RESPIRATORY FUNCTION AND MUSCULAR CAPACITY IN OLD ADULTS: THE AGA@4LIFE PROJECT

Padrão ventilatório e capacidade muscular em idosos: projeto AGA@4life

Daniel Alexandre Dias Pedroso[a], Telmo Pereira[a], Jorge Conde[a]

ABSTRACT

INTRODUCTION: Age-related muscle changes, translated into a decrease both in muscle imass and functionality, are determinants of a decrease in strength and resistance to exercise in older adults. **OBJECTIVE:** To correlate the loss of muscle mass and functionality with the respiratory function in older adults. **METHODS:** Cross-sectional study including 18 volunteers with age above 65 years (13 women and 5 men) included in the AGA@4life Project. All participants performed functional respiratory tests with an Flowhandy ZAN 100 spirometer, and handgrip strength was assessed with an appropriate dynamometer. Nutritional profile was assessed and body composition was evaluated via bioimpedance. **RESULTS:** There was a significant association between the percentage of lean mass and several spirometric parameters, namely the FEV1, FVC, PEF25, PEF50, PEF25/75 and PEF. Significant associations were also found with the self-efficacy for exercise and the same respiratory parameters. A significant and positive correlation was observed between the percentage of lean mass and handgrip strength. **CONCLUSIONS:** The results show an association between respiratory function and functional and clinical parameters characteristic of sarcopenia, suggesting common pathophysiological mechanisms in the limitation observed with the worsening of these parameters.
KEYWORDS: sarcopenia; pulmonary ventilation; body composition; hand strength; aging.

RESUMO

INTRODUÇÃO: As alterações musculares que acompanham o envelhecimento, traduzidas numa diminuição quer na massa quer na capacidade de trabalho da musculatura, condicionam diminuições na força e resistência ao esforço no idoso. **OBJETIVO:** Correlacionar a perda de capacidade de trabalho muscular com as possíveis alterações ventilatórias derivadas dessa perda em idosos. **MÉTODOS:** Estudo transversal com 18 adultos voluntários com idade superior a 65 anos (13 do sexo feminino e cinco do sexo masculino), incluídos no Projeto AGA@4life. Todos os participantes realizaram provas funcionais respiratórias com espirômetro Flowhandy ZAN 100, e foi-lhes avaliada a força de preensão com um dinamômetro apropriado. Avaliaram-se ainda a composição corporal por bioimpedância e o perfil nutricional. **RESULTADOS:** Observou-se associação significativa entre a percentagem de massa magra e diversos parâmetros espirométricos, nomeadamente o volume expiratório máximo no primeiro segundo (VEMS), a capacidade vital forçada (CVF), o débito expiratório máximo a 25% da CVF (DEM25), o débito expiratório máximo a 50% da CVF (DEM50), o débito expiratório máximo entre 25 e 75% da capacidade vital forçada (DEM25/75) e o débito expiratório máximo (PEF). Também, a autoeficácia no exercício se associou significativamente com VEMS, CVF, DEM25, DEM50, DEM75 e DEM25/75 e PEF. Constatou-se ainda correlação significativa e positiva da percentagem de massa magra com a força de preensão. **CONCLUSÕES:** Os resultados demonstram associação entre a função ventilatória e parâmetros funcionais e clínicos característicos da sarcopenia, sugerindo a partilha de mecanismos fisiopatológicos na limitação observada com o agravamento desses parâmetros.
PALAVRAS-CHAVE: sarcopenia; ventilação pulmonar; composição corporal; força da mão; envelhecimento.

[a]Instituto Politécnico de Coimbra, Escola Superior de Tecnologia da Saúde de Coimbra – Coimbra, Portugal.

Correspoding data:
Telmo Pereira – Instituto Politécnico de Coimbra, Escola Superior de Tecnologia da Saúde de Coimbra – Rua 5 de Outubro – SM Bispo, Apartado 7006 – CEP: 3046-854 – Coimbra, Portugal. E-mail: telmo@estescoimbra.pt
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INTRODUCTION

Sarcopenia is a condition that leads to loss of strength and function of the musculoskeletal system.[1,2] It is a disease that usually begins to manifest around 30/40 years of age and, after the first manifestation, maintains a partially regular evolutionary pace with regard to the loss of muscle function.[3] It can therefore be considered that sarcopenia is intrinsically linked with aging and tends to worsen with advancing age. It is also noteworthy that the problem manifests itself in older adults with comorbidities and pulmonary pathology as well as in healthy older adults without any major health problems.[4]

Its mechanism of action is loss of type II nerve fibers, increase of type I muscle fibers, loss of motor units, neuromuscular changes and increase in fat mass between muscle fibers.[5] Due to the morbidities and disability caused by the disease, sarcopenia affects the individual not only at the physical level, but also at the social and economic levels, by compromising the autonomy to perform daily activities, and also to the execution of more physically demanding labors.[6]

According to the European Working Group on Sarcopenia in Older People,[7] sarcopenia translates into decreased muscle mass coupled with loss of muscle function and performance (at least 2 of the 3 previously mentioned criteria), and is classified in line with lean mass threshold, grip strength and walking speed. This allows sarcopenia to be divided into 3 groups: pre-sarcopenia (decreased muscle mass without loss of strength or function), sarcopenia (decreased muscle mass and loss of strength or function) and severe sarcopenia (decreased mass, strength and muscle function).[2,3,7,8] This condition affects up to 45% of older adults, a number that is expected to double in the next 25 years.[6]

Considering the link described above, it is possible to identify a number of aging-related factors that contribute to the worsening of sarcopenia as a pathological condition: myocyte cell dysfunction, loss of alpha motor neurons, reduced body production of anabolic hormones, oxidative stress and consequent accumulation of free radicals, as well as physical inactivity and loss of quality with respect to eating habits.[2]

Manifesting in the loss of muscle function, an individual diagnosed with sarcopenia will inevitably begin to feel less physical availability and resistance to fatigue, along with slower walking, becoming a more sedentary and inactive person, as mentioned. This inactivity translates into an increase in fat mass and loss of lean mass, which allows the person to acquire other types of pathologies characteristic of physical inactivity, namely metabolic, cardiovascular and / or loss of bone density. These, in turn, can lead to conditions such as diabetes, atherosclerosis, or osteoporosis.[9] In addition to loss of strength in the limbs, fatigue and low physical endurance, these diseases are also influenced by the loss of strength of the respiratory muscles, which, once affected, compromise the individual's ventilation and, consequently, aerobic resistance to exercise.[2,10]

In interpreting the effects of sarcopenia, it is assumed that the respiratory muscles are also affected. Since the condition tends to cause loss of muscle strength, it is expected that the individual will have difficulty ventilating and making rapid, deep inhalations and exhalations, considerably decreasing the volume of air they mobilize in the lungs. As a result, their physical capacity and resistance to exertion are reduced even in low levels of intensity.[10] On the other hand; the reversal of this situation may have a positive impact on better respiratory performance. There are currently several strategies aimed at mitigating the impact of sarcopenia, including adapted physical exercise and the adoption of an adequate, preferably protein-rich diet, to promote muscle protein synthesis and decrease muscle degradation.[11]

The aim of this study was to verify the association between clinical and functional indicators of sarcopenia and respiratory function in older adults by correlation analysis with the percentage of lean mass and physical and muscular capacity in a cohort of older adults included in the AGA@4life Project.

METHODS

Study design, population and ethics

A cross-sectional study was conducted with older adults participants of the AGA@4life Project, which takes place at a private social solidarity institution in the region of Coimbra, the Association for the Defense of the Elderly and the Child (ADIC), whose target population is users of the respective day care center. Individuals older than 65 years of age, with no clinical history of cardiovascular, neurological or cognitive deficits, who consented to participate in the project entirely voluntarily were invited to participate in this study, thus totaling 18 individuals (5 men and 13 women), aged between 65 and 93 years.

The study was conducted in compliance with the recommendations of the Declaration of Helsinki and approved by the Research Ethics Committee of the Polytechnic of Coimbra. Anonymity and confidentiality of the data collected were guaranteed. The study has strictly scientific objectives and there are no conflicts of interest to declare. All participants signed an informed consent.

General procedure

For data collection, participants who met the inclusion criteria were submitted to a previously defined evaluation protocol. All evaluations took place in the morning, in a space with adequate conditions of temperature, humidity, luminosity and loudness. A structured questionnaire was used to collect sociodemographic and clinical information including gender, age, education, profession, smoking habits, alcohol habits, comorbidities, personal and family history, ongoing therapy and household characterization.

Respiratory functional parameters were assessed with a spirometer (Flowhandy ZAN 100), in accordance with the recommendations established by the standards of the American Thoracic Society / European Respiratory Society (ATS/ERS).[12,13] Spirometries were performed with the participant seated with the back straight against the chair, the neck slightly extended and the nose covered with tweezers. The maneuver began with 3 tidal volume cycles, followed by a forced maximum inhalation and then a forced maximum expiration. The maneuver was performed until 3 reproducible and 2 acceptable curves were obtained (not varying by more than 10%), up to a maximum of 8 repetitions. The parameters considered for analysis were the values of mobilizable volumes, namely forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1), Tiffeneau index (TI), peak expiratory flow (PEF), maximal expiratory rate at 25% FVC (PEF25), maximal expiratory rate at 50% FVC (PEF50), maximal expiratory rate at 75% FVC (PEF75) and maximal expiratory rate at 25 to 75% of forced vital capacity (PEF25 / 75). The normal values used to determine the volumes were those previously stipulated in the ATS / ERS criteria.[12,13]

Weight and body composition were obtained by bioimpedance using an OMRON BF511 apparatus (Omron Healthcare Co., Osaka, Japan) measuring body fat percentage, lean mass percentage and visceral fat level. Height was measured with a calibrated stadiometer. Body mass index (BMI) was calculated by the equation weight (kg) / height^2 (m). Hip and waist perimeters were also measured with an appropriate tape measure using the appropriate anatomical points according to the World Health Organization STEPwise Surveillance (STEPS) procedure.[14]

Handgrip strength was measured with a Jamar hydraulic hand dynamometer (measured in kg/f), with the participant sitting comfortably and holding the dominant arm close to the body (without support), the adductor shoulder, the elbow flexed at 90º and the forearm in a resting position. Handgrip strength was measured with a Jamar hydraulic hand dynamometer (measured in kg/f), with the participant sitting comfortably and holding the dominant arm close to the body (without support), the adductor shoulder, the elbow flexed at 90º and the forearm in a resting position.[15]

To assess the patient's nutritional profile, the Portuguese version of the mini nutritional assessment (MNA) questionnaire was used.[16] Data collection took place between February and March 2018, and all procedures were performed by duly certified professionals with competence in their respective areas.

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Statistical analysis

Data were compiled from an Excel 2016 database (Microsoft Office, Redmond, WA, United States) and verified for quality control, after which they were imported into the Statistical Package for the Social Sciences (SPSS), version 24 (IBM, Armonk, NY, United States).

A simple descriptive analysis was performed for demographic and clinical characterization. Continuous variables were presented as mean and standard deviation, and categorical variables as absolute and relative frequency. To compare categorical variables, we used the χ^2 test and Fisher's exact test. The association between continuous variables was tested by simple linear regression analysis and Pearson's bivariate correlation analysis.

The $p < 0.05$ was established as a criterion of statistical significance for the 95% confidence interval (95%CI).

RESULTS

This study included 18 participants — 13 (72%) women and 5 (28%) men —, with a mean age of 82 ± 10 years, ranging from 65 to 93 years. Of this population, 89% had associated comorbidity and 11% smoked. All participants were retired, with low level of education (less than 7th grade — elementary school), and none indicated significant alcoholic habits. Most participants live with a partner (67%). Hypertension was the most representative comorbidity in the population (83%), followed by dyslipidemia (56%) and type 2 diabetes *mellitus* (33%).

Table 1 summarizes the fundamental characteristics of the study sample. Regarding the respiratory function measured by spirometry, mean values of FEV1 and FVC were verified according to normality. The Tiffeneau index, as well as the expiratory rates, decreased on average, as shown in Table 1. In an individualized analysis of the spirometric results, 14 cases with alterations, predominantly small-line obstruction, corresponding to 10 cases in women and 4 in men.

Regarding the correlation of results obtained in respiratory studies, a significant association was found between FEV1, FVC and PEF and grip strength, self-efficacy for exercise and lean mass (Table 2). The bivariate correlation coefficients observed for the association of FEV1 with lean mass, grip strength and self-efficacy for exercise were, respectively, $r = 0.829$ ($r^2 = 0.687$; $p < 0.001$), $r = 0.599$ ($r^2 = 0.359$; $p = 0.009$) and $r = 0.556$ ($r^2 = 0.309$; $p = 0.017$). For FCV association, $r = 0.762$ ($r^2 = 0.580$; $p < 0.001$), $r = 0.654$ ($r^2 = 0.428$; $p = 0.003$) and $r = 0.479$ ($r^2 = 0.271$; $p = 0.049$), in that order, with lean mass, grip strength and self-efficacy for exercise. For the association of lean mass, grip strength and self-efficacy for exercise with PEF, the coefficients were: $r = 0.834$ ($r^2 = 0.696$; $p < 0.001$), $r = 0.594$ ($r^2 = 0.353$; $p = 0.009$) and $r = 0.481$ ($r^2 = 0.231$; $p = 0.043$), respectively.

Regarding the analysis of correlation with expiratory outputs, a significant association between the PEF25, PEF75 and PEF25/75 was found to be associated with exercise and self-efficacy and lean mass. For the PEF50, a significant and positive association with grip strength was additionally demonstrated (Table 3). Pearson's bivariate correlation coefficients for the association of PEF25 with lean mass and self-efficacy for exercise were $r = 0.662$ ($r^2 = 0.438$; $p = 0.003$) and $r = 0.663$ ($r^2 = 0.440$; $p = 0.003$), respectively. For the association of the same parameters with the PEF 25/75, the following correlation coefficients were found: $r = 0.510$ ($r^2 = 0.260$; $p = 0.030$), with lean mass; and $r = 0.622$ ($r^2 = 0.387$; $p = 0.006$), with self-efficacy for exercise. For PEF75, the correlation coefficients extracted from the bivariate correlation analysis were: $r = 0.452$ ($r^2 = 0.204$; $p = 0.049$), for lean mass; and $r = 0.485$ ($r^2 = 0.235$; $p = 0.006$), for self-efficacy for exercise. The association between PEF50 and lean mass, grip strength and exercise self-efficacy corresponded to bivariate correlation coefficients of $r = 0.656$ ($r^2 = 0.430$; $p = 0.003$), $r = 0.471$ ($r^2 = 0.222$; $p = 0.049$) and $r = 0.626$ ($r^2 = 0.392$; $p = 0.006$), in that order.

In addition, a bivariate correlation analysis was performed between the functional parameters and a significant association was identified between lean mass and grip strength ($r = 0.722$; $r^2 = 0.521$; $p = 0.001$), as well as between self-efficacy for exercise and lean mass ($r = 0.618$ $r^2 = 0.381$; $p = 0.006$), as illustrated in Figure 1.

Table 1 Clinical and spirometric characteristics of the study sample.

Parameters under analysis	Mean ± standard deviation	Minimum	Maximum
Age (years)	82.0 ± 10.6	65.0	93.0
Weight (kg)	68.1 ± 11.8	50.0	94.0
Height (m)	1.6 ± 0.1	1.5	1.7
BMI (kg/m^2)	26.7 ± 3.6	19.5	32.9
Grip Strength (kg/f)	18.1 ± 12.7	4.0	49.0
Self-efficacy for exercise	10.6 ± 4.4	5.0	18.0
Lean mass (%)	23.7 ± 7.6	16.3	42.9
Fat mass (%)	25.5 ± 9.3	6.8	37.4
Waist circumference (cm)	100.6 ± 12.1	79.0	122.0
Waist/hip	0.9 ± 0.1	0.8	1.1
Dominant Arm Perimeter (cm)	28.7 ± 3.1	24.3	33.5
Leg circumference (cm)	34.5 ± 4.4	28.5	45.5
FEV1 (%)	75.2 ± 24.1	35	125
FVC (%)	83.2 ± 21.3	42	121
Tiffeneau Index	73.6 ± 12.8	52	97
PEF25 (%)	65.0 ± 42.3	9	152
PEF50 (%)	47.7 ± 26.6	8	94
PEF75 (%)	51.4 ± 26.1	13	103
PEF25/75 (%)	53.5 ± 30.4	9	115
PEF (%)	51.3 ± 22.2	22	88

BMI: body mass index; FEV1: forced expiratory volume in 1 second; FCV: forced vital capacity; PEF: peak expiratory flow at a given percentage of FVC; PEF: absolute peak expiratory flow.

DISCUSSION AND CONCLUSIONS

This study aimed to verify whether there is an association between clinical and functional indicators of sarcopenia and respiratory function in geriatric patients. The obtained results identified the existence of a direct relation between the percentage of lean body mass and the values of the mobilizable respiratory volumes. Lean mass is a parameter closely linked to the percentage of skeletal muscle present in the body, so the identification of a significant association between this anthropometric parameter and respiratory parameters intrinsically dependent on expiratory effort capacity reveals the need for specific action of the thoracic skeletal muscle mass in the respiratory function of older adults. The significant association concomitantly identified between lean body mass percentage and muscle strength reinforces the pathophysiological and functional link between clinical and functional indicators of sarcopenia and respiratory function, particularly in respiratory components dependent on more intense chest muscle action.

The objectification of a significant relationship between scores of self-efficacy for exercise, i.e., the subjective perception of the older adults' effort capacity, and the percentage of lean mass is an additional factor that reinforces the identified causal link. These results, thus, recognize the close connection between the studied respiratory parameters and sarcopenia in older adults and, consequently, suggest that sarcopenia may have a negative effect on the respiratory capacity of individuals with this pathology. This is because the reduction in muscle mass, as well as the work capacity (strength and endurance) exerted by it, decreases one's ability to mobilize air in the airways. However, this conclusion needs confirmation in larger studies.

Table 2 Simple linear regression analysis with FEV1, FVC, TI and PEF as dependent variables, and age, sex, and muscle capacity and nutrition parameters as independent variables.

	FEV1			FVC		
	β	95%CI	p	β	95%CI	p
Grip strength	1.1	0.3–2.0	0.009	1.1	0.4–1.8	0.003
Exercise self-efficacy	3.0	0.6–5.4	0.017	2.2	0.1–4.5	0.044
MNA	- 0.1	-3.2–3.0	0.926	-0.6	-3.4–2.1	0.631
Lean Mass	2.6	1.7–3.6	< 0.001	2.1	1.2–3.1	< 0.001
Age	0.4	0.8–1.6	0.442	0.0	1.0–1.1	0.943
Sex	-4.5	-------------	0.737	6.3	-------------	0.587
	TI			PEF		
	β	95%CI	p	β	95%CI	p
Grip strength	0.1	0.5–0.6	0.928	1.1	0.3–1.8	0.009
Exercise self-efficacy	0.2	1.5–1.9	0.830	2.4	0.1–4.7	0.043
MNA	0.6	1.1–2.3	0.482	-0.3	-3.2–2.5	0.870
Lean Mass	0.3	0.7–1.2	0.587	2.4	1.6–3.3	< 0.001
Age	0.2	0.4–0.9	0.507	-0.1	1.2–1.0	0.833
Sex	-8.5	-------------	0.233	9.5	-------------	0.433

FEV1: forced expiratory volume in 1 second; FVC: forced vital capacity; TI: Tiffeneau index; PEF: peak expiratory flow; MNA: mini nutritional assessment; 95%CI: 95% confidence interval.

Table 3 Simple linear regression analysis with the PEF25, o PEF50, o PEF75 e o EMO25/75, as dependent variables, and age, sex and muscle capacity and nutrition parameters, as independent variables.

	PEF25			PEF50		
	β	95%CI	p	β	95%CI	p
Grip strength	1.2	0.4–2.9	0.135	1.0	0.1–2.0	0.049
Exercise self-efficacy	6.3	2.6–10.1	0.003	3.7	1.2–6.2	0.006
MNA	-2.2	-7.5–3.1	0.392	-1.2	-4.6–2.2	0.457
Lean mass	3.7	1.5–5.9	0.003	2.3	0.9–3.7	0.003
Age	1.8	0.1–3.7	0.067	0.5	0.8–1.8	0.454
Sex	-7.5	-------------	0.748	-6.0	-------------	0.682
	PEF75			PEF 25/75		
	β	95% CI	p	β	95%CI	p
Grip Strength	0.7	0.3–1.7	0.167	0.8	0.4–2.0	0.183
Exercise self-efficacy	2.9	0.1–5.6	0.041	4.3	1.4–7.1	0.006
MNA	0.7	4.1–2.6	0.653	-1.5	-5.4–2.3	0.408
Lean Mass	1.5	0.1–3.2	0.060	2.0	0.2–3.9	0.030
Age	0.4	0.9–1.7	0.525	0.9	0.6–2.4	0.207
Sex	-8.4	-------------	0.558	-11.5	-------------	0.489

PEF25: peak expiratory flow at 25% of forced vital capacity; PEF50: peak expiratory flow at 50% of forced vital capacity; PEF75: peak expiratory flow at 75% of forced vital capacity; PEF25/75: peak expiratory flow between 25 and 75% of forced vital capacity; MNA: mini nutritional assessment; 95%CI: 95% confidence interval.

The relationship between the percentage of lean mass and muscle strength was found in previous studies. For example, Stoever et al.[17] conducted a study to assess muscle mass predictors in older men. These authors also observed a positive and significant relationship between skeletal musculature (measured by percentage of lean mass) and grip strength and documented the predictive value of skeletal muscle index for the diagnosis of sarcopenia, to which another study added predictive value of skeletal muscles to identify the degree of sarcopenia.[4]

The impairment of muscle strength inherent to the age-related muscle loss and its consequences in terms of respiratory function were also investigated by Moon et al.,[4] in a cohort of 1,583 older men and women, which also documented an association between lower percentage of muscle mass and impaired respiratory performance.[18] These results are similar to those obtained by Park et al.,[19] aiming at a significant relationship between skeletal muscle index and respiratory parameters (FEV1 and FVC) in a sample of 240,000 individuals.

This study has several limitations that should be considered. It is a small investigation, which restricts its extrapolation to the general population and recommends caution in the evaluation of the results and their conclusions, despite the consistency in the results obtained. On the other hand, because it is not randomized, it is not possible to identify unambiguous causal relationships between the variables, although the results raise interesting pathophysiological hypotheses, which may be further explored in studies with a more appropriate design. The methodology for the assessment of body composition, although clinically validated, is not the most rigorous, so the evaluation of these parameters in future studies and by more sophisticated methods such as, dual energy X-ray absorptiometry (DeXA), will add informative value and consistency to the correlational analysis between functional and respiratory parameters.

The assessment of inspiratory and expiratory muscle strength is an important aspect to be considered, but the lack of technical resources for this did not allow the collection of this information. Thus, it is suggested that this assessment be considered in future studies on this theme.

Another aspect to consider in the future is smoking stratification. In the present study, only 2 smokers were identified, and a sensitivity analysis that removed these participants from the sample did not change the associations found in the total sample, so we chose to maintain the results of the global sample, thus respecting the ecology of the collection data and population analyzed.

Analysis of diaphragmatic function is another pertinent component for consideration in future studies, as measured by spirometric acquisition at different positions or by analysis of diaphragm excursion by ultrasound.

The combination of the previous results with those obtained in our study allows us to hypothesize that sarcopenia indirectly affects the respiratory capacity of individuals, by decreasing skeletal muscle mass, which will limit the individual's ability to perform inspiratory and expiratory maneuvers by affecting the muscles responsible for this effect.

Future, prospective and larger studies will answer this hypothesis and clearly document the relationship between respiratory capacity and sarcopenia. On the other hand, intervention studies aimed at muscle strengthening through the implementation of adapted physical exercise programs, as recommended by AGA@4life,[20] will be important to understand if strength and muscle mass gains translate into better

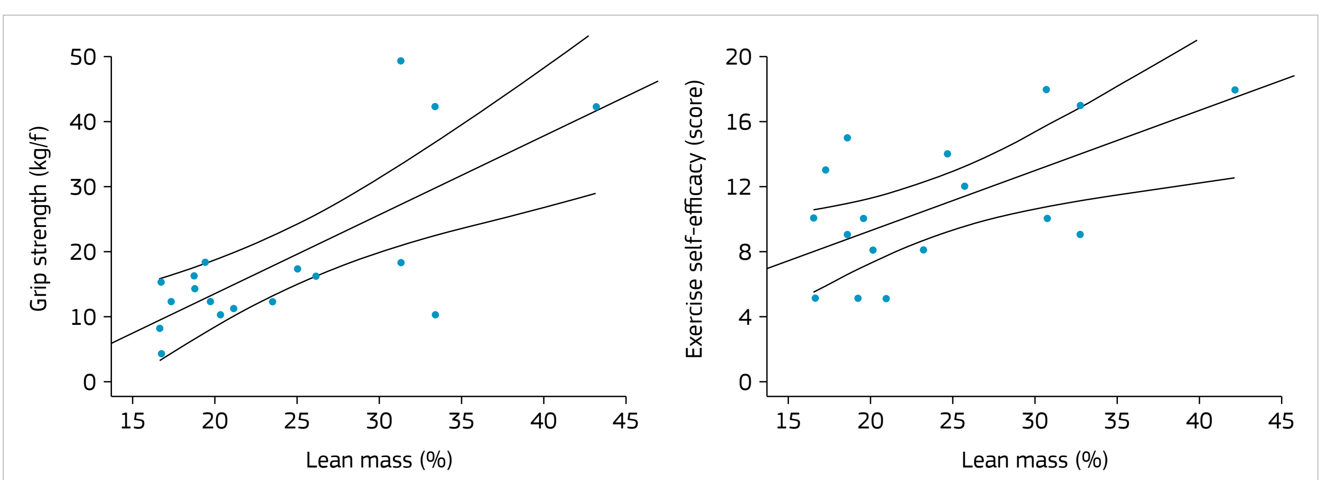

Figure 1 Scatter plot illustrating the association between lean mass and grip strength (left panel) and between lean mass and self-efficacy for exercise (right panel).

respiratory capacity, promoting better functionality, autonomy, and quality of life for older adults.

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CONFLICT OF INTEREST

There are no relevant conflicts of interest.

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