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ORIGINAL RESEARCH

# Association between isokinetic strength measures and functional performance in community-dwelling older adults

*Associação entre medidas de força isocinética e desempenho funcional em pessoas idosas da comunidade*

*Asociación entre las medidas de fuerza isocinética y el rendimiento funcional en personas mayores en la comunidad*

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**ABSTRACT |** Previous studies have shown an association between lower limb muscle strength and functional performance, but a dose-response relationship between the strength of each lower limb muscle group and performance in daily life activities in older adults has not been well established. Thus, this study aimed to investigate the association between isokinetic muscle strength of all eight major lower limb muscle groups and functional performance in community-dwelling older adults. The muscle strength of the plantar flexors and dorsiflexors of the ankle, flexors and extensors of the knee, and flexors, extensors, adductors, and abductors of the hip were evaluated using a Biodex System 4 Pro® isokinetic dynamometer. Functional performance was evaluated in 109 participants using the five-times sit-to-stand test (STS) and 4-meter usual walking speed (UWS). The multiple linear regression analyses showed that the hip abductors strength predicted 31.3% of the variability for UWS (p=0.011), and the knee extensors strength (p=0.015) predicted 31.6% of the variability for the STS. We conclude that hip abductors and knee extensors could be the key muscle groups involved in sit to stand and walking speed performance in older adults.

Keywords | Muscle Strength; Activities of Daily Living; Walking Speed; Sitting Position.

**RESUMO |** Estudos anteriores já demonstraram a associação entre força muscular de membros inferiores e desempenho funcional, mas a contribuição dos principais músculos dos membros inferiores para o desempenho de pessoas idosas nas atividades cotidianas não foi bem estabelecida. O objetivo deste estudo foi investigar a associação entre a força muscular isocinética dos oito principais grupos musculares dos membros inferiores e o desempenho funcional em pessoas idosas da comunidade. A força muscular dos plantiflexores e dorsiflexores do tornozelo, flexores e extensores do joelho e flexores, extensores, adutores e abdutores do quadril foi avaliada utilizando um dinamômetro isocinético Biodex System 4 Pro®. O desempenho funcional de 109 participantes foi avaliado usando o teste de sentar e levantar cinco vezes (TSL) e de velocidade de marcha habitual de 4 metros (VMH). As análises de regressão linear múltipla mostraram que a força dos abdutores do quadril previu 31,3% da variabilidade para a VMH (p=0,011), e a força dos extensores do joelho (p=0,015) 31,6% da variabilidade para o TSL. Concluímos que os abdutores do quadril e os extensores do joelho podem ser os principais grupos musculares envolvidos no desempenho de pessoas idosas para sentar-levantar e caminhar.

Descritores | Força Muscular; Atividades de Vida Diária; Velocidade de Caminhada; Postura Sentada.

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**RESUMEN |** Estudios previos ya demostraron la asociación entre la fuerza muscular de los miembros inferiores y el rendimiento funcional, sin embargo, no está bien establecida la contribución de los principales músculos de los miembros inferiores sobre el rendimiento de las personas mayores en las actividades diarias. El objetivo de este estudio fue evaluar la asociación entre la fuerza muscular isocinética de los ocho principales grupos musculares de los miembros inferiores y el rendimiento funcional en personas mayores que viven en la comunidad. La fuerza muscular de los plantiflexores y dorsiflexores del tobillo, los flexores y extensores de la rodilla y los flexores, extensores, aductores y abductores de la cadera se evaluaron por medio del dinamómetro isocinético Biodex System 4 Pro®. El rendimiento funcional de 109 participantes se evaluó mediante el test de sentarse y pararse cinco veces (STS) y la velocidad de marcha habitual de 4 metros. Los análisis de regresión lineal múltiple mostraron que la fuerza de los abductores de la cadera predijo el 31,3% de la variabilidad para la velocidad de marcha habitual (p=0,011); y la fuerza de los extensores de la rodilla (p=0,015), el 31,6% de variabilidad para STS. Se concluyó que los abductores de la cadera y los extensores de la rodilla pueden ser los principales grupos musculares involucrados en el rendimiento de los adultos mayores para sentarse, pararse y caminar.
Palabras clave | Fuerza Muscular; Actividades Cotidianas; Velocidad al Caminar; Sedestación.

## INTRODUCTION

Walking and rising from a seated to a standing position is one of the most common activities of daily living. Thua, the ability to perform these tasks is important to maintain physical independence and may be one of the most important measures of functional performance in older adults[1]. Gait speed and the time necessary to get up from a chair help predict risk of decline in functional performance and risk of adverse events in older adults, and it has been recommended as the "sixth vital sign"[2]. They may also be useful to identify community-dwelling older people at risk of adverse outcomes, being a consistent risk factor for disability[3], cognitive impairment, institutionalization, falls, and/or mortality and severe sarcopenia[4].

Sarcopenia is a multifactorial condition defined as a musculoskeletal disorder that manifests itself via progressive and generalized loss of strength and muscle mass, compromising muscle quality and functional performance[4]. By the European Group on Sarcopenia definition, low muscle strength is the key parameter of sarcopenia, and the functional performance is used to categorize the severity of sarcopenia[4]. Previous studies have shown the association between the strength of the knee extensors[5-11] and flexors[6,11], ankle plantiflexors[1,12,13] and dorsiflexors[11], hip flexors[1,10] and abductors[7,10,14] with the ability to perform sit to stand[1,5-7,9,11-13], walking[5-10,12-14], keep postural balance[5,13], climb stairs[5,12,13] and reach tasks[6].

Although the association of muscle strength on functional performance has already been demonstrated[1,5,6-14], a dose-response relationship between the strength of each lower limb muscle group and the performance in daily life activities in older individuals, aiming at a time-efficient functional performance decline prevention, has not been well established. Most available studies did not evaluate muscular strength using the isokinetic dynamometer[5,6,8-11,13,14] (gold standard to assess muscle strength[1]) and have explored isolated muscle groups[5-14], which could not faithfully represent the functional tasks. Therefore, concomitant association of all the eight lower limb muscle groups with functional performance has yet to be determined.

In this context, it is necessary to systematically identify the key muscle groups involved in most activities of daily living and the absolute (or relative) contribution of each key muscle group to important tasks[7]. Studying this topic may help healthcare professionals to develop time-efficient strategies to preserve mobility and independence in older people[4], to take actions that could promote early sarcopenia detection and treatment[4], and encourage more research in this topic to prevent or delay adverse outcomes that also incur a heavy burden for patients and healthcare systems[4]. Thus, trying to give some help in this field, this study aimed to examine the association between isokinetic muscle strength of all the eight major lower limb muscle groups and functional performance in community-dwelling older adults.

## METHODOLOGY

This is a cross-sectional study.

Participants were recruited through flyers distributed in the community from October 2017 to July 2018. Eligibility criteria were individuals aged ≥60 years old, with an independent gait and without severe cardiorespiratory or neurological diseases and recent history of fractures or recent surgeries (<6 months) in the lower limbs, all assessed by a prior telephone call. Participants who presented risk of cognitive impairment (verified by the mini mental state examination – MMSE)[15], negative fatigue in some isokinetic muscle strength tests, extreme outliers or who eventually failed to perform the functional or strength tests were excluded. Figure 1 shows the flowchart of the recruitment process of the sample. All participants signed an informed consent form.

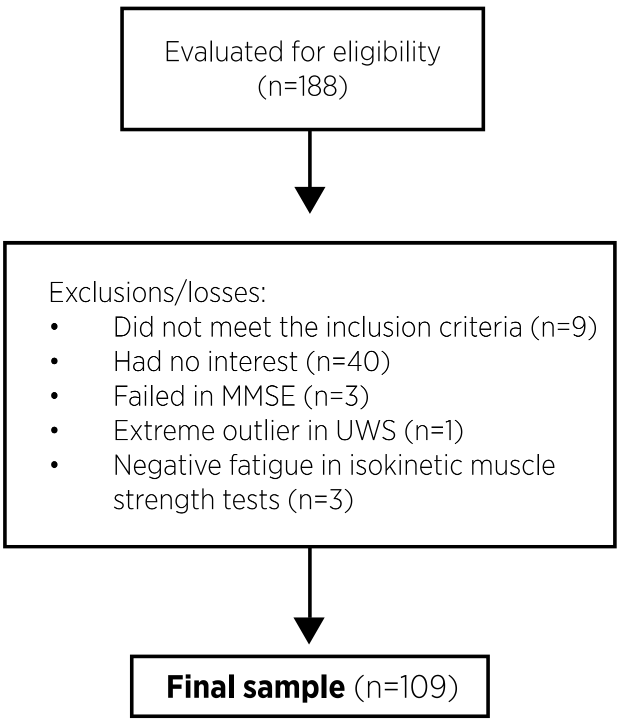


Figure 1. Flowchart of participants
MMSE: mini mental state examination; UWS: usual walking speed; STS: sit-to-stand test.

To characterize participants, data was recorded for age, gender, nutritional status, level of physical activity. Nutritional status was determined by body mass index (BMI), and classified according to Lipschitz[16]. To determine physical activity levels, participants were asked how many minutes per week they practiced moderate to vigorous exercise and were classified as active (≥150 minutes of activity per week) or sedentary[17].

Lower limb muscle strength of the extensors and flexors of the knee, the plantiflexors and dorsiflexors of the ankle, and the flexors, extensors, adductors and abductors of the hip was evaluated using the Biodex System 4 Pro® isokinetic dynamometer (Biodex Medical Systems Inc.), ICC=0.99 to 1.0[18]. Participants were instructed not to practice any physical exercise and not to drink energetic or alcoholic beverages within 24 hours prior to the laboratory visit. The equipment was calibrated according to the manufacturer's instructions before the start of each testing session.

Before assessment, a warm-up was performed on the cycle ergometer for 5 minutes. To familiarize participants with the procedures, attempts were performed with 3 submaximal repetitions at the same test speeds[1]. Evaluation order was randomized by drawing opaque envelopes containing the names of the joints. Measurements were only collected for the dominant limb (determined by the Waterloo questionnaire[19]), using concentric contractions, constant angular velocities and careful positioning (Figure 2). Participants were instructed to keep the knee extended during the hip flexion and extension tests. They were also instructed to keep the toes forward and to not flex the knee during hip abduction and adduction tests. The evaluation of muscle strength was performed at 120°/s or 180°/s (Figure 2). The strength index used in the analysis was the peak torque per body weight (Nm/Kg). During the tests, participants were verbally encouraged to produce their maximum torque and rested for 2 minutes between sets. The test was repeated only once if the fatigue index at 120°/s or 180°/s presented negative values.

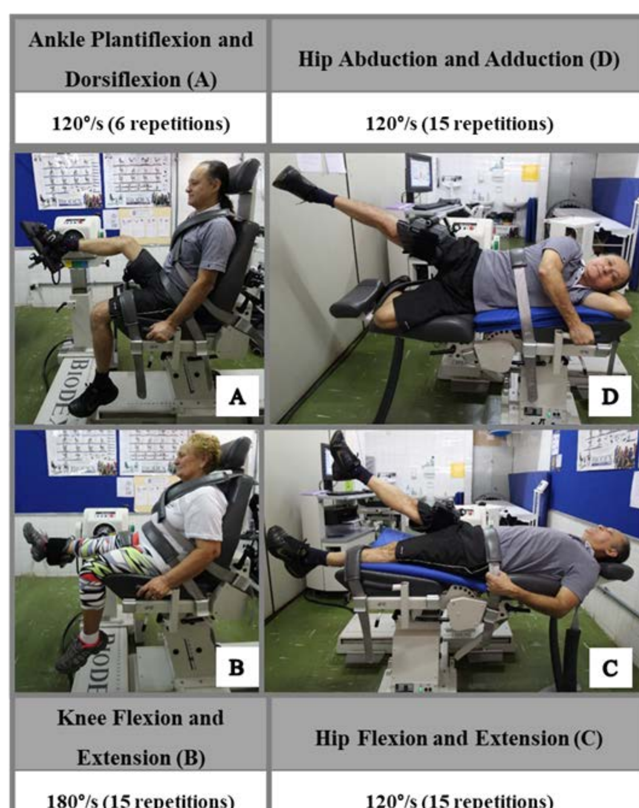


Figure 2. Parameters for evaluation of lower limb muscle strength

Functional performance was evaluated by usual walking speed test (UWS) and five times sit-to-stand test (STS).

To evaluate walking speed (ICC=0.97)[20], a 4 meters distance was delimited and the participants were instructed to walk at their usual speed. The time elapsed was recorded in 2 attempts, and the shortest time was considered for analyses. Usual Walking Speed (UWS) was calculated by dividing the distance covered in the test (4 meters) by the time recorded in the fastest attempt.

To evaluate the sit-to-stand performance (ICC=0.95)[3], participants were instructed to stand from the seated position in a standard chair (43cm) five times, with arms crossed over the chest, as quickly as possible. The time required to complete the five repetitions was recorded.

## Data analysis

Sample estimation was performed a priori for multiple linear regression analysis, following the recommendation of Field[21], in which a minimum sample size of 104+*k* is suggested to test the predictors individually, where *k* is the number of predictors inserted in the model. According to this estimation, a sample of 112 participants was suggested, since we would evaluate eight predictors in total.

Data analysis was performed in Statistical Package for Social Sciences (SPSS), version 22.0. Two multiple linear regression analyses were conducted to verify the strength of the eight muscle groups, which were associated with performance on UWS and STS tests. These two regressions were then adjusted for age, gender, BMI, and physical activity level. In all analyses, the enter method was used to identify significant associated factors. A 5% significance level was set. The models respected the postulates of a multiple linear regression: homogeneity, homoscedasticity, absence of collinearity and normality of residues.

The effect size ($R^2$) was classified according to Cohen[22], and considered less than 0.02 as very weak; from 0.02 to 0.13 as weak; from 0.13 to 0.26 as moderate; and 0.26 or greater as substantial. The statistical power was estimated in GPower version 3.1.

## RESULTS

Table 1 shows the main characteristics of the participants.

The multiple linear regression analyses showed that the strength of hip abductors predicted 31.3% of the variability for usual walking speed (p=0.011), and the strength of knee extensors' (p=0.015) predicted 31.6% of the variability for the STS (Table 2). The adjusted analysis revealed that age, gender, BMI and physical activity level were not significant on predicting usual walking speed and sit to stand time but increased the predictive value of the regression model ($R^2$=0.333 and $R^2$=0.334, respectively) (data not shown).

Table 1. Main sample characteristics (n=109)

| Characteristic | Value | Characteristic | Value |
|---|---|---|---|
| Age (years)[a] | 68.00 (64-74) | Sit-to-Stand (s)[a] | 10.03 (8.18-11.25) |
| Gender[b] | | Poor functional performance[b] | 14 (12.8) |
| Women | 68 (62.4) | Walking Speed (m/s)[c] | 1.00 (0.02) |
| Men | 41 (37.6) | Poor functional performance[b] | 7 (6.4) |
| **Nutritional status[b]** | | **Isokinetic Muscle Strength (Nm/Kg)** | |
| Underweight | 12 (11) | Ankle Plantiflexors[a] | 0.38 (0.29-0.47) |
| Eutrophy | 43 (39.4) | Ankle Dorsiflexors[c] | 0.23 (0.00) |
| Overweight | 54 (49.5) | Knee Flexors[c] | 0.56 (0.02) |
| **Physical Activity Level[b]** | | Knee Extensors[c] | 0.90 (0.02) |
| Active | 51 (46.8) | Hip Flexors[c] | 0.61 (0.02) |
| Sedentary | 58 (53.2) | Hip Extensors[a] | 0.75 (0.47-1.07) |
| | | Hip Abductors[c] | 0.79 (0.02) |
| | | Hip Adductors[c] | 0.69 (0.03) |

[a]Median (interquartile range 25%-75%), non-normally distributed data; [b]Frequency (percentage); [c]Mean (standard deviation), normally distributed data.

Table 2. Multiple Linear Regression Analyses (Enter Method) including Usual Walking Speed (m/s) and Sit-to-Stand time (s) as dependent variables and the isokinetic muscle strength (Nm/Kg) as independent variables. The association remained significant even when adjusted for confounding variables age, gender, body mass index and level of physical activity (n=109)

| Dependent Variable | Independent Variable | Unstandardized β | Individual Significance (p value) | 95% CI | | Power (Effect Size) |
|---|---|---|---|---|---|---|
| | | | | Lower | Upper | |
| $R^2$ ($R^2$adj)=0.313** (0.258) | | | | | | 0.999 (0.456)[1] |
| Usual Walking Speed | Ankle Plantiflexors | 0.002 | 0.285 | −0.001 | 0.005 | |
| | Ankle Dorsiflexors | −0.005 | 0.089 | −0.011 | 0.001 | |
| | Knee Extensors | 0.001 | 0.457 | −0.001 | 0.003 | |
| | Knee Flexors | 0.002 | 0.137 | −0.001 | 0.005 | |
| | Hip Flexors | −0.002 | 0.134 | −0.004 | 0.001 | |
| | Hip Extensors | −2.285E-05 | 0.963 | −0.001 | 0.001 | |
| | Hip Abductors | 0.003 | 0.011* | 0.001 | 0.006 | |
| | Hip Adductors | −3.535E-05 | 0.968 | −0.002 | 0.002 | |
| $R^2$ ($R^2$adj)=0.316** (0.261) | | | | | | 0.999 (0.462)[1] |
| Sit-to-Stand Test | Ankle Plantiflexors | −0.030 | 0.191 | −0.075 | 0.015 | |
| | Ankle Dorsiflexors | 0.019 | 0.662 | −0.068 | 0.106 | |
| | Knee Extensors | −0.037 | 0.015* | −0.067 | −0.007 | |
| | Knee Flexors | 0.027 | 0.233 | −0.018 | 0.073 | |
| | Hip Flexors | −0.010 | 0.548 | −0.044 | 0.023 | |
| | Hip Extensors | −0.005 | 0.537 | −0.019 | 0.010 | |
| | Hip Abductors | −0.015 | 0.420 | −0.053 | 0.022 | |
| | Hip Adductors | −0.003 | 0.831 | −0.029 | 0.023 | |

[1]Post Hoc analysis.
CI: confidence interval; β: partial regression coefficient; $R^2$: coefficient of determination.

## DISCUSSION

This study analyzed the association between the eight major lower limb muscles and the functional performance in walking and sit-to-stand tasks among community-dwelling older adults. The salient findings indicated that there was an association of more than 30% between the muscle strength of the hip abductors and the usual walking speed, and the strength of the knee extensor muscles and the sit to stand performance in the study participants. The results indicate a preliminary dose-response relationship between the strength of these key muscle groups and the performance in walking and rising from a chair.

The results of this study showed that the isokinetic strength of the knee extensor muscles was substantially[22] associated ($R^2$=0.316) with the sit-to-stand time. This association had already been demonstrated in previous studies, with a contribution of 12%[9] to 16.5%[11] of this muscles, however these studies had only evaluated the knee joint[9] or had included a maximum of three muscle groups in the analysis[11]. As other studies had found different results, demonstrating that plantiflexors (β=−0.450, p=0.014)[1] and dorsiflexors[1], hip flexors (β=−0.337, p=0.045)[11] and knee flexors[6,11] also explained 20 to 29% of the variability in the five sit-to-stand test, there was still doubt about which muscles would have the greatest contribution to this task. In fact, as it is a complex task, the activity of rising from a chair involves all lower limb muscles, as well as other parameters in addition to muscle strength. However, the contribution of 31.6% of the knee extensors in this task highlights that this can be the key muscle group in the performance of this task.

Our findings also indicated that hip abductor strength is substantially associated[22] ($R^2$=0.313) with the usual walking speed. The importance of the hip abductor muscle strength in the variability of community-dwelling older adults gait speed had also been indicated in previous studies (12.9%[14] to 18%[10]) that included in the analysis a maximum of five muscle groups. However, unlike our study, the muscle strength of ankle plantiflexors[12,13], knee extensors[5,6,8-10] and hip flexors[10] had also been associated with walking speed in community-dwelling older adults, explaining 7%[8] to 14%[9] from variability in the walking test when analyzed by hand-held dynamometer[6,10,13], isokinetic dynamometer[12], or spring gauge[5,8,9]. Walking speed is also a complex and multifactorial task that requires the contribution of all lower limb muscles. However, the important role of the hip abductor muscles during the single-limb support phase of gait, when these muscles generate frontal plane stability of the hip, avoiding the contralateral pelvis drop[23-25] corroborates the finding that 31.3% of the performance of this function is due to the strength of the hip abductor muscles, indicating that this could be the key muscle group for walking.

To the best of our knowledge, this is the first study that analyzed the association of the isokinetic strength of the eight major muscle groups of the lower limbs with the functional performance of the older adults. This is the main strength of our study and perhaps this is one of the factors that justifies the divergence of our results to those of the literature. However, this study shows some limitations that could affect interpretation of the results. Firstly, as a cross-sectional study, the relationship detected between muscle strength and functional performance do not reflect causal relationship, but it can provide an explanation of older adults' performance and indicate targets for potential interventions and topics for future longitudinal research. Furthermore, despite the sample being mostly composed of individuals with sedentary lifestyles and with overweight, most participants also presented good functional performance, not allowing extrapolation the findings for impaired older people. This relationship will probably have greater magnitude in most impaired older individuals, with greater functional loss associated with muscle weakness; however, this is purely speculative. Future research should study whether this relationship is also observed in weak, functionally incapable, sarcopenic and severe sarcopenic older people.

In conclusion, despite the limitations, we demonstrated that hip abductors and knee extensors could be the key muscle groups involved in two of the most common activities of daily living. Thus, this study results may assist in designing time-efficient prevention and intervention strategies toward maintaining or improving walking and sit to stand ability in older people, minimizing the development of functional disabilities, sarcopenia and severe sarcopenia. The adherence of healthy older adults to exercise programs can be a challenge, with prescribed exercise duration being the strongest determinant of adherence in this population[26]. Therefore, reducing the training time needed by focusing on the key muscles for these functional tasks could be a valid strategy. In this sense, further studies should assess whether intervention programs that include resistance training for hip abductor and knee extensor muscles cause clinically significant increases in walking speed and sit-to-stand performance in community-dwelling older adults.

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