

Heart failure compromises muscle power of lower limbs of sedentary elderly people

Insuficiência cardíaca compromete potência muscular dos membros inferiores de idosos sedentários

Insuficiencia cardíaca compromete potencia muscular de extremidades inferiores de los ancianos sedentarios

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Abstract

Purpose. To analyze and to compare the absolute and relative muscle power of the lower limbs in sedentary elderly subjects with and without heart failure. **Methods.** The study included 36 elderly subjects (72 ± 6.5 years, 76.8 ± 4.8 kg, 171 ± 9.4 cm) divided into two groups: sixteen patients with heart failure versus twenty patients with coronary artery disease, but without heart failure. The muscle power of the lower limbs was assessed with a half-squat exercise; three repetitions were performed with three seconds of the interval between repetitions as fast as possible in the concentric phase. For the statistical analysis, unpaired Student's t-tests were used to compare the absolute and relative muscular power between groups. **Results.** Subjects without heart failure had significantly greater absolute (362 ± 18.5

W vs. 438 ± 22.3 W, $p = 0.015$) and relative (4.6 ± 0.2 W / kg vs. 5.9 ± 0.2 W / Kg, $p = 0.001$) muscle power versus subjects with heart failure. Conclusion. Heart failure harms the muscular power of the lower limbs in the elderly, which may influence the prognosis and evolution of the disease and capacity functional.

Keywords: Heart failure; Elderly; Muscle strength.

Resumo

Objetivo. Analisar e comparar a potência muscular absoluta e relativa dos membros inferiores em idosos sedentários com e sem insuficiência cardíaca. **Métodos.** O estudo incluiu 36 idosos ($72 \pm 6,5$ anos, $76,8 \pm 4,8$ kg, $171 \pm 9,4$ cm) divididos em dois grupos: dezesseis pacientes com insuficiência cardíaca versus vinte pacientes com doença arterial coronariana, mas sem insuficiência cardíaca. A potência muscular dos membros inferiores foi avaliada com um exercício de meio agachamento através de três repetições executadas com três segundos de intervalo entre elas e com a máxima velocidade na fase concêntrica. Para análise estatística, os testes t Student's não pareados foi usado para comparar a potência muscular absoluta e relativa entre os grupos. **Resultados.** Indivíduos sem insuficiência cardíaca tiveram significativamente maior potência muscular absoluta ($362 \pm 18,5$ W vs. $438 \pm 22,3$ W, $p = 0,015$) e relativa ($4,6 \pm 0,2$ W / kg vs. $5,9 \pm 0,2$ W / Kg, $p = 0,001$) comparados com os indivíduos com insuficiência cardíaca. **Conclusão.** A insuficiência cardíaca prejudica a potência muscular dos membros inferiores em idosos, o que pode influenciar no prognóstico e na evolução da doença e na capacidade funcional.

Palavras-chave: Insuficiência cardíaca; Idoso; Força muscular.

Resumen

Objetivo. Analizar y comparar la potencia muscular absoluta y relativa de los miembros inferiores en ancianos sedentarios con y sin insuficiencia cardíaca. **Métodos.** El estudio incluyó a 36 ancianos ($72 \pm 6,5$ años, $76,8 \pm 4,8$ kg, $171 \pm 9,4$ cm) divididos en dos grupos: dieciséis pacientes con insuficiencia cardíaca versus veinte pacientes con enfermedad de las arterias coronarias pero sin insuficiencia cardíaca parada cardíaca. A potência muscular dos membros inferiores foi avaliada com um exercício de meio agachamento através de três repetições executadas com três segundos de intervalo entre elas e com a máxima velocidade na fase concêntrica. La potencia muscular relativa y absoluta de las extremidades inferiores se evaluó con un ejercicio de media sentadilla. Para el análisis estadístico, se utilizaron pruebas t de Student para datos no apareados para comparar la potencia muscular absoluta y relativa entre grupos. **Resultados.** Los individuos sin insuficiencia cardíaca tenían una potencia muscular absoluta significativamente mayor ($362 \pm 18,5$ W frente a $438 \pm 22,3$ W, $p = 0,015$) y relativa ($4,6 \pm 0,2$ W / kg frente a $5,9 \pm 0,2$ W / kg, $p = 0,001$) en comparación con las personas con insuficiencia cardíaca. **Conclusión.** La insuficiencia cardíaca deteriora la potencia muscular de los miembros inferiores en el anciano, lo que puede influir en el pronóstico y evolución de la enfermedad y la capacidad funcional.

Palabras clave: Insuficiencia cardíaca; Anciano; Fuerza muscular.

1. Introduction

Cardiovascular disease (CVD) is the leading worldwide cause of premature death (Naghavi et al. 2016), being the practice of strength training (ST) one important strategy for prevention and rehabilitation in this population (Drenowatz et al. 2015, Price et al. 2016, Shiroma et al. 2017; Xanthos et al. 2017; Hansen et al. 2019; Singh et al. 2019). Another group that may benefit from this type of exercise is elderly by increasing the muscle function, mainly through muscle power (MP) exercises (Fragala et al. 2019). However, the evidence concerning the ST for this purpose by the elderly with heart failure (HF) and coronary artery disease (CAD) need more explanation.

HF and CAD are common diseases with age (Dharmarajan et al. 2017) characterized by structural or functional impairment of ventricular filling or blood ejection (Yancy et al. 2013) and an atherosclerotic occlusion that results in functional alterations of coronary arteries (European Society of Cardiology, 2013), respectively. Both imply hemodynamic and neuroendocrine adaptations, such as parasympathetic withdrawal, impaired regulation of the renin-angiotensin-aldosterone system, and inflammatory status (Malakar et al. 2019). These changes contribute to sarcopenia (i.e., loss of muscle mass and function) commonly observed with aging (Fleg et al. 2017; Springer et al. 2017; Von Haehling et al. 2017). Consequently, the physical function is impaired, affecting the performance in activities of daily living, independence, and quality of life negatively (Fragala et al. 2019).

MP is an important physical characteristic concerned with an ST program for the elderly, and the power training (PT) is recommended for this purpose (Ratamess et al. 2009). The PT is characterized by strength exercises performed at light to moderate loads (30 – 60% of 1 Repetition Maximum – RM) at high velocities in explosive movements, mainly in the concentric phase (Ratamess et al. 2009; Fragala et al. 2019). The PT is strongly associated with performance in daily living activities for the elderly. Ramirez-Campillo et al. (2014) compared a 12-week ST program with the exercises performed at high and low-speed. Strength, functional capacity, muscular performance, and quality of life improved in all conditions. These studies reinforces the high-speed protocol improved the MP and functional task performance. Which corroborates the result of the meta-analysis published previously (Tschopp et al. 2011).

The sarcopenia is caused by age and enhanced by HF and CAD which compromises even more the neuromuscular function (Von Haehling et al. 2017; Fragala et al. 2019). A recent NSCA position (Fragala et al. 2019) reinforced that PT increases strength, power, and hypertrophy in the elderly. Therefore, the inclusion of PT seems to be essential and safe for a well-rounded ST program for healthy and cardiovascular disease elderly (Lamotte et al. 2010; Cadore et al. 2018). Although there is evidence about the benefits of ST in elderly patients with HF and CAD, for muscle power stimulate and, consequently, gains in functional capacity, the higher speed in the concentric phase during ST could be considered in patients undergoing a cardiac rehabilitation program. However, little is known about the assessment of lower limb MP in this population. Thus, the purpose of the present study was to assess and to compare the absolute and relative MP of the lower limbs in the elderly with HF and elderly with CAD, but without HF.

2. Methodology

Subjects

Thirty-six sedentary HF and CAD patients of both sexes participated in this study. They were divided into two groups: a) HF - sixteen patients with HF with an ejection fraction below 50% in echocardiogram trough *Teicholz* method (72 ± 4.3 years, 75 ± 5.2 kg, 171 ± 9.1 cm); and b) CAD - twenty patients with CAD diagnosed through clinical trials and images exams like scintigraphy and cardiac catheterization, but without HF (71 ± 5.2 years, 75 ± 5.6 kg, 170 ± 4.8 cm). Before all the procedures, the participants were informed about the risks and benefits of the research and signed the consent form. The study was approved by the Research Ethics Committee of the Faculties of Health Sciences of Juiz de Fora, with an opinion number 847.611.

Experimental Protocol

Two visits were necessary for the experimental protocol. In the first visit, the participants were submitted on medical evaluation to participate cardiac rehabilitation program. In the second visit, anthropometric and MP assessment were performed. For the anthropometric data, height and body weight were measured with a scale and stadiometer. The MP was evaluated in a half-squat exercise using a linear position transducer (Fitrodyne; Fitronic; Bratislava; Slovakia).

For the MP test, the participants were attached to a belt. The body weight was inserted into the Fitrodyne microcomputer, and then the force in Newtons was calculated ($\text{bodyweight} \times 9.81\text{m/s}^2$). The force was then multiplied by the velocity obtained directly from the linear position transducer during the upward phase of a half squat to obtain the power in Watts. The absolute power was recorded as well as the relative power (absolute power/body weight).

To better discriminate the performance of the exercise, the following stages of execution were established: (1) Initial position - seated, knees flexed 90° with a small lateral displacement, feet fully supported on the ground with little parallel lateral displacement, arms crossed in front of the thorax and the head positioned with the Frankfurt plane; (2) Concentric phase

- the complete extension of the lower limbs as fast as possible, keeping the feet resting on the ground; (3) Eccentric phase – the return to the starting position with controlled speed from the end of the concentric phase.

Three repetitions were performed with three seconds of the interval between repetitions. The participants were encouraged to perform the half-squat exercise as fast as possible in the concentric phase. Three attempts were permitted with an interval of 1 minute between them. The highest score obtained was recorded and used for data analysis.

The following strategies were used to minimize error in the test protocol: (1) standardized information about the correct technique was given to the subjects before the test; (2) at least two attempts for familiarization were permitted; (3) a unique experienced professional was responsible for the test; (4) the patient's body weight was measured prior to all tests for the accuracy of the results.

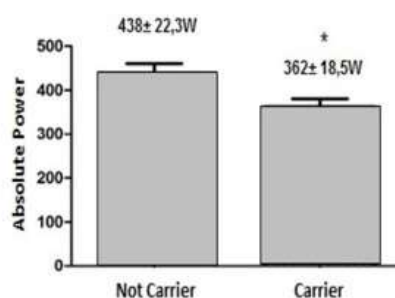
Statistical Analysis

The sample size was calculated was used the G*Power (v. 3.1.94) and we adopted the following parameters: tails = 2; effect size = 6.50; $\alpha = 0.05$ and, total sample size HF= 16, CAD = 20. It was calculated that the sample size was sufficient to provide more than 95% of statistical power. All the results were described by mean and standard deviation (SD). The parametric assumptions of normality and sphericity were validated by the Shapiro-Wilk test and the Mauchly test, respectively. Unpaired Student's t-tests were used to compare the absolute and relative MP scores between groups. All statistical analyses were performed in Prism software (v.5). Alpha was set at $p \leq 0.05$.

3. Results and Discussion

It was shown that the CAD group exhibited significantly higher absolute MP than the HF group (438 ± 22.3 W vs. 362 ± 18.5 W; $p = 0.015$) (Figure 1).

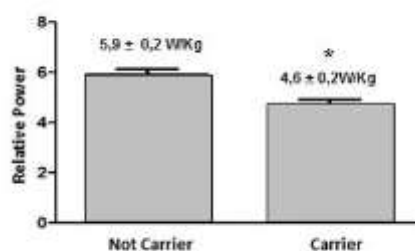
Figure 1. Analysis of absolute power, for individuals with and without heart failure.



Source: Authors.

Similarly, the relative MP in CAD group was significantly higher than the HF group (5.9 ± 0.2 W / kg vs. 4.6 ± 0.2 W / kg, $p = 0.001$) (Figure 2).

Figure 2. Analysis of relative power, for individuals with and without heart failure.



Source: Authors.

4. Discussion

In the present study, a higher absolute and relative MP was demonstrated CAD elderly patients compared to HF ones. These results confirmed our hypothesis. The positive association between MP and functional capacity (Barbat – Artigas et al. 2012) demonstrate the poor muscle quality observed in HF elderly patients. Sarcopenia and cachexia are considered ‘a muscle disease (muscle failure) rooted in adverse muscle changes that accrue across a lifetime’⁴ and plays a main pathophysiological role in frailty in older adults,⁵ leading to adverse health outcomes, such as disability, hospital admission, poor quality of life, and mortality (Harrington et al. 1997). As consequence of HF, affecting 20% and 10% of the HF ambulatorial patients (Dutt et al. 2015; Von Haehling et al. 2015; Fleg et al. 2017; Von Haehling et al. 2017).. The causes are multifactorial (Von Haehling et al. 2017). Disorders in inflammatory markers as interleukin-6 (IL-6), interleukin-10 (IL-10), and tumor necrosis factor α (TNF- α) must be considered in HF patients because it impairs the gene expression of muscle proteins (Hambrecht et al. 2002). Neuroendocrine and immunological disorders also influence the sarcopenia in HF patients because it controls the balance between the anabolic and catabolic status of the muscle tissue (Josiak et al. 2014). Several treatment approaches are recommended (Dutt et al. 2015). However, the practice of physical exercises is pointed as an essential non-pharmacological therapy for older HF patients (Fleg et al. 2017).

The practice of physical exercise is mostly recommended for CVD rehabilitation (Price et al. 2016). In HF patients, the main goals of the physical exercise therapy are an increase in VO_{2peak} , exercise tolerance and skeletal muscle function, which imply in improvement in the quality of life and daily activities, as walking, climbing stairs, housework and gardening and recreational activities (Selig et al. 2010; Piepoli et al. 2011). According to previous studies, the ST complies with this role. Giuliano et al. (2016) meta-analyzed the effects of the ST as a unique intervention in the strength, endurance, and quality of life in HF patients. They have demonstrated improvement in the strength, VO_{2peak} , 6 minutes walking test, and quality of life. The combined training (ST + endurance training) is another recommended approach. In another meta-analysis, Jewiss et al. (2016) quantified if isolated ST or combined training to induce changes in clinical markers in HF patients. The authors revealed that both types of training improved VO_{2peak} , left ventricular ejection fraction, 6 minutes walking test. However, only the combined training increased the quality of life and reduced systolic blood pressure and the heart rate at rest.

An ST program may also contribute indirectly to HF elderly patients. According to Conraads et al. (2012), adherence to a physical exercise program for rehabilitation in HF patients is a challenge. Older age, level of disability, difficulty to incorporate exercise into daily life, and lack of time are reasons that compromise the participation. However, an ST program may contribute to this problem. Munch et al. (2018) compared six weeks of low-volume and time-efficient strength and an endurance program. The VO_{2peak} , 6 minutes walking test performance, blood flow, endothelial function, and quality of life

significantly improved in booth programs without significant differences between them. However, the ST program was concluded in 44% less time and 35% less energy expended.

The sarcopenic process in HF patients is well described in the literature. However, the assessment of MP in this population was lacking. Therefore, the present study compared the MP in HF patients to CAD ones without HF. It was shown that in the progression of CVD to terminal HF induced a significant difference in muscle function as indicated by MP scores obtained. Future randomized controlled trials manipulating the ST variables (i.e., volume, load, rest interval length, methods, range and speed of motion) is needed. It may evaluate potential associations between HF, muscle dysfunction, specific biochemical markers to establish the functional to pathological connection better.

5. Conclusion

In conclusion, patients with HF exhibited significantly less PM in lower limbs compared to patients with CAD without HF, demonstrated by a lower ability to stand, which reflects a lower functional capacity, compromising daily activities and quality of life. It is recommended that patients with HF participate in an ST program to maintain maximum strength and MP levels to increase muscle quality and potentially better treatment outcomes.

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