Comparison of respiratory muscle strength between fragility subgroups in community elderly

Comparação da força muscular respiratória entre os subgrupos de fragilidade em idosas da comunidade

Comparación de la fuerza muscular respiratoria entre los subgrupos de fragilidad en añosas de la comunidad

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ABSTRACT | The fragility consist in a tripod comprising: sarcopenia, immune dysregulation, and neuroendocrine dysfunction. Sarcopenia is defined as a decrease in strength and muscle power, so that the respiratory muscles are also affected. The aim was to compare respiratory muscle strength (RMS) in elderly community residents, classified as nonfrail (NF), pre frail (PF) and frail (F), and correlate RMS with the handgrip strength (HS). The study was cross-sectional, with a convenience sample of 106 elderly women. Participants were classified according to the phenotype of frailty. The RMS was assessed by maximal inspiratory pressure (MIP) and maximum expiratory pressure (MEP). Significant differences were found in RMS between groups NF and F (MIP: p=0.001 and MEP: p<0.001) and between groups PF and F (MIP: p<0.001 and MEP: p<0.001). In relation to HS, significant differences were observed between all groups (p<0.001). There was correlation between HS and RMS only in the frail group. Thus, the HS may be important in the clinical evaluation to differentiate subgroups of fragility and identify the loss of muscle strength, including the loss of RMS.

Keywords | Frail Elderly; Muscle Strength; Respiratory System; Aged.

RESUMO | A fragilidade é composta por um tripé constituído por: sarcopenia, disfunção imunológica e desregulação neuroendócrina. A sarcopenia é definida como uma diminuição na força e na potência muscular, sendo que os músculos respiratórios também são afetados. O objetivo foi comparar a força muscular respiratória (FMR) em idosas residentes na comunidade, classificadas como não frágeis (NF), pré-frágeis (PF) e frágeis (F) e correlacionar a FMR com a força de preensão manual (FPM). O estudo foi do tipo transversal, com uma amostra de conveniência composta por 106 idosas. As participantes foram classificadas quanto ao fenótipo de fragilidade. A FMR foi avaliada por meio da pressão inspiratória máxima (PImáx) e da pressão expiratória máxima (PEmáx). Foram encontradas diferenças significativas da FMR entre os grupos NF e F (PImáx: p=0,001 e PEmáx: p<0,001) e entre os grupos PF e F (PImáx: p<0,001 e PEmáx: p<0,001). Em relação à FPM, foram observadas diferenças significativas entre todos os grupos (p<0,001). Houve correlação entre FMR e FPM apenas no grupo frágil. Desta forma, a FPM pode ser importante na prática clínica para diferenciar os subgrupos de fragilidade e identificar a perda de força muscular, incluindo a perda da FMR.

Descritores | Idoso Fragilizado; Força Muscular; Sistema Respiratório; Idoso.

RESUMEN | La fragilidad está compuesta por un trípode constituido por: sarcopenia, disfunción inmunológica y desregulación neuroendócrina. La sarcopenia es definida como una disminución de la fuerza y de la potencia muscular, donde los músculos respiratorios también son afectados. El objetivo fue comparar la fuerza muscular respiratoria (FMR) en añosas residentes en la comunidad, clasificadas como no frágiles (NF), pre-frágiles (PF) y

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frágiles (F) y correlacionar la FMR con la fuerza de prensión manual (FPM). El estudio fue del tipo transversal, con una muestra de conveniencia compuesta por 106 añosas. Las participantes fueron clasificadas en cuanto al fenotipo de fragilidad. La FMR fue evaluada por medio de la presión inspiratoria máxima (PImáx) y de la presión expiratoria máxima (PEmáx). Fueron encontradas diferencias significativas de la FMR entre los grupos NF y F (PImáx: p=0,001 y PEmáx: p<0,001) y entre los grupos PF y F (PImáx: p<0,001 y PEmáx: p<0,001). En relación a la FPM, fueron observadas diferencias significativas entre todos los grupos (p<0,001). Hubo correlación entre FMR y FPM apenas en el grupo frágil. De esta forma, la FPM puede ser importante en la práctica clínica para diferenciar los subgrupos de fragilidad e identificar la pérdida de fuerza muscular, incluyendo la pérdida de la FMR.

Palabras clave | Anciano Frágil; Fuerza Muscular; Sistema Respiratorio; Anciano.

INTRODUCTION

The aging process is characterized by physiological alterations that compromise various organs and systems, culminating in functional decline[1]. In this context, the phenomenon "frailty", attributed to elderly people, can be defined as a clinical state of greater vulnerability consequential of a decline in the reserve and function of multiple physiological systems[2,3].

Fried *et al.*[2] consider five criteria to detect frailty syndrome: self-report of exhaustion, low gait speed (GS), weakness assessed through handgrip strength (HGS), involuntary weight loss greater or equal to 4.5 kg or 5% in the past year, and low level of physical activity, measured through weekly energy expenditure[2,4]. Three or more of these criteria must be clinically present to classify an elderly individual as frail (F); when one or two factors exist, this elderly person is considered pre frail (PF), and when none of these criteria is detected, he/she can be classified as non frail (NF)[2].

The tripod that composes the main physiological alterations associated with the frailty syndrome comprises immune dysfunction, neuroendocrine dysregulation and sarcopenia[2,5]; the latter is considered a central component[5].

In this context of frailty syndrome, sarcopenia is the alteration most commonly observed in the muscles as ageing progresses[6], and it is the main factor that contributes to the loss of functional mobility and independence in many elderly people[7]. It is defined as a decrease in muscle strength and power due to the atrophy of muscle fibers[6].

This decline in strength has also been documented in respiratory muscles[8,9]. In this case, it can lead to a decrease in pulmonary functioning and inadequate energy supply, which can affect the strength of lower limbs (LL), thus contributing to the development of functional incapacity[10]. However, it is known that respiratory muscle strength (RMS) is related to a decrease in mobility in elderly people, regardless of the level of physical activity and LL strength[11], and that HGS has been considered one of the best predictors of the loss of overall muscle strength[12].

In light of this, the aim of this study was to compare the RMS of elderly women who reside in the community, classified as NF, PF and F, and to verify the correlation between RMS and HGS.

METHODOLOGY

Sample

This is a transversal study conducted with a convenience sample composed of 106 female volunteers recruited through the registers of four Family Health Strategies in the city of Diamantina, Minas Gerais. The study was approved by UFVJM's Research Ethics Committee, report number 056/11. All volunteers signed the Free and Informed Consent.

We included female elderly individuals ≥ 65 years of age. We excluded elderly women whose Mini Mental State Exam (MMSE) scores were incompatible with their schooling; those unable to roam without mechanical or human help; those with neurological illnesses; individuals who had been hospitalized less than three months prior to the study; those who had fractures acquired less than six months before; those with acute musculoskeletal impairment and/or decompensated respiratory or cardiovascular illnesses; those who were unable to perform the actions required to measure RMS and HGS; individuals who were taking digoxin, due to its positive influence on RMS[13]; and those who refused to participate in the study.

Procedures

The elderly women were submitted to previously scheduled individual assessments, and all collections were performed in the afternoon at an adequate location in the community. Initially, they answered a questionnaire in order to ensure the inclusion criteria. Then, their body weight and height were measured and the body mass index (BMI=height/weight²)[14] was calculated. Lastly, they were submitted to the application of the five criteria proposed by Fried *et al.*[2], in order to be classified as NF, PF or F, in addition to having their respiratory pressure measured.

Classification of Frailty Phenotypes

For the purposes of classifying the frailty phenotypes, we assessed the five criteria proposed by Fried *et al.*[2], namely:

- Self-reported unintended weight loss in the past year (4.5 kg or 5% of body weight);
- The HGS was measured with the use of a duly calibrated SH5001 – SAEHAN hydraulic hand dynamometer. Three measurements were taken from the dominant hand with 60-second intervals between each measurement. We considered the average of these measurements, adjusted in regards to sex and BMI[2,15]. The position adopted for the conduction of this procedure was recommended by the *American Society of Hand Therapists*, and the standardized verbal stimulus was "Squeeze as hard as possible"[15].
- The self-report of exhaustion was assessed by means of two statements from the CES-D questionnaire of depressive symptoms: "I felt that I had to make an effort to handle routinely tasks", and "I could not carry my things forward"[2,16].
- In order to assess GS, we used a stopwatch to track the time taken by the volunteers, in seconds, to walk for 4,6 meters at their usual speed. We considered the best performance out of two attempts[2,17].
- The level of physical activity was measured through low weekly energy expenditures in kcal, obtained by applying the Brazilian Portuguese version of the *Minnesota Leisure Time Activities Questionnaire*[18]. We evaluated the activities performed during the two weeks prior to the evaluation. We considered a weekly expenditure ≤270 kcal as low weekly energy expenditure[2].

Assessment of respiratory muscle strength

RMS was assessed by measuring the maximal inspiratory pressure (MIP) and the maximal expiratory pressure (MEP) using a hand vacuum pump, model MV-150/300, manufactured by Ger-Ar Comércio e Equipamentos Ltda®.

Each volunteer was seated with her feet supported and her nose occluded with a nasal clip. The maneuvers were repeated up to five times. We collected three acceptable maneuvers and the maximal respiratory efforts that were sustained for at least two seconds[19]. We considered acceptable the measurements without air leaks and with a variation≤10% than the highest value detected. The sequence of MIP and MEP measurements was random, and the highest measurement was selected for analysis[19,20].

The MIP was measured based on the residual volume, and the MEP on total lung capacity. An interval of at least one minute was established between each MIP and MEP measurement so as to allow the participant to recover[19,20]. In order to precise the interval between MIP and MEP collection, we observed the normalization of O_2 saturation and the return of systemic blood pressure to basal levels.

Statistical Analysis

We conducted a pilot study with ten volunteers using the Intraclass Correlation Coefficient (ICC) with the purpose of assessing the reliability of the measurements between two evaluators. ICC values that varied between 0.69 and 1.00 revealed an adequate intra- and inter-examiner concordance for all measurements (RMS, HGS, GS, and *Minnesota Leisure Time Activities Questionnaire*).

The sample calculation for the comparison of quantitative variables among the groups[21] considered a 95% confidence interval (95%CI) and indicated the necessity of allocating 31 elderly women in each group.

For data analysis, we used the statistical package SPSS, version 14, and adopted a significance level of 5%. Through Kolmogorov-Smirnov's test, we verified that only the data concerning the variables BMI and HGS presented normal distribution; thus, we used the one-way ANOVA to compare them among the three groups. The comparison of the variables RMS, age, weight and height in the three groups was conducted by means of Kruskal-Wallis' test, given that the distribution in this case was not normal. In order to investigate the differences between each of the groups, we relied on paired comparisons (NF x PF; NF x F; PF x F), using Bonferroni's test for HGS and Mann-Whitney's test for RMS and age. We utilized Spearman's correlation analysis to evaluate the correlation between HGS and RMS.

RESULTS

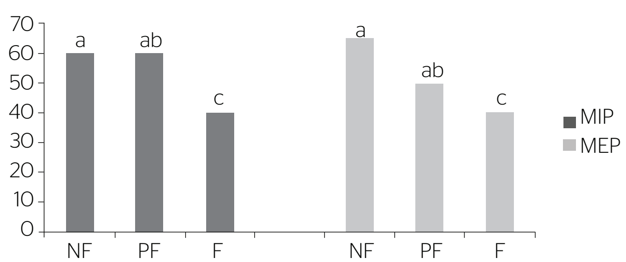
We evaluated 113 elderly women with age average of 73.96±6.91 years (varying between 65 and 91 years of age). Seven volunteers were excluded from the study: three due to the use of digoxin, two because of MMSE scores incompatible with their schooling, and two because they were unable to participate in the tests. In the end, we included 106 volunteers in the study who, after the classification of their frailty phenotype, were divided in three groups: 32 were considered NF, 42 were PF, and 32 were F.

The characterization of the sample is presented on Table 1. There was a significant difference in age between the groups NF and F (p=0.001), and PF and F (p=0.001), which demonstrates that F elderly women are older. Regarding weight, height and BMI, we did not find significant differences among the groups.

Table 1. Characteristics of the population studied in relation to age, weight, height and body mass index

Variables	NF	PF	F	p-value
n	32	42	32	
Age (years)	71.59±5.62[a]	72.64±6.05[ab]	78.06±7.49[c]	0,001
Weight (kg)	64.94±14.62	68.97±13.70	66.50±18.24	0,274
Height (meters)	1.54±0.05	1.53±0.05	1.53±0.07	0,519
BMI (kg/m^2)	27.16±5.89	29.03±5.37	28.11±6.25	0,391

BMI: body mass index; NF: non frail; PF: pre frail; F: frail
The values represented by the letter c are statistically different than those with the letters a and b



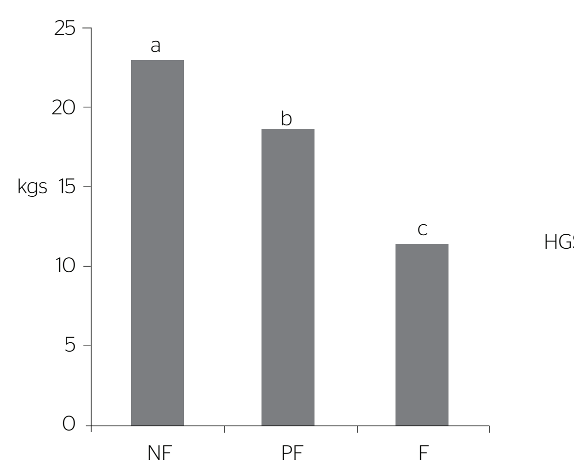
NF: non frail; PF: pre frail; F: frail; MIP: Maximal inspiratory pressure (cmH_2O); MEP: maximal expiratory pressure (cmH_2O).
The values represented by the letter c are statistically different than those with the letters a and b

Figure 1. Median values of Respiratory Muscle Strength in all categories of frailty syndrome

Figure 1 displays the median values of the variables MIP and MEP by group. There was a significant difference (p<0.001) in relation to RMS when the three groups were compared (NF, PF and F). After the paired comparison of RMS between the groups, we did not find significant differences between NF and PF (MIP: p=0.723 and MPE: p=0.118), but we verified significant differences between the groups NF and F (MIP: p=0.001 and MEP: p<0.001), and between the groups PF and F (MIP: p<0.001 and MEP: p<0.001).

Regarding HGS, the average values are presented by group on Figure 2. There were significant differences among the three groups (p<0.001) and also when comparing them pair by pair (p<0.001), which demonstrates that the F elderly women had lower HGS than the other groups, and that the PF participants had lower HGS than those in the NF group.

The statistical power found for the correlation between MIP and HGS was higher than 86%, and it surpassed 90% between MEP and HGS. We found moderate significant correlations between HGS and MIP (r=0.303) and MEP (r=0.386) when we considered the analysis with all participants. In the analysis by group, only the F elderly women presented a significant correlation between HGS and RMS, as it is shown on Table 2.



The letters a, b and c represent the existence of statistically significant differences
NF: non frail; PF: pre frail; F: frail; HGS: handgrip strength; kgs: kilogram/strength

Figure 2. Average values of Handgrip Strength in all categories of frailty syndrome

Table 2. Correlations between the measurements of Respiratory Muscle Strength and Handgrip Strength considering the groups separately and together

Variables	Non frail n=32		Pre frail n=42		Frail n=32		All groups n=106	
	r	p-value	r	p-value	r	p-value	r	p-value
MIP and HGS	0,110	0,549	-0,103	0,517	0,508***	0,003*	0,303**	0,002*
MEP and HGS	0,142	0,439	-0,027	0,866	0,383**	0,030*	0,386**	0,0001*

MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure; HGS: handgrip strength Statistically significant (p<0.05); **Moderate correlation (0.30<r<0.50); ***High correlation (r>0.50)

DISCUSSION

This study had the purpose of comparing RMS in elderly women of the community, classified as NF, PF and F, and correlating RMS and HGS. In the present study, group F presented statistically lower values of MIP, MEP and HGS when compared to the NF and PF groups, and it also had positive significant correlations among these variables. We also found lower HGS values in the PF group when compared to the NF group.

Simões *et al.*[22] found negative correlations between age and RMS, which reinforces the results of this study. Moreover, some studies have demonstrated a relation between ageing and frailty[5], which is also in accordance with the present study, since we found that the frail elderly participants were older. Therefore, we believe that these two factors, older age and lower RMS, can contribute to a higher risk of functional incapacity, and these individuals have higher chances of experiencing adverse health effects, as it is shown in the literature[2,5].

Moreover, some authors point out that the main factor that contributes to frailty and loss of functional mobility is skeletal muscle atrophy associated with weakness, which are characteristic of sarcopenia[7]. This decline in strength can be assessed through HGS measurement, which, in addition to predicting a reduction in overall muscle strength[12], can indicate functionality limitations[23], life quality[24], mortality[25], and fast decay of daily life activities and cognition[26].

In this case, the HGS decline found in the present study can be an indirect indicator of functional limitations and of a greater need for care for these individuals. However, since the aim of this study was not to assess functional losses, this might be a limitation that must be investigated in future studies. Nevertheless, the decrease in HGS observed in elderly people can be used to suggest more adequate strategies of prevention and health measures, given that these measures can be fundamental in delaying the loss of muscle mass consequential of ageing, and thus promote a smaller impact on the life quality of these elderly women[27,28].

Likewise, the training of respiratory muscles increases the benefits of aerobic exercises and it can be an alternative to those who have no conditions to perform this exercise[8]. Weiss *et al.*[29] have demonstrated that frail elderly women suffer a decrease in their capacity to practice exercises as well as compromising of lung functioning, which can suggest RMS decrease. Therefore, based on the literature, it is possible to infer that RMS is an important physiological variable that helps to prevent functional decline[8,30].

In addition, authors have pointed out the necessity of actions that have the purpose of strengthening respiratory muscles in elderly people in order to reduce mortality, given that RMS can explain the association between mortality and the muscle strength of body extremities[25]. In this sense, the fact that RMS is related to HGS reinforces the use of the latter in clinical practice.

It is worth highlighting that the recruitment of elderly women from different locations enabled us to obtain data that portray more accurately the diversity of residents of the community in question.

To our knowledge, there are no studies in the literature that correlate RMS and HGS. In a study carried out by Buchman *et al.*[25], the authors concluded that the measurement of the muscle strength of the extremities can replace RMS. Therefore, the positive association found in this study between RMS and HGS suggests that the latter can be useful in clinical practice when inferring about the RMS of frail elderly women, given that the measurement of RMS requires greater cognitive capacity in understanding the commands. Moreover, some authors have affirmed that HGS loss is a sign of frailty and it can be used as a single marker of frailty[31].

CONCLUSION

The results of this study demonstrate that frail elderly women suffer significant RMS and HGS losses. Likewise, we observed that a decline in HGS begins to appear already in the preceding stage, that is, when these people are classified as pre frail. Therefore, HGS, which is a simple and easily applicable measurement, can be an important factor to differentiate frailty subgroups and identify muscle strength loss, including RSM loss, in clinical assessment.

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