resistance training in older men. *Int J Sports Med.* 2014;35(1):69-74
24. Dias JMD, Arantes PMM, Alencar MA, Faria JC, Machala CC, Camargos FFO, et al. Relação isquiotibiais/quadriceps em mulheres idosas utilizando o dinamometro isocinético. *Rev Bras Fisioter.* 2004;8(2):111-5.
25. Pereira LSM. Avaliação pelo fisioterapeuta. In: Maciel A. Avaliação multidisciplinar do paciente geriátrico. Rio de Janeiro: Revinter; 2002. p. 43-86.
26. Portney LG, Watkins MP. Foundations of clinical research: applications to practice. New Jersey: Prentice Hall; 2000.
27. Felício DC, Pereira DS, Assumpção AM, Jesus-Moraleida FR, Queiroz BZ, Silva JP, et al. Poor correlation between handgrip strength and isokinetic performance of knee flexor and extensor muscles in community-dwelling elderly women. *Geriatr Gerontol Int.* 2014;14(1):185-9.

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