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Muscle Dysfunction, which Impact on Exercise Tolerance and Quality of Life in COPD Patients?

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Abstract

Introduction: COPD is currently considered a real systemic disease due to the concomitant presence of several comorbidities, including peripheral muscle dysfunction, which arises from the interaction of several factors such as undernutrition, inactivity, and systemic inflammation.

Method: To evaluate their muscle dysfunction, stable COPD patients underwent body composition assessment using bioelectrical impedance (BIA), isometric voluntary contraction (MVC) and quadriceps endurance measurement of the lower limb. Patients' exercise tolerance was assessed by the 6-min walk test (6WT), dyspnoea by the m MRC scale and quality of life by the Q11 questionnaire. The aim of our study is to assess the prevalence of muscle dysfunction in COPD patients and to identify its relationship with the severity of bronchial obstruction, as well as its impact on effort tolerance and quality of life in these patients.

Results: 175 COPD patients (166 men and 9 women) aged 67(+/-9) years were recruited, smoking was estimated at 35 (20) p/year, FEV1 averaged 52 (21) %, BMI was 21.32 (4.10) Kg/m2, while FFMI was estimated at 18(4.7) (Kg/m2). Dyspnea was estimated at 2±1 of the m MRC scale. 64% of COPD patients showed muscle weakness with isometric voluntary contraction (MVC) below 80% of normal. Decreased muscle strength was found at all stages of COPD with 13% (GOLD I), 30% (GOLD II), 37% (GOLD III), 20% (GOLD IV). 75% of COPD patients with muscle weakness had dyspnea at stages ≥ 2 m MRC. A significant correlation of quadriceps (MVC) was found with FFMI ($p<0.016$) and FEV1 ($p<0.014$). Whereas quadriceps endurance correlated with FEV1 ($P<0.0001$) and 6-minute walk distance ($P<0.0001$).

Keywords: Muscle Dysfunction, COPD Patients, Dyspnea, Algeria

Introduction

Muscle dysfunction is one of the extra-pulmonary manifestations of COPD, which has a considerable impact on effort tolerance, quality of life and survival, without mentioning its medico-economic impact.

Methods

Stable COPD patients were recruited in order to assess their muscle dysfunction by measuring body composition using bioelectrical impedance (BIA), isometric voluntary contraction (MVC) as well as evaluating quadriceps endurance of the right lower limb. Patients' exercise tolerance was assessed by the 6-min walk test (6WT), dyspnea was estimate by the m MRC scale, and quality of life by the questionnaire (Q11).

The aim of our study was to assess the prevalence of muscle dysfunction in COPD patients and to identify its relationship to the severity of bronchial obstruction, as well as its impact on exercise tolerance and quality of life in these patients.

Muscle strength was measured by isometric maximal voluntary contraction (MVC) of the right lower limb while the patient was seated on an exercise bench with trunk and thigh fixed at 90°. The highest value of three brief (3 s) reproducible maneuvers was recorded.

Quadriceps endurance was assessed by the dynamic test, which consisted in measuring how long the patient could repeat leg extension-relaxation movements at a rate of 10 movements per minute and at a load equivalent to 30 or 40% of the MVC. Exercise was stopped if patients reached a fatigue-free time of 30 min.

Results

175 COPD patients (166 men and 9 women) aged 67(+/-9) years were recruited. The characteristics of the COPD patients are shown in Table 1.

Table 1: Characteristics of COPD

Parameters	Results
Number	175
Age (year)	67(9)
Sex M: F	166:9
Smoking (p / year)	35(20)
FEV1 (% pred)	52(21)
BMI (Kg/m^2)	21,32 (4,10)
FFMI (Kg/m^2)	18(4,7)
m MRC	2±1
Q11 score	30,60(10,85)

33.73% (56) of COPD males have an FFMI < 17 Kg/m^2 and 44.44% (4) of COPD females have an FMMI < 16 Kg/m^2 (Table 2), signifying a state of malnutrition, among them 5 (8%) have a normal BMI (Table 3).

Table 2: FFMI in COPD patients

Women (FFMI < 16 Kg/m^2)	Men (FFMI < 17 Kg/m^2)
44,44%	33,73%

Table 3: FFMI vs BMI in COPD patients

FFMI reduced	BMI normal
60	5
100%	8%

Prevalence of muscle dysfunction in COPD patients

Measurement of segmental muscle mass in COPD patients using BIA revealed an average value of 7.01(±1.25) kg for the legs and 2.33(±0.65) kg for the arms. Measurement of maximum voluntary force (MVC) in COPD patients revealed an average max force equal to 109.26 (± 42.79) (Nm), corresponding to 36.29 (± 13.98) (Kg) and 72.86 (± 21.22) %. As for quadriceps dynamic endurance time, the average value found was 3.74 (±1.14) min (Table 4). 111 (63.43%) COPD patients had a MVC below 80% of normal, with 29 (16.57%) below 50% (Fig 1).

Table 4: Results of muscle exploration in COPD patients

Parameters	Results
Muscle mass (leg) (kg)	7,01(1,25)
Muscle mass (Arm) (kg)	2,33(0,65)
MVC (Nm)	109,27 (42,8)
MVC (kg)	36,29 (13,98)
MVC %	72,86 (21,22)
Endurance (Min)	3,75(1,14)

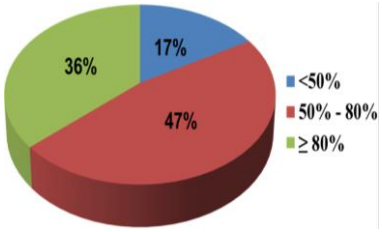

Fig 1: Results of quadriceps MVC measurement in COPD patients

Muscle weakness was found as early as the first stages of the disease, with 43% of COPD patients in GOLD stages I and II vs. 47% in stages III and VI (Fig 2).

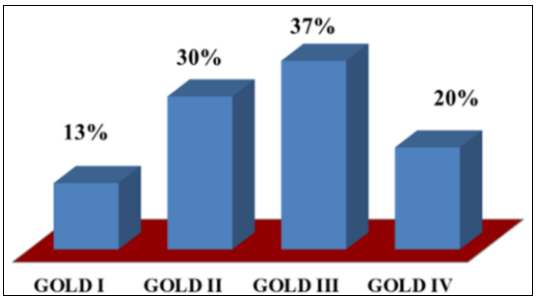

Fig 2: Distribution of COPD patients with muscle weakness according to functional stages (GOLD)

83 COPD patients (75%) with muscle weakness had dyspnea at a stage ≥ 2 m MRC (Fig 3).

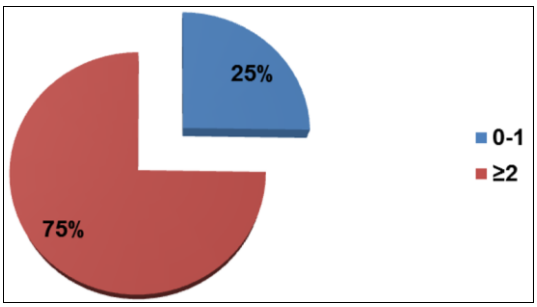

Fig 3: Stages of dyspnea in COPD patients with muscle weakness

Multiple regression analysis for quadriceps strength and endurance:

Maximal quadriceps strength correlated with FEV1 (P<0.014), FFMI (0.0001), which reflects overall muscle mass, and distance covered on 6WT (P<0.05). No correlation with quality of life (P<0.914) or endurance (P<0.66) (Table 5).

Quadriceps endurance correlated with FEV1 (P<0.0001) and 6WT (P<0.0001). No objective correlation of quadriceps endurance with BMI (P<0.681), FFMI (P<0.225) and quality of life (P<0.117) (Table 6).

Table 5: Multiple regression analysis of quadriceps strength

	A	Standard Error	Beta	P
(Constant)	-60,286	24,739		,016
FVI	,339	,136	,172	**,014**
BMI	,673	1,533	,064	,661
Q11	,029	,266	,007	,914
FFMI	8,554	1,072	,480	**,000**
6 WT (min)	,078	,040	,238	,050

Table 6: Quadriceps endurance multiple regression analysis

	A	Standard Error	Beta	P
Constant	2,579	,639		000
FV1	,022	,004	,416	**,000**
BMI	,018	,043	,063	,681
Q11	-,010	,007	-,096	,177
FFMI	-,009	,022	-,018	,689
6 WT (min)	,007	,000	,823	**,000**

Discussion

It is currently accepted that measuring BMI alone doesn't quantify the impact of COPD on body composition especially muscle mass [1]. In our study, general fat free masse FFM and segmental muscle mass was assessed using (BIA), which currently appears to be the method of choice for measuring body composition in COPD patients, given its ease, rapidity, and reproducibility, but its results must be interpreted with caution in cases of right heart failure with fluid retention [2, 3, 4]. 16% of our patients have a reduced FFMI despite a normal BMI, peripheral muscle atrophy accompanies COPD in 30% of cases, 10% of whom have a normal weight in several studies [2, 5].

Furthermore, Malaguti and al had observed a significant difference in the overall muscle mass and the segmental mass of the lower limbs ($P < 0.005$) in COPD compared to healthy control subjects [6].

The quadriceps is a fundamental ambulatory muscle, as it is the most solicited in the subjects' daily activities and is therefore the muscle that is essentially weakened in COPD [7, 8, 9, 10]**.** In our series, the prevalence of muscle weakness (MVC less than 80% of normal) in our COPD patients is 63.43%, and less than 50% in 29 (16.57%) patients. The mean value for quadriceps dynamic endurance time was 3.74 (±1.14) min.

In a study by Bernard and al, a 27% reduction in quadriceps MVC was observed in COPD patients compared to healthy controls. Similar findings have been demonstrated in other studies in the literature [11, 12, 13].

As for quadriceps endurance, we used dynamic measurement for our patients, whereas several comparative studies have looked at quadriceps endurance and found a decrease of 32% to 77% compared with healthy controls. This wide range is linked to the diversity of measurement methods used in these studies [14, 15, 16].

As reported in other studies [17, 18, 19] variations in quadriceps MVC correlate significantly with FMMI (0.0001), which reflects overall muscle mass.

A significant correlation was also found with FEV1 ($p<0.014$) in our series, similar results have been reported by some previous studies [20], something that is not always found sometimes muscle weakness is found even in mild to moderate COPD patients [21]. While no correlation was found with BMI or total quality of life score (Q11) ($P<0.661$) and ($P<0.914$) respectively.

In our study, quadriceps endurance correlated with FEV1 ($P<0.0001$), and the same finding was reported in a Chinese study [22]. This has not been reported in other studies [16, 23]. Quadriceps endurance correlated significantly with distance covered on 6WT in our series. No correlation with BMI ($P< 0.681$), or FFMI ($P< 0.225$), or quality of life (Q11) ($P< 0.117$). The only factor correlated with endurance is in fact the presence of hypoxia reported in the Koechlin study [24].

Conclusion

Muscular dysfunction in COPD patients leads to physical disability, which in turn results in high demand on healthcare services, high costs for healthcare organizations, and above all, effort intolerance leading to significant disability in activities of daily living.

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