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# Relationship between functional capacity assessed by walking test and respiratory and lower limb muscle function in community-dwelling elders

## Relação da função muscular respiratória e de membros inferiores de idosos comunitários com a capacidade funcional avaliada por teste de caminhada

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### Abstract

**Background:** Sarcopenia is the most significant factor in the decline of peripheral and respiratory muscle strength. It can lead to progressive disability, loss of independence and impaired functional capacity. **Objectives:** To determine the strength of respiratory muscles (maximal inspiratory pressure – MIP and maximal expiratory pressure – MEP) and lower limb muscles, and to explore the possible relationships between these variables and the functional capacity of the elderly. **Methods:** Sixty-five elderly patients (71.7±4.9 years old) took part in the study. Isokinetic dynamometry was used to assess the knee flexors and extensors, an analog vacuum manometer was used to assess the respiratory muscles, and the six-minute walking test was used as an outcome of functional capacity. The Mann-Whitney test and Student's t-test were used for gender comparison. The relationships were investigated using Pearson's correlation. The significance level was $p<0.05$. **Results:** The lower limb and respiratory muscle strength variables and the walking distance variables were higher in men than women ($p<0.05$). Moderate and significant correlations were found between these variables ($p<0.001$). The higher values were between right knee extensor average peak torque (APT) and MIP ($r=0.587$), left knee flexor APT and MEP ($r=0.638$), as well as between walking distance and left knee extensor average power (AP; $r=0.614$), right knee flexor AP ($r=0.539$), MIP ($r=0.508$) and MEP ($r=0.541$) respectively. **Conclusions:** The relationship between walking distance and respiratory and lower limb muscle strength found in this study suggests that optimizing these functions may contribute to maintaining and improving functional capacity in the elderly.

**Key words:** elderly; muscle strength; physical fitness.

### Resumo

**Contextualização:** A sarcopenia é considerada o fator mais significativo na redução da força muscular periférica e respiratória e pode ocasionar incapacidades progressivas, perda de independência e interferir na capacidade funcional dos idosos. **Objetivos:** Caracterizar a força dos músculos respiratórios (pressão inspiratória máxima – PImax e pressão expiratória máxima – PEmax) e de membros inferiores (MMII), bem como as possíveis correlações existentes com a capacidade funcional dos idosos. **Métodos:** Sessenta e cinco idosos, com 71,7±4,9 anos; foram avaliados por dinamometria isocinética para flexores e extensores dos joelhos, manovacuometria analógica para os músculos respiratórios pelo teste de caminhada de 6 minutos para capacidade funcional. Foram utilizados os testes *Mann-Whitney* e *t* de *Student* para comparação entre os gêneros. As correlações foram calculadas pelo coeficiente de correlação de *Pearson*. Para todos os testes foi considerado $p<0,05$. **Resultados:** As variáveis isocinéticas, de força respiratória e distância caminhada apresentaram valores médios maiores para os homens em relação às mulheres ($p<0,05$). Foram encontradas correlações moderadas e significativas entre essas variáveis ($p<0,001$), sendo as de maior valor entre a média do pico de torque (MPT) extensor direito e PImax ($r=0,587$), MPT flexor esquerdo e PEmax ($r=0,638$), assim como da distância caminhada com a potência média extensora esquerda ($r=0,614$) e flexora direita ($r=0,539$) e com PImax ($r=0,508$) e PEmax ($r=0,541$). **Conclusões:** A associação entre força muscular respiratória e de MMII com a distância caminhada encontrada neste estudo sugere que a otimização dessas funções pode contribuir para manter e/ou melhorar a capacidade funcional da população idosa.

**Palavras-chave:** idoso; força muscular; aptidão física.

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# Introduction

One of the consequences of the aging process is the decline in strength of the skeletal and respiratory muscles[1], which can hinder the functional capacity and performance of activities of daily living (ADLs) in the elderly[2,3]. This reduction in muscle mass and strength, known as sarcopenia, happens even in healthy elders[4], and it is considered the most significant factor of loss of independence and function in this age group[2,4]. It is well known that regular physical activity can slow this process, and resistance exercises are considered an effective intervention[2,5]. However, further studies are still necessary to identify the variables that affect exercise capacity in this population.

Previous studies have addressed the aspects related to aging and functional changes and, regarding musculoskeletal performance, they noted the reduction in strength in the respiratory[1,6-12] and lower limb (LL)[2,13-15] muscles. A study conducted in 1999 by Neder et al.[6] assessed the maximal respiratory pressures (maximal inspiratory pressure – MIP and maximal expiratory pressure – MEP) and the muscle strength of the knee extensors of Brazilian individuals aged 20 to 80 years, and it found a significant association between these two variables ($p<0.001$). In another study, these authors also assessed the strength and power of the knee flexors and extensors of non-athletes from the same age group and found significant relationships between the studied variables, i.e. gender, age, height, and lean mass ($p<0.001$)[13]. Vasconcellos et al.[7] evaluated MIP, MEP and functional capacity through the distance covered in the six-minute walking test (6MWT) in sedentary elderly women. The results showed a significant and positive correlation ($r=0.45$; $p=0.005$) between the walking distance and the inspiratory muscle strength.

Prevention and rehabilitation programs play an important role in the maintenance or restoration of the physical capacity of elders[4,5]. Therefore, the assessment of the muscle function of elders and its relationship with functional capacity may help to identify more effective therapeutic approaches. Some studies have provided values related to the respiratory muscle strength[6,7,16] and LL muscle strength[6,13,17] of Brazilian elders, but they did not assess the relationship between the 6MWT and LL muscle function. Thus, the objectives of the present study were to assess the strength of the respiratory and the knee flexor and extensor muscles, the walking distance in the 6MWT, and the relationships between the physical parameters of these muscles and the functional capacity of community-dwelling elders.

# Methods

This is an observational cross-sectional study developed in the laboratories of the Department of Physical Therapy of Universidade Federal de Minas Gerais (UFMG) and approved by the Research Ethics Committee of UFMG, under protocol no. 410/06.

## Participants

The sample size was calculated based on a pilot study with 20 participants of both genders, which investigated the correlation between the variables: average peak torque (APT) in Newton-meters (Nm) and the average power (AP) in watts (W) of the knee flexors and extensors, MIP and MEP in $cmH_2O$ and the walking distance in meters (m). Considering a level of significance of 5% and a level of power of 90%, the sample size was estimated to be a minimum of 51 participants. Sixty-eight community-dwelling elders (46 women and 22 men) were selected by convenience and assessed. To be included in this study, the participants had to be 65 years old or more. The exclusion criteria were: difficulty to comprehend and execute the procedures correctly according to the Mini-Mental State Exam (MMSE) scores[18]; a body mass index (BMI) >30 $Kg/m^2$; significant changes in blood pressure (BP), heart rate (HR) or peripheral oxygen saturation ($SpO_2$) before, during or after the measurements; the presence of acute orthopedic or rheumatologic symptoms before or during the measurements; smoking; uncontrolled diabetes mellitus; cardiac, respiratory or neuromuscular diseases and the use of medication that could interfere with the studied variables.

## Assessment procedures

The participants signed an informed consent form and filled out the clinical and sociodemographic questionnaires. Their cognitive state was assessed by the MMSE[18], and their level of functional activity by the Human Activity Profile (HAP) through the adjusted activity score (AAS)[19]. After these procedures, anthropometric measurements were taken: respiratory muscle strength by the analogical vacuum manometer Gerar® Class B, with operational interval of ±300 $cmH_2O$; walking distance through the 6MWT; and LL muscle function through the isokinetic dynamometer Biodex System 3 Pro®. The assessments were performed by the same examiner, always in this same order, on the same day, with intervals of at least 5 minutes between tests. For safety reasons, the participants were monitored at the beginning and at the end of each procedure for the following cardiorespiratory variables: BP, HR, $SpO_2$ and the perceived exertion through the Modified Borg Scale.

## Measurement protocols

The MIP and MEP measurements were based on the American Thoracic Society/European Respiratory Society

(ATS/ERS)[20] guidelines and on the protocol by Souza[21]. The participant sat upright and performed two maneuvers for familiarization and learning. The position reached at the end of the maximal efforts was maintained for at least one second in order to characterize the plateau pressure[6]. Five maneuvers were executed, and three were considered acceptable, including at least two reproducible maneuvers with values that differed from the highest value by less than 10%. There was a rest interval of one minute between maneuvers.

The 6MWT was executed according to the guidelines established by Steele[22] and by the ATS[23]. The following equipment was used: a digital chronometer (Sport Timer®); a tape measure; a pulse oximeter (model 1001 J G Moriya®); a heart monitor (Polar S 810™), a sphygmomanometer (Diasyst®) and a stethoscope (Duo-Sonic-BD®). The test was conducted in a 34-meter level corridor at room temperature and with minimal traffic. The participant performed one practice test to become familiar with the circuit. Standard phrases of encouragement were given every two minutes. The longest distance covered by the participant at the end of the six minutes was recorded.

Before measuring the muscle performance, the knee flexors and extensors of both limbs were passively stretched, and the participant performed the 6MWT as a warm-up. The participant then sat on the dynamometer chair with the backrest at 85°. The rotational axes of the knee and the equipment were aligned, and the participant was stabilized with straps. The tests were performed with gravity correction according to the manufacturer's recommendation of 5° of knee flexion. The total range of motion (ROM) was limited to 85º starting from the angle of 90º of knee flexion. Before the test, three submaximal repetitions were performed for familiarization. The participant performed five, ten and fifteen reciprocal concentric contractions of knee flexion-extension, bilaterally, at 60º/s, 120º/s and 180º/s, respectively, with a rest period of 90 seconds between series[17]. During the assessment, the participants were verbally encouraged to move the dynamometer lever with as much speed and strength as possible to produce maximal torque[13,17]. Because strength and power are best assessed at low (60º/s) and high (180º/s)[13] velocities, respectively, the velocity of 120º/s was used in the protocol to avoid an abrupt change in velocities and to optimize the performance of the elderly participants. Thus, the values obtained for this intermediate velocity were not analyzed.

For the relationship analysis, the LL and the respiratory muscle groups, the average peak torque (APT) was used because this variable better represents strength. For the relationship analysis with the walking distance, the average power (AP) was used because it is related to the muscle endurance needed for the activity[24].

## Statistical aspects

The Kolmogorov-Smirnov test was used to verify the normality of data distribution. Descriptive analyses were performed to characterize the sample and to analyze the study variables. To compare the mean values between the different genders, Student's t test was used when data distribution was normal, and the Mann-Whitney test, when the distribution was not normal. To verify the relationship between the variables, Pearson's correlation coefficient was used. A significance level of $p<0.05$ was adopted for all tests.

# Results

Three elders (one woman and two men) were excluded because they did not meet the criteria for reproducibility of the measures of isokinetic muscle performance. Thus, the final sample was composed of 65 elders, with a mean age of 71.7±4.9 years, including 45 women (69.23%) and 20 men (30.77%). According to the sample calculation (n=51), the loss of three participants did not affect the power of the present study.

Table 1 shows the anthropometric, sociodemographic and clinical data of the sample, described as mean and standard deviation. When analyzed according to gender, the variables showed higher values among men, with $p<0.05$, except the BMI and MMSE results. Considering the adjusted activity score from the HAP questionnaire, 30 elders were classified as active (46.2%) and 35 as moderately active (53.8%).

All analyses indicated moderate correlations with statistical significance ($p<0.001$) between the function of the LL muscles and the respiratory muscles, and between these functions and the walking distance. The correlations between the flexor and extensor APT at 60º/s and the MIP and MEP were: right flexor APT (r=0.527 for MIP and r=0.639 for MEP), left flexor APT (r=0.556 for MIP and r=0.638 for MEP), right extensor APT (r=0.587 for MIP and r=0.565 for MEP) and left extensor APT (r=0.543 for MIP and r=0.572 for MEP). The correlations between the walking distance and the flexor and extensor AP at 180º/s, and with the MIP and MEP are shown in Figure 1.

# Discussion

The results of the present study showed positive and significant correlations between the function of the respiratory and LL muscles and between the physical parameters of these muscles and the functional capacity of elders. Previous studies found a correlation between the strength of the respiratory muscles (MIP and MEP) and the peripheral muscles[6,8] and between the

**Table 1.** Anthropometric, demographic and clinical data (mean±standard deviation) of 65 participants according to gender (45 women and 20 men).

| Variables | Total (n=65) | Women (n=45) | Men (n=20) | p Value |
|---|---|---|---|---|
| Height (m) | 1.57± 0.09 | 1.54± 0.06 | 1.65± 0.06 | <0.001* |
| Weight (kg) | 64.9±9.1 | 62.2± 7.6 | 71.2± 9.1 | <0.001* |
| BMI (Kg/m$^2$) | 26± 2.7 | 26.2± 2.9 | 25.7± 1.9 | 0.409 |
| MMSE | 25.8± 3.0 | 25.5± 3.4 | 26.5± 2.1 | 0.353 |
| HAP (AAS) | 73.6± 7.1 | 71.6± 6.9 | 78.1± 5.2 | <0.001* |
| MIP (cm$H_2O$) | 96.5± 18.9 | 89.8± 14.5 | 111.8± 19.3 | <0.001* |
| MEP (cm$H_2O$) | 110.5± 34.4 | 96.0± 19.7 | 143.0± 38.3 | <0.001* [a] |
| R flex APT 60°/s(Nm) | 38.98±12.71 | 34.32±8.15 | 49.48±14.93 | <0.001* |
| L flex APT 60°/s (Nm) | 39.47± 12.23 | 34.77±8.67 | 50.03±12.64 | <0.001* |
| R ext APT 60°/s (Nm) | 84.44± 24.77 | 74.40±18.80 | 107.03±21.76 | <0.001* |
| L ext APT 60°/s (Nm) | 88.38± 24.65 | 77.86±17.34 | 112.04±22.34 | <0.001* |
| R flex AP 180°/s (W) | 34.12± 14.36 | 29.75±8.99 | 43.95±19.00 | <0.001* |
| L flex AP 180°/s (W) | 31.38± 14.50 | 26.34±10.00 | 42.73±16.75 | <0.001* |
| R ext AP 180°/s (W) | 75.4± 24.39 | 63.89±15.03 | 101.32±21.46 | <0.001* |
| L ext AP 180°/s (W) | 78.93± 22.69 | 68.77±15.58 | 101.78±20.73 | <0.001* |
| 6MWT (m) | 493.3±67.4 | 475.2± 62.1 | 534.2± 61.6 | <0.001* |

[a] Mann-Whitney statistical test. For all other comparisons, Student's t-test was used.

* Statistical difference between genders (p<0.05). BMI=body mass index; MMSE=Mini-Mental State Examination; HAP (AAS)=adjusted activity score of Human Activity Profile; MIP=maximal inspiratory pressure; MEP=maximal expiratory pressure; R=right; L=left; flex=flexor; ext=extensor; APT=average peak torque; 6MWT=walking distance in the six-minute walking test.

inspiratory force and the walking distance[7] in elders, corroborating the results of the present study. At present, however, no studies have performed these three analyses of correlation.

In the study by Neder et al.[6], the age range of the studied population was very wide (20 to 80 years), and from a total of 100 participants, only 37 were elders. In contrast, the present study's sample (n=65) was composed exclusively of elders. The authors[6] assessed the extensor torque of the dominant knee, the maximal respiratory pressures and the maximal oxygen uptake ($VO_{2max}$) assessed through a test of incremental effort and found a significant positive linear association between these variables, irrespective of gender or age. In this study, this association may have been favored because only the dominant limb was evaluated. In contrast, the present assessed both the knees to perform the correlation analysis between the two isokinetic variables (APT and AP), MIP and MEP and the walking distance. Therefore, all correlations were significant, even with the functional capacity being evaluated by the 6MWT. According to Steele[22], walking tests and endurance tests have characteristics in common. Additionally, the literature describes a good correlation between the 6MWT and the $VO_{2max}$ [22,23,25,26].

Another study that showed significant correlations between respiratory and peripheral strength was conducted by Enright et al.[8], in which 4443 elders were evaluated to determine the reference values for MIP and MEP. The variable for peripheral strength was hand grip measured by the JAMAR dynamometer. Among the predictive factors of MIP, the following were found to be positive: male gender, hand grip strength and higher lean body mass. The negative factors were advanced age, low stature and smoking. As in the present study, the exclusive inclusion of the elder population gives higher specificity to the results.

In the present study, the mean values obtained, in cm$H_2O$, were higher than those observed by Vasconcellos et al.[7] for the MIP (89.8±14.5 x 55.6±21.0) and MEP (96.0±19.7 x 71.3±22.0) of older women. The correlation observed between MIP and the walking distance (r=0.508; p<0.001) was higher than the one found in this study[7], which may be related to the fact that the sample consisted only of sedentary women (n=39). The present study included participants of both genders (45 women and 20 men), classified by the HAP as active or moderately active.

The male gender is one of the positive predictors of respiratory muscle strength[6,8] and that of other skeletal muscles[8,13]. Because of their greater muscle strength, men are expected to have better functional performance than women. This was confirmed because, when the genders were compared, the male elders had higher mean values for all the variables, confirming the previous results from the literature for MIP and MEP[6,8-11], for knee flexor and extensor strength[6,13-15,17,] and for walking distance[27,28]. Tolep et al.[12] found evidence that the muscle changes associated with the aging process affect respiratory muscle function, with a significant reduction of about 25% in the diaphragm strength of elders compared to young adults, which may predispose them to respiratory fatigue during the exercise. Enright et al.[8] found reductions in MIP and MEP ranging from 0.8 to 2.7 cm$H_2O$ per year in elders starting at age 65, especially men. In contrast, Carpenter et al.[11] demonstrated

a reduction in MIP of 0.93 $cmH_2O$ per year in women and 1.2 $cmH_2O$ in men starting at age 47.

Considering the isokinetic variables, studies on elders often measure peak torque to express "strength"[6,13,14,17]. However, mean peak torque can be a more appropriate indicator of the maximal performance of a certain muscle group. There is also a strong correlation (frequently higher than 0.90) between peak torque and average peak torque[24]. For this reason, in the present study, the average peak torque was used as a variable. The lower APT and AP of the knee flexors and extensors of women compared to men is in accordance with previous studies[13-15]. Katsiaras et al.[14] and Taaffe et al.[15] showed that, despite a gender difference, there are no differences according to the ethnicity. Neder et al.[13] classified their sample according to ethnic background and found no differences.

For the walking distance assessed by the 6MWT, there was a significant difference between genders because the men covered a greater average distance. In 2004, a similar result was also found in another Brazilian study by Soares et al.[27]. From the functional point of view, this test is widely used to assess the physical fitness and exercise capacity of individuals with poor physical condition, heart disease or advanced age[22,26-29]. Pires et al.[28] recently used the 6MWT in participants of both genders aged 18 to 80 years to assess the walking distance and investigate its relationship with the age groups. The results demonstrated strong and significant correlations between the 6MWT and the age groups, and the older participants (>60 year) walked the shortest distance. The authors concluded that the 6MWT is reproducible and sensitive to evaluate the functional capacity and

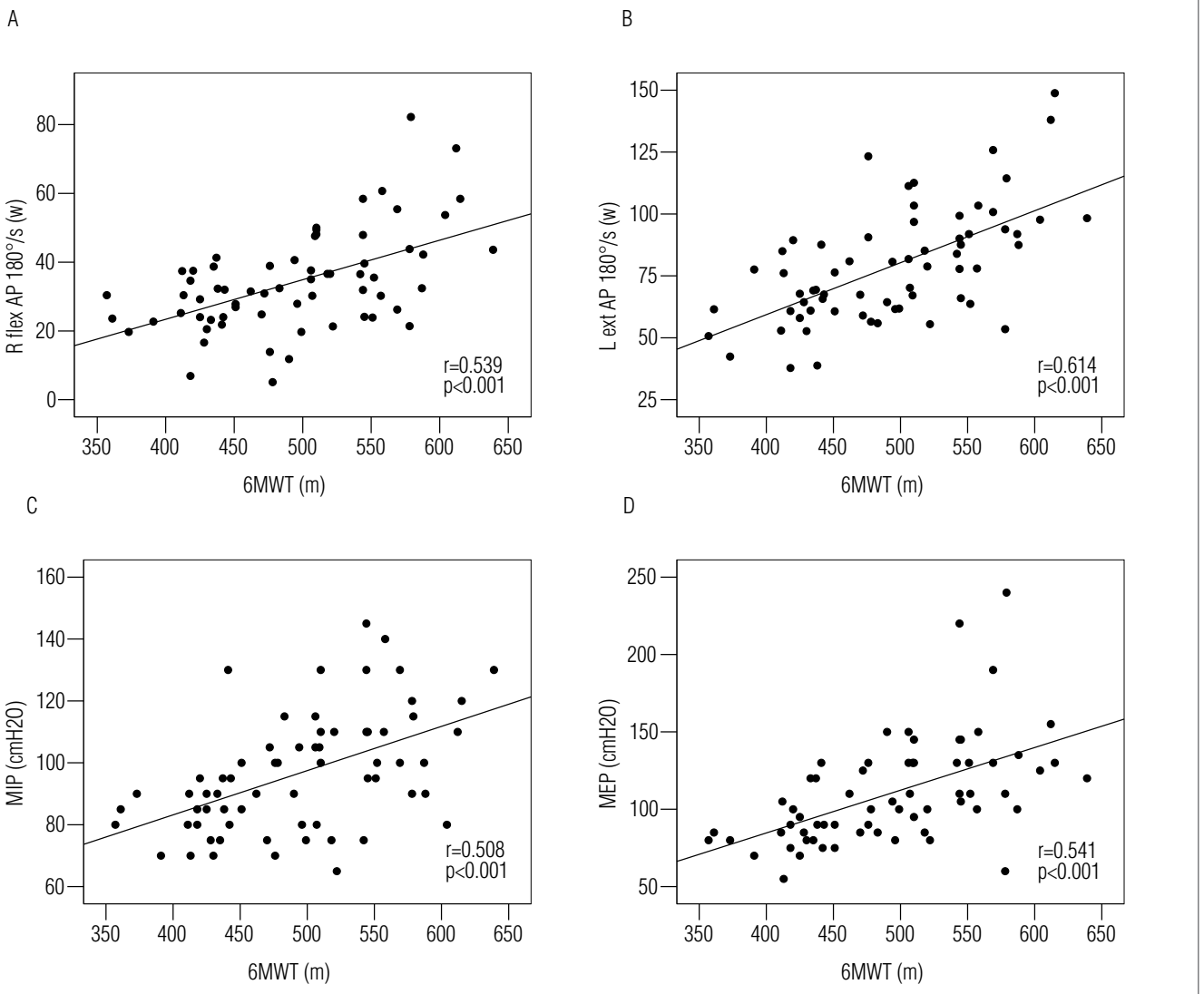


**Figure 1.** Correlation diagrams between walking distance (m) in the six-minute walking test (6MWT) and A-right knee flexor average power (R flex AP) at 180°/s (W); B-left knee extensor average power (L ext AP) at 180°/s (W); C-maximal inspiratory pressure (MIP $cmH_2O$); D-maximal expiratory pressure (MEP $cmH_2O$).

performance of participants from different age groups[28]. In fact, the 6MWT is considered a favorable instrument to assess the physical and functional capacity of elders because it is low-cost and easy-to-use. The test is also well tolerated because it is submaximal, and it has been considered more adequate than the maximal tests to reflect individual ability in ADLs[23,25-28].

Although some studies[6,8,13] corroborate the present study results, it is important to note some methodological differences such as the selection process, the sample size and the use of different assessment techniques[16,30]. The fact that the selection was not random and the absence of evaluation of respiratory function through spirometry[30] can be considered limitations. However, the composition of the sample exclusively by elders, as in the study by Enright et al.[8], reinforces the specificity of this study. The equipment use for assessment also has inherent manufacturing characteristics that can produce varying results. Regarding LL muscle strength, the studies by Neder et al.[6,13] used the Cybex 6000 dynamometer, with very similar protocols. In relation to the evaluation of respiratory muscle strength, all four studies used similar protocols, although Enright et al.[8] did not specify the type of instrument used to assess MIP and MEP.

## Conclusions

The present study found positive and moderate correlations between the function of the respiratory muscles and the LL muscles, and between the function of these muscles and functional capacity. This association suggests that the optimization of these functions should be included in prevention and rehabilitation programs, including the training of respiratory muscles to maintain and/or improve the functional capacity of the elderly population, thus contributing to minimize the impact of the aging process.

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