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Association between inspiratory muscle strength and functionality variables in older people with COPD: a cross-sectional study

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ABSTRACT

Introduction: Inspiratory muscle strength is related to functional variables in chronic obstructive pulmonary disease (COPD). However, literature is scarce, specifically considering older people with COPD. **Objective:** To investigate whether inspiratory muscle strength is related to functional variables in older people with COPD. **Methods**: Cross-sectional study in which older people with a clinical diagnosis of COPD (GOLD criteria) and candidates for rehabilitation were eligible. The following variables were measured: maximum inspiratory pressure (MIP) (manovacuometry), functional capacity (six-minute walk test), functional mobility (Timed Up and Go Test), fear of falling (Falls Efficacy Scale-International questionnaire), handgrip strength (HGS) (dynamometry), peripheral muscular endurance (30-second sit-to-stand test), Health-related quality of life (HRQL), St. George's Respiratory Questionnaire (SGRQ), and the impact of COPD on health status (COPD Assessment Test). **Results:** 32 older people (68.63±5.35 years, 17 male) with moderate to very severe COPD participated in the study. MIP correlated negatively and strongly with functional mobility ($r=-0.706$; $p<0.0001$). There was a positive and moderate correlation between MIP with functional capacity ($r=0.431$; $p=0.014$), HGS ($r=0.565$; $p<0.001$), and peripheral muscular resistance ($r=0.546$; $p=0.001$). The MIP showed a moderate negative correlation with fear of falling ($r=-0.539$; $p=0.001$). There was no association between MIP with HRQL ($r=-0.089$; $p=0.628$) and with the impact of COPD on health status ($r=-0.297$; $p=0.098$). **Conclusion:** Inspiratory muscle strength was associated with functionality variables, such as mobility, functional capacity, fear of falls, peripheral muscle strength, and resistance in older people with COPD.

Keywords: Pulmonary Disease, Chronic Obstructive; muscle strength; functional status; Quality of life; aging.

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INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a growing public health problem with a significant impact on global morbidity and mortality[1,2]. According to the recent report by the Global Initiative for Chronic Obstructive Lung Disease (GOLD), COPD is the 3rd leading cause of death in the world, and this disease is projected to increase in the coming decades[3].

The primary pathophysiology of COPD is related to damage to the respiratory system, with airflow limitation being one of the main clinical characteristics of patients with COPD. This progressive and partially reversible ventilatory dysfunction occurs due to an abnormal pulmonary inflammatory process, which is triggered by exposure to harmful particles and gases[1]. In addition, respiratory muscle dysfunction, especially of the diaphragm muscle[4], is observed in COPD, directly affecting respiratory efficiency and contributing to the progressive exacerbation of the disease and consequently to respiratory failure, which is directly related to mortality[5].

Several systemic manifestations are observed with the progression of the disease, among which peripheral muscle dysfunction stands out as an independent risk factor for accelerating disease progression and predicting mortality in COPD patients[6]. In addition, changes in peripheral muscle function hurt functional capacity and postural balance, culminating in clinical implications for health-related quality of life (HRQL) and the patient's prognosis[7,8].

Recent studies in COPD patients have shown that inspiratory muscle strength, determined by maximum inspiratory pressure (MIP), correlates with functional capacity (measured by the six-minute walk test) and peripheral muscle parameters (sarcopenia)[9]. In addition, respiratory strength was associated with worsening acute exacerbation and increased dyspnea, and related to survival in COPD patients[10]. On the other hand, the possible relationship between inspiratory muscle strength and functional variables in older patients with COPD has yet to be elucidated. Given the above, identifying functional outcomes in which inspiratory muscle strength is related is of clinical relevance, especially in older people with COPD, since these individuals are doubly affected by both the aging process and the progression of the disease.

Based on the assumptions described above, this study aimed to investigate whether there is a relationship between inspiratory muscle strength and various functional variables, such as functional mobility, fear of falling, functional capacity, peripheral muscle function, impact of the disease on health and quality of life in older people with COPD who are candidates for a pulmonary rehabilitation program.

METHODS

This cross-sectional study was carried out at the Rehabilitation Unit of the Hospital Universitário de Santa Maria (HUSM), Santa Maria, Rio Grande do Sul, Brazil. The study was approved by the institution's Research Ethics Committee (CEP) under CAAE number: 08527219.0.0000.5346. By the guidelines of the National Health Council in Resolution 466/2012, all participants signed the Informed Consent Form (ICF).

Eligible individuals were those with a clinical diagnosis of COPD according to the GOLD[3] criteria (forced expiratory volume in one second/forced vital capacity; FEV_1/FVC <70 and FEV_1 predicted <80%), older people (≥60 years), of both sexes, referred by the HUSM Pulmonology Service and candidates for a pulmonary rehabilitation program.

The inclusion criteria were: patients with a clinically stable diagnosis of COPD (i.e., no infections or exacerbations in the last three months), with the consent of the medical team to practice physical exercise. Patients who were smokers and alcoholics, diagnosed with neurological impairment, unstable psychiatric illnesses, symptomatic heart disease, hemodynamically unstable patients, who participated in pulmonary rehabilitation programs in the 3 months before the study, or physically active were excluded. All patients were informed about the procedures and signed an informed consent form before the start of the study.

Reviews

The functional variables analyzed were muscle strength and endurance (peripheral and respiratory), functional capacity, functional mobility, fear of falling, quality of life, and the impact of the disease on health. All the patients underwent two days of assessment, at least 48 hours apart. On the first day, anamnesis, physical examination, application of the COPD Assessment Test (CAT), measurement of inspiratory muscle strength, functional mobility, and fear of falling were carried out. On the second day, functional capacity, handgrip strength, peripheral muscle endurance, and quality of life were assessed, in that order. All the assessments were carried out by previously trained assessors.

Inspiratory Muscle Strength

Inspiratory muscle strength was assessed by MIP measured using a previously calibrated digital manovacuometer (MVD300-U, Homed, Brazil). The assessment was carried out by the recommendations of the ATS/ERS[11]. All the patients performed at least eight maneuvers, with an interval of 1 minute between each one, three of which had to be acceptable and reproducible. The highest MIP value was recorded and compared with the predicted values[12].

Functional Mobility

Functional mobility was assessed using the "Timed Up and Go" (TUG) test. The test requires the patient to get up from a standard chair with a height of approximately 46cm, walk 3 meters at a comfortable pace, return to the chair, and sit down. Three

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evaluations were carried out, and the best attempt with the shortest execution time was considered for analysis. A TUG execution time of ≥12 seconds was adopted as the cut-off point for predicting impaired functional mobility and balance[13].

Fear of Falling

Fear of falling was assessed using the Falls Efficacy Scale - International - Brazil (FES-I-Brazil)[14]. The FES-I presents questions about worrying about the possibility of falling when carrying out 16 activities, with respective scores from one to four. The total score can vary from 16 (no concern) to 64 (extreme concern)[14].

Functional Capacity

Functional capacity was assessed by the six-minute walk test (6MWT), according to the ATS/ERS guidelines[15] and the longest distance walked was considered for analysis, the 6-minute walk distance (6MWD) and compared with the predicted values[16].

Palmar Grip Strength

HGS was measured using a Saehan hand-held mechanical dynamometer (Saehan corporation SH5001, Korea). For analysis, the average of the three evaluations recorded in each upper limb was taken, followed by the average between the right and left upper limbs[17] and compared with the predicted values[18].

Peripheral Muscular Strength

Peripheral muscle endurance was assessed using the 30-second chair stand test (30CTS)[19], and the number of repetitions obtained was used for analysis. The equation proposed by Tveter et al.[20] was used to calculate the predicted value.

Health-related quality of life

The Portuguese version of the Saint George's Hospital Respiratory Questionnaire (SGRQ) was used to assess HRQL[21].

Clinical impact of COPD on health status

The Portuguese version of the CAT questionnaire, validated for the Brazilian population, was applied in the form of an interview to assess the health status of patients with COPD[22]. The total score varies according to the range of scores obtained, classified according to clinical impact as: mild (1-10 points); moderate (11-20 points); severe (21-30 points), and very severe (31-40 points)[22].

Statistical analysis

The data was analyzed using GraphPad Prism 5 statistical software (GraphPad Software Inc., San Diego, CA, USA). The normality of the variables was assessed using the Shapiro-Wilk test. Continuous variables with a normal distribution and those with a non-normal distribution are presented as mean (standard deviation) and median (interquartile range), respectively, while categorical variables are presented as absolute frequencies and percentages. The correlation between MIP and the other variables was analyzed using Pearson's correlation coefficient. The correlations were classified as weak (r values between 0.10 and 0.39), moderate (r values between 0.40 and 0.69), and strong (r values between 0.70 and 1.00)[23]. The significance level established was 5% ($p<0.05$).

RESULTS

Thirty-two older people (68.63±5.35 years) with a clinical diagnosis of COPD were included in the study using convenience sampling (Table 1). It should be noted that most of the sample was made up of male patients who were overweight and in a severe stage of COPD. The functional variables analyzed in the study are shown in Table 2.

The relationships between maximum inspiratory pressure (MIP) and other parameters were evaluated (Figure 1). MIP was negatively and strongly correlated with functional mobility ($r=-0.706$; $p<0.0001$). There was a moderate positive correlation between MIP and functional capacity ($r=0.431$; $p=0.014$), handgrip strength ($r=0.565$; $p<0.001$), and peripheral muscle endurance

Table 1: Demographic and clinical characteristics of the sample

Variables	n=32
Anthropometric	
Age (years)	68.63±5.35
Male, n (%)	17 (53.13)
BMI, (Kg/m²)	26.04±3.44
Clinics	
FEV1/FVC, (% predicted) mean ± SD	50.60±8.66
FEV1, (% predicted)	37.78±10.42
GOLD II, n (%)	10 (31.25)
GOLD III, n (%)	13 (40.63)
GOLD IV, n (%)	9 (28.12)
Comorbidities	
SAH, n (%)	16 (50.0)
Diabetes, n (%)	6 (18.75)
Previous smoking, n (%)	32 (100.0)
Impact of the disease	
CAT (points)	24.03±5.67
CAT classification	
Moderate, n (%)	10 (31.25)
Severe, n (%)	16 (50.0)
Very severe, n (%)	6 (18.75)

Values expressed as mean ± standard deviation or frequency (percentage). BMI: body mass index; FEV_1/FVC: ratio of forced expiratory volume in the first second to forced vital capacity; FEV_1: forced expiratory volume in the first second; GOLD: Global Initiative for Chronic Obstructive Lung Disease; SAH: systemic arterial hypertension; mMRC: modified Medical Research Council; CAT: COPD Assessment Test.

Table 2: Functional variables - inspiratory muscle strength, functional capacity and mobility, fear of falling, peripheral muscle strength and endurance, and the sample's quality of life

Functionality variables	n=32
Inspiratory muscle strength	
MIP (cmH_2O), mean ± SD	64.09±9.91
MIP (%pred.), mean ± SD	88.9±18.11
Functional capacity	
6MWD (m), mean ± SD	299.0±79.71
6MWD (% pred.), mean ± SD	58.0±14.84
Functional mobility	
TUG (s), mean ± SD	9.86±1.74
Fear of falling	
FES - I - BR (points), mean ± SD	29.78±8.43
Peripheral muscle strength (dominant limb)	
HGS (Kgf), mean ± SD	27.14±9.55
HGS (%pred.), median (IQR)	80.88 (67.68-95.23)
Peripheral muscle endurance	
30CST (no. of repeats), mean ± SD	7.12±1.73
30CST (% pred.), mean ± SD	33.75±8.39
HRQL	
Symptoms, mean ± SD	47.58±17.57
Activity, median (IQR)	80.01 (71.64-86.75)
Psychosocial impact, median (IQR)	59.21 (41.80-77.01)
Total, mean ± SD	62.17±12.02

Values expressed as mean ± standard deviation, median (interquartile range), or frequency and percentage. MIP: maximum inspiratory pressure; SD = standard deviation; IQR = interquartile range; pred = predicted; 6MWD: distance covered in the six-minute walk test; TUG = Timed Up and Go; FES - I - BR = Falls Efficacy Scale-International-Brazil; HGS: handgrip strength; 30CST = 30-second sit and stand test; HRQL: health-related quality of life.

(r=0.546; p=0.001). In addition, MIP showed a moderate negative correlation with fear of falling (r=-0.539; p=0.001). However, MIP was not correlated with health-related quality of life (r=-0.089; p=0.628) or with the clinical impact of COPD on health status (r=-0.297; p=0.098).

DISCUSSION

The main findings of this study showed that the MIP was associated with functional variables such as mobility, functional capacity, fear of falls, peripheral muscle strength, and endurance in older people with COPD. However, there was no association between MIP and the variables quality of life and state of health, even though a large part of the sample had a moderate to severe impact of the disease on their state of health, according to the CAT score. It should be noted that the MIP values showed that the sample did not have weak inspiratory muscles.

Our results showed a strong negative correlation between MIP and functional mobility, indicating that higher MIP values were associated with better performance in the TUG test. According to Develi et al.[24] increasing inspiratory muscle strength plays a crucial role in maintaining the balance between intrapleural and intra-abdominal pressures, and higher MIP values likely contribute to a better dynamic balance. A recent study by Florian et al.[25] demonstrated that increases in inspiratory muscle strength, achieved through an inspiratory muscle training program, were associated with improved performance in the TUG test in non-older individuals with severe COPD.

The positive and moderate correlation between MIP and functional capacity, assessed using the 6MWT, shown in this study, is in line with the findings described by Souza et al.[9], where the authors also showed a positive but strong correlation between these variables. Interestingly, in this study, the authors adopted cut-off points above and below 350 meters in the 6MWT. When stratifying the patients, the study showed that the individuals with the worst performance in the test were those with the weakest respiratory muscles. In this sense, it is important to note that in our study, the average distance covered in the 6MWT was 299 meters, indicating an overall performance below the established threshold of 350 meters.

In this study, MIP also showed a moderate positive correlation with peripheral muscle strength. In this sense, it is important to mention that handgrip strength is a good reflection of overall peripheral muscle strength (quadriceps and diaphragm) in individuals with COPD[26]. It should be noted that the sample in our study did not show, according to the reference values, weakness in the inspiratory muscles or a reduction in handgrip strength. It is known that in COPD patients the respiratory muscles, especially the diaphragm, undergo a process of adaptation to chronic overload, which makes them more resistant to fatigue[27].

Another finding demonstrated was the positive and moderate correlation between MIP and peripheral muscle endurance, assessed by the 30CST. Given the scarcity of studies that have investigated the existence of an association between MIP and peripheral muscle endurance, assessed by the sit and stand test, in older people people with COPD, it is important to mention the findings of Zanini et al.[28], where the authors showed a positive association between FEV_1 and performance on the 30CST in older people people with moderate and severe COPD. The study also pointed out that compared to 1-min sit-to-stand test (1-STST), 30CST was better tolerated in terms of fatigue by patients. It is worth noting that in the present study, performance on the 1-STST was 33.75% predicted, showing that the sample's peripheral muscular endurance was compromised.

The negative and moderate association between MIP and fear of falling suggests that greater inspiratory muscle strength may be associated with less concern about falls. This fear of falling, also mentioned in the Brazilian study by Oliveira-Zmuda et al.[29], can lead older people to compensatory walking strategies which, paradoxically, are not enough to prevent falls and, in some cases, may even increase the risk of falls. This corroborates the observation that the fear of falling can negatively influence patients' confidence in their mobility capabilities, resulting in a cycle of functional decline and increased risk of falls. In this context, it is important to note that a growing body of evidence has shown that patients with COPD also have significant deficits in postural balance control[30] and consequently an increased risk of falls[31].

In this sense, the strong negative association between MIP and functional mobility also observed in this study complements and reinforces the findings, highlighting that both dynamic balance and fear of falling, assessed by the FES-I-BR, are closely related factors that affect functional mobility and, consequently, the risk of falls in older people with COPD. In this sense, we can infer the importance of including therapeutic strategies for training the inspiratory muscles in pulmonary rehabilitation programs to not only improve functional capacity, but also postural balance and the confidence of older people with COPD to carry out daily activities.

On the other hand, MIP showed no correlation with HRQL or with the clinical impact of COPD on the participants' state of health. This may indicate that although the IMF influences functional and mobility aspects, other factors may play a more significant role in the general perception of QL, as analyzed by

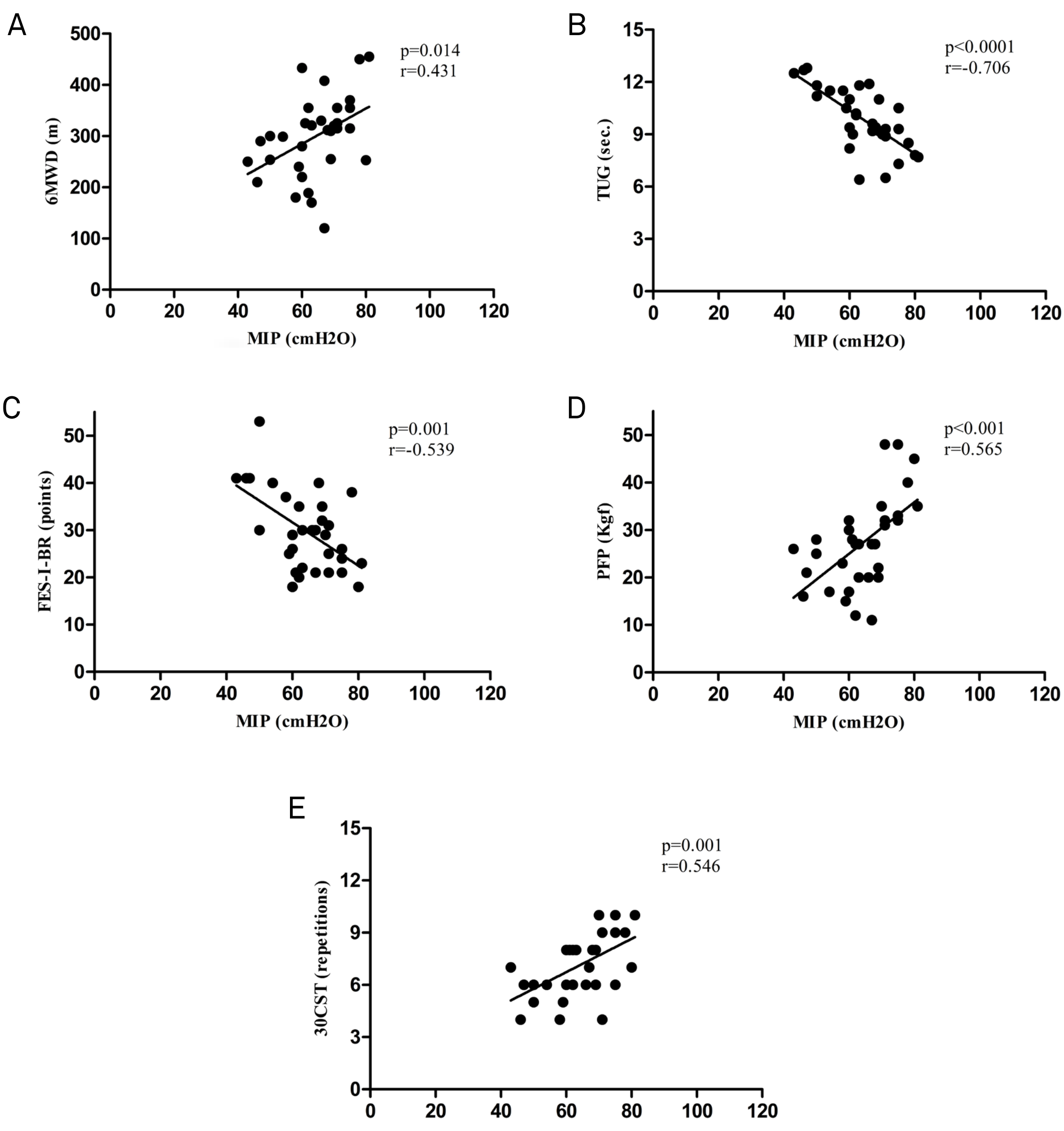

Figure 1: Relationship between maximum inspiratory pressure (MIP) and: A) Functional capacity (6MWD); B) Functional mobility (TUG); c) Fear of falling (FES-I-BR); D) Peripheral muscle strength (PFP) and E) Peripheral muscle endurance (30CST).

Ceyhan et al.[32], who showed that HRQL increases when dyspnea symptoms cease or stabilize. The lack of correlation between the MIP and CAT score suggests that respiratory muscle function was not a significant predictor of the perceived severity of symptoms or the psychosocial impact reported by COPD patients. However, Karloh et al.[33] showed that the CAT was sensitive in differentiating health status between patients with COPD and individuals without the disease, including smokers without a previous diagnosis.

The results of the study indicate that MIP assessment and inspiratory muscle training are important for improving functional capacity, peripheral muscle strength and endurance, and reducing the risk of falls in older people with COPD. However, more studies are needed to confirm these findings, as well as to determine the best therapeutic strategies. MIP is a crucial indicator of physical functionality and should be a valuable focus in pulmonary rehabilitation programs, specifically in older people with COPD, to improve mobility, functional capacity, peripheral muscle strength, and postural balance. It is also worth noting that our findings confirm the feasibility, benefit, and low cost of assessing the functionality variables used in our study for use in the context of clinical practice.

Despite the clinical relevance of our findings, the study has some limitations which need to be considered: the absence of a control group of older people without COPD made it impossible to compare the findings shown in our study, the cross-sectional nature of the research, which prevents the confirmation of causal relationships, and the specificity of the sample which may limit the generalization of the results. In addition, variables that were not assessed, such as psychological and social conditions, may have influenced the results, and it is speculated that the lack of a significant correlation between MIP and HRQL or the clinical impact of COPD may be attributable to these uncontrolled factors. Future research should adopt a longitudinal design, include a control group of healthy older people without COPD, as well as a comprehensive assessment of psychological, social, and ageing conditions, and other variables that may impact the functionality of these patients.

Conclusion

The main findings of this study showed that inspiratory muscle strength was associated with functional variables such as mobility, functional capacity, fear of falls, peripheral muscle strength, and endurance in older people with COPD.

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