

Nutritional status and its relationship with different dimensions of functional status in patients with chronic obstructive pulmonary disease

Estado nutricional e sua relação com diferentes dimensões do estado funcional em pacientes com doença pulmonar obstrutiva crônica

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ABSTRACT

Objective

To investigate whether there is a relationship between nutritional status and limitations in activities of daily living in patients with chronic obstructive pulmonary disease.

Methods

A cross sectional study was conducted from July to December 2011 in *Santa Catarina*. Seventeen chronic obstructive pulmonary disease patients [age (years) = 67±8; forced expiratory volume in one second (% of the predicted value) = 38.6±16.1; body mass index (kg/m²) = 24.7±5.4] underwent the assessments: pulmonary function (spirometry); functional status (London Chest Activity of Daily Living scale, physical activities in daily life, and Glittre ADL-Test; nutritional status (anthropometry and dual-energy X-Ray absorptiometry).

Results

The total score of the London Chest Activity of Daily Living scale correlated with fat-free mass ($r=-0.50$; $p=0.04$) and lean mass ($r=-0.50$; $p=0.04$). The lying time in physical activities in daily life correlated with bone mineral content ($r=-0.50$; $p=0.04$). Nutritional status was not correlated with time spent on Glittre ADL-test.

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Conclusion

Variables that reflect muscle mass depletion are related to variables of self-reported limitation in activities of daily living. Bone mineral content is correlated with time patients spend lying, reflecting the impact of inactive postures on the nutritional status of these patients.

Keywords: Activities of daily living. Evaluation. Chronic obstructive pulmonary disease. Nutritional status.

RESUMO

Objetivo

Investigar se existe relação entre o estado nutricional e a limitação em atividades de vida diária em pacientes com doença pulmonar obstrutiva crônica.

Métodos

Um estudo transversal foi conduzido de julho a dezembro de 2011 em Santa Catarina. Dezessete pacientes com doença pulmonar obstrutiva crônica [idade (anos) = 67 ± 8 ; volume expiratório forçado no primeiro segundo (% do valor predito) = $38,6 \pm 16,1$; índice de massa corporal (kg/m^2) = $24,7 \pm 5,4$] foram submetidos à avaliação da função pulmonar (espirometria); do estado funcional (escala London Chest Activity of Daily Living, monitorização das atividades físicas na vida diária e teste de AVD-Glittre); e do estado nutricional (antropometria e absorciometria por dupla emissão de Raios X).

Resultados

O escore total da escala London Chest Activity of Daily Living correlacionou-se negativamente com a massa livre de gordura ($r = -0,50$; $p = 0,04$) e com a massa magra ($r = -0,50$; $p = 0,04$). O tempo deitado nas atividades físicas na vida diária apresentou correlação negativa com o conteúdo mineral ósseo ($r = -0,50$; $p = 0,04$). Não foram encontradas correlações significativas entre variáveis de estado nutricional e tempo despendido no TGlittre.

Conclusão

Variáveis que refletem a depleção muscular estão relacionadas a variáveis de autorrelato de limitação em atividades de vida diária. O conteúdo mineral ósseo correlaciona-se ao tempo que os pacientes permanecem deitados, refletindo o impacto de posturas inativas no estado nutricional desses indivíduos.

Palavras-chave: Atividades cotidianas. Avaliação. Doença pulmonar obstrutiva crônica. Estado nutricional

INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is associated with pulmonary and systemic manifestations, such as nutritional abnormalities and skeletal muscle dysfunction¹ - which have an impact on patients' exercise capacity and on their ability to perform Activities of Daily Living (ADL)².

Among the nutritional abnormalities, the most common clinical manifestation is weight loss, especially related to muscle mass, which is particularly prevalent in more severe patients. Even in the absence of weight loss, the body composition of COPD patients present significant differences^{3,4}. These changes in body composition

are justified by factors like age, inflammation, oxidative stress, hypoxemia, hypercapnia, low levels of anabolic hormones and growth factors, impaired energy balance, corticosteroid use, vitamin D deficiency, and peripheral muscle disuse⁵.

Chronic obstructive pulmonary disease patients experience limitations in ADL, which lead to complaints of dyspnea and fatigue⁶. Thus, COPD patients start to avoid physical activities that trigger those symptoms, becoming increasingly deconditioned and less physically active². Considering that physical exercise can act as an anabolic stimulus in COPD patients⁷, low level of physical activity may exacerbate the imbalance between anabolism and catabolism, further reducing the muscle mass of these patients.

The relationship between nutritional status and exercise tolerance in COPD patients has been evidenced by the association of anthropometric and body composition variables with performance variables in maximum⁸⁻¹⁰ and submaximal^{11,12} exercise tests. However, the relationship between nutritional status and dimensions of functional status, such as functional capacity (people's maximum potential to perform activities in the normal course of their lives)¹³ and functional performance (activities that people actually perform in the normal course of their lives)¹³, evaluated by specific tests to assess limitations in ADL, has been little explored. Based on the above, this study aims to investigate the relationship between nutritional status and limitation in ADL in COPD assessed by instruments covering different dimensions of functional status.

Methods

A cross sectional study was conducted from July to December 2011 in *Florianópolis - Santa Catarina*. The study included patients with moderate to very severe COPD, of both genders, clinically stable during the previous month to the beginning of the study protocol, aged over 40 years, and with smoking history ≥ 20 pack-years. Patients unable to perform any part of the study protocol, currently smoking, or having other diseases - such as cardiomyopathy, musculoskeletal diseases, cancer, tuberculosis, asthma - were excluded. A total of 32 clinically stable patients from the pulmonology outpatient services of public hospitals and private clinics were invited to participate in the study. Twelve of the 32 declined to take part in the study and 20 agreed to participate. Seventeen patients completed the study and 3 were excluded: 2 due to inability to perform the proposed tests, and one for restarting to smoke during the protocol. The research was approved by the *Universidade Estadual Santa Catarina* (State University of *Santa Catarina*) Human Research Ethics Committee under the reference n° 85/2010.

Pulmonary function testing

Pulmonary function was tested by a spirometer (EasyOne, NDD Medical Technologies®, Andover, Massachusetts, USA), whose calibration was checked before the evaluations. Spirometry was performed in accordance with the American Thoracic Society/European Respiratory Society (ATS/ERS) standards¹⁴. The Post-Bronchodilator (BD) variables Forced Expiratory Volume in One Second (FEV₁), in Liters (L), and in percentage of the predicted value (%pred), Forced Vital Capacity (FVC), also in L and in %pred, and their *ratio* (FEV₁/FVC) were included. The post-BD FEV₁/FVC and FEV₁ in %pred were used to identify airflow limitation and to classify it (mild, moderate, severe, or very severe)¹⁵. The predicted values were calculated from the equations proposed by Pereira *et al.*¹⁶ for Brazilians.

Functional Status

The London Chest Activity of Daily Living (LCADL) scale, validated for Brazilian Portuguese, consists of ordinary ADL divided into four domains (personal care, household activities, physical activities, and leisure), which are arranged in 15 quantitative items for a maximum score of 75 points. The total LCADL score and percentage of the total LCADL score (LCADL % total score) were calculated¹⁷.

The Physical Activities in Daily Life (PADL) were monitored by a triaxial accelerometer (DynaPort Activity Monitor, McRoberts BV®, The Hague, The Netherlands), which measures the time in minutes (min) spent standing, sitting, lying, and walking, and movement intensity during walking, in meters per second squared (m/s²). The participants were monitored for two consecutive week days for 12 hours after awakening. All patients received thorough instructions on equipment use, an explanatory and illustrated manual, and a diary to record monitoring times and difficulties. Patients were instructed not to change their usual activities while using the device². The MIRA 2nd version software (DynaPort

Activity Monitor, McRoberts BV®, The Hague, The Netherlands) processed the collected data.

The Glittre ADL-test (TGlittre) consists of completing a circuit while carrying a weighted backpack (2.5 kg for women, 5.0 kg for men). The circuit is as follows: from a sitting position, the patient stands up and walks along a flat 10-m long course; in the middle of which is a two-step staircase (each step 17 cm high × 27 cm deep) to be traversed; after completing the second 5 m, the subject faces a shelf containing three objects, each weighing 1 kg, positioned on the top shelf (shoulder height) and moves them one by one to the bottom shelf (waist height) and then to the floor; the objects are then returned to the bottom shelf and finally to the top shelf again; the patient then walks back along the circuit, climbing the stairs up and down, until reaching the starting point (chair); sitting down and immediately beginning the next lap. Patients were instructed to complete five laps on this circuit as quickly as possible¹⁸. Heart Rate (HR monitor FS2c, Polar®, Finland), Saturation of Peripheral Oxygen (SpO₂) (Oxi-Go, Oximeter Plus®, New York, New York, USA) and index of dyspnea (modified Borg scale) were measured at the beginning, at every turn, and at the end of the test. The test was performed in the absence of verbal stimuli.

Nutritional Status

Patients used nothing but an apron during nutritional status assessment. Weight in kilograms (kg) was measured by a scale accurate to 100 g (BC-558 Ironman, Tanita Corporation®, Tokyo, Japan). Height in meters (m) was measured by stadiometer with accuracy of 0.1 cm (Standard, Sanny®, São Bernardo do Campo, São Paulo, Brazil). Body Mass Index (BMI) was calculated by dividing weight by the square of the height (kg/m²)¹⁹.

Body composition was assessed by Dual Energy X-Ray Absorptiometry (DEXA), which is based on the differential attenuation of X-Rays between body tissues²⁰. Dual energy X-Ray

absorptiometry whole body scan was performed with the patients in the supine position by a medical radiology technician certified by the Brazilian Society of Clinical Densitometry. Bone density was measured by a bone densitometer (Lunar Prodigy Advance, GE Medical Systems Lunar®, Diegem, Belgium), calibrated as instructed by the manufacturer and the software Prodigy encore v.12.30 (GE Medical Systems Lunar®, Diegem, Belgium). The included variables were fat mass, Bone Mineral Content (BMC), Lean Mass (LM), and Fat-Free Mass (FFM - consisting of the sum of LM and BMC²¹) in kg; and Fat-Free Mass Index (FFMI), calculated by the dividing FFM in kg by the square of the height in meters²².

The body mass index and fat-free mass index were used for detecting depletion of body weight and FFM and for categorizing patients into cachexia, semi-starvation, muscle atrophy, and no impairment of body composition²³. Body mass index was also used for classifying overweight and obesity¹⁹.

Statistical Analysis

The Shapiro-Wilk test was used, along with the parametric (Pearson) or nonparametric (Spearman) correspondent test according to data distribution. The data were summarized using the Statistical Package for the Social Sciences version 20.0 (SPSS, IBM®, Somers, New York, USA). The significance level for the statistical treatment was 5% ($p < 0.05$).

RESULTS

Seventeen patients (14 men) with moderate ($n=4$), severe ($n=6$), and very severe ($n=7$) airflow limitation were included in the study. Sixteen patients were treated with β_2 agonists, and 9 with anticholinergics. Table 1 shows the sample characteristics.

In the functional status assessment, the average time spent in TGlittre varied between 4.20 min (4 min and 12 s) and 5.83 min (5 min and 50 s). The average LCADL total score ranged

from 14.4 to 21.5 points while the LCADL %total score from 22.3 to 33. Regarding PADL, patients spent an average of 67.4±10.7% of monitored time in sedentary positions (lying or sitting) and 31.2±9.5% of the time in active positions (standing or walking). Table 1 describes the functional status variables.

Six patients had body weight depletion, 5 were overweight, and 3 were obese. Depletion of FFM was present in 4 patients. Two patients presented semi-starvation, 4 presented cachexia, and the others had no impairment of body composition. Table 1 provides the nutritional status variables.

The LCADL total score was negatively correlated with FFM ($r=-0.50, p=0.04$) and LM ($r=-0.50, p=0.04$). Lying time in PADL was negatively correlated with BMC ($r=-0.50, p=0.04$), and the latter was correlated with BMI ($r=0.62, p=0.007$) but not with age. No other PADL correlated with nutritional status. No significant

correlations between nutritional status variables and time spent in TGlitre were found. Figure 1 shows the correlations.

DISCUSSION

The present study was able to show correlations between body composition variables, related to muscle and bone mass, and functional performance variables, however, no significant correlations between the variables of nutritional status and functional capacity could be observed.

Low level of physical activity in daily living may worsen the imbalance between muscle anabolism and catabolism, and influence the functional status of COPD patients. In this context, functional performance may reflect more appropriately LM and BMC as it regards the activities that individuals actually perform in everyday life and reveal how individuals are active.

Table 1. Sample characteristics, and functional and nutritional statuses.

| Variables | Mean | SD | Median | 95%CI | |
|--|--------|------|--------|-------|--------|
| | | | | LL | UL |
| Age (years) | 67 | 8 | | 63.0 | 71.00 |
| Smoking history (pack-years)# | | | 50.00 | 24.0 | 74.00 |
| FEV ₁ /FVC | 0.45 | 0.11 | | 0.39 | 0.51 |
| FEV ₁ (L) | 1.17 | 0.49 | | 0.92 | 1.42 |
| FEV ₁ (%pred) | 38.70 | 16.1 | | 30.4 | 46.90 |
| FVC (L) | 2.63 | 0.61 | | 2.21 | 2.84 |
| FVC (%pred) | 64.50 | 16.0 | | 56.2 | 72.70 |
| LCADL (points) | | | 18.00 | 13.0 | 21.00 |
| LCADL (%total score) | 27.70 | 10.4 | | 22.3 | 33.00 |
| Lying time (min)# | | | 76.00 | 0 | 143.50 |
| Sitting time (min) | 394.90 | 93.6 | | 346.7 | 443.00 |
| Standing time (min)# | | | 130.00 | 112.0 | 163.50 |
| Walking time (min)# | | | 68.00 | 57.5 | 87.00 |
| Movement intensity (m/s ²) | 1.81 | 0.30 | | 1.65 | 1.96 |
| TGlitre (min)# | | | 4.67 | 3.97 | 5.47 |
| BMI (kg/m ²) | 24.70 | 5.40 | | 21.9 | 27.50 |
| FM (kg) | 20.70 | 9.37 | | 15.9 | 25.60 |
| BMC (kg) | 2.43 | 0.46 | | 2.19 | 2.66 |
| LM (kg) | 48.30 | 8.16 | | 44.1 | 52.50 |
| FFM (kg) | 50.70 | 8.53 | | 46.3 | 55.10 |
| FFMI (kg/m ²) | 18.80 | 2.88 | | 17.3 | 20.30 |

Note: #Median and interquartile range (25% - 75%); %Pred: Percentage of the Predicted value; %total: percentage of LCADL: London Chest Activity of Daily Living scale; %total: percentage of LCADL total score; SD: Standard Deviation; CI: Confidence Interval; LL: Lower Limit; UL: Upper Limit; FEV₁: Forced Expiratory Volume in 1 s; FVC: Forced Vital Capacity; LCADL: London Chest Activity of Daily Living scale; TGlitre: Glitire ADL-test; BMI: Body Mass Index; BMC: Bone Mineral Content; FM: Fat Mass; LM: Lean Mass; FFM: Fat-Free Mass; FFMI: Fat-Free Mass Index.

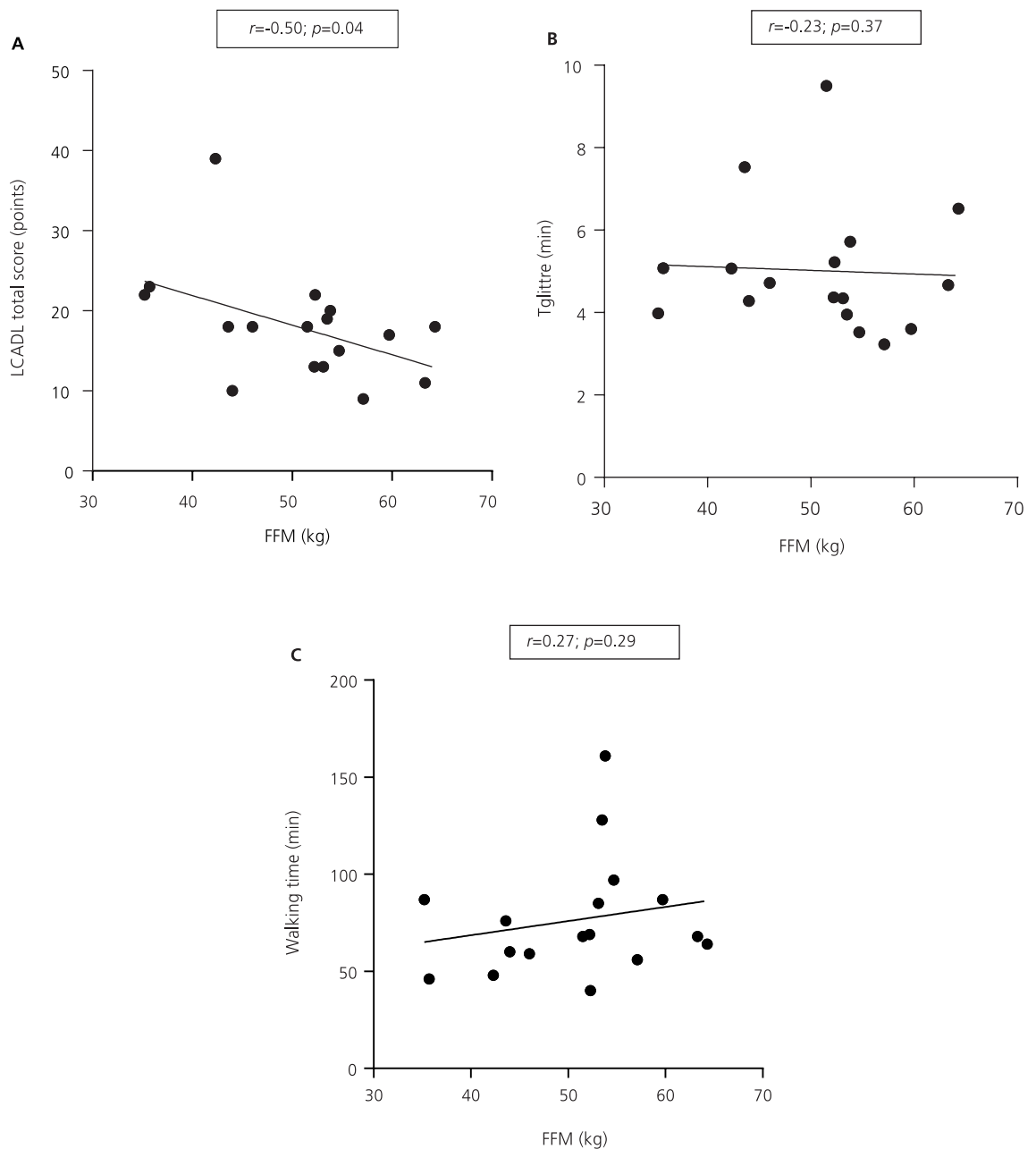


Figure 1. Correlation between Fat-Free Mass (FFM) and (A) London Chest Activity of Daily Living (LCADL) scale total score; (B) Time spent in Glittre ADL-test (TGlittre); (C) walking time.

The associations of BMI with peak work rate¹⁰, peak workload⁹, oxygen uptake at peak^{8,9}, and oxygen uptake at anaerobic threshold⁸ have already been demonstrated. Also, FFM was a determining factor of peak workload and oxygen uptake at peak⁹, suggesting the influence of nutritional status on muscle aerobic capacity and

exercise tolerance in COPD patients. Furthermore, depletion of FFM has been identified as an important negative factor for the functional capacity of COPD patients, regardless of FEV₁²⁴.

Pulmonary function alone has not been considered a good predictor of nutritional status³ and functional performance in these patients².

The study patients had severe impairment of lung function (13 patients with severe or very severe airflow limitation). Notwithstanding, they presented no significant impairment of body composition, and nutritional depletion was observed in only 6 of the 17 patients. Additionally, these patients had less functional impairment than Brazilian patients from other studies^{17,25,26}. The present patients were more active than those of other studies; walked more (on average 76.4 min/day vs. 55 min/day)²⁵, and spent less time lying (mean 84.4 vs 119 min/day)²⁶ during their PADL. In addition, patients had an average LCADL %total score of less than 50, indicating that those patients were possibly only slightly limited in their functional status²⁷.

The relationship between LCADL and nutritional status has been analyzed previously²⁷, but it only included BMI. The present study found correlations of LCADL total score with LM and FFM. Indeed, functional limitation is strongly related to muscle wasting and reduced muscle mass^{11,12,24}. This means that LCADL total score is sensitive to detect this relationship.

Despite everything, an ADL multiple-task test, such as the TGlittre, had not yet been used to investigate this relationship. Previous studies that sought to assess the functional capacity of COPD patients by Six-Minute Walk Test (6MWT) found that BMI and FFMI were positively correlated with the distance covered in this test^{11,12,24}. However, the present study found no correlations between nutritional status variables and time spent in TGlittre, which mimics the situations experienced in ADL with a set of common activities of daily living, generally limited in COPD patients. But it is worth noting that the authors who validated the TGlittre suggested that the test may not discriminate patients with lower functional limitation well¹⁸, a factor that may have contributed to the absence of correlations.

In the physical activities in daily life analysis, the study patients spent most of the monitored time in sedentary postures. Nevertheless, this time was still lower than times reported by previous

studies^{2,25}. Moreover, BMC and the time the study patients spent lying were negatively correlated.

Physical inactivity is a risk factor for low Bone Mineral Density (BMD), as well as higher age, smoking, low BMI, systemic inflammation, pulmonary dysfunction, glucocorticoid use, and vitamin D insufficiency/deficiency²⁸. Besides the correlation between BMC and physical inactivity, the present study also found a correlation between BMC and BMI, but not between bone mineral content and age. Bone is a biomechanical tissue that adapts its structure to withstand varying forces stemming from muscle activity and gravity²⁹. The relationship between physical activity, objectively measured by triaxial accelerometers, and BMD has been described in both healthy older adults³⁰ and in COPD patients³¹. In healthy older adults, a positive association was found between moderate to vigorous physical activity and femoral neck BMD³⁰. Moreover, COPD patients with osteoporosis had lower level of daily physical activity than those without COPD, and daily physical activity correlated positively with lumbar spine, total hip, and femoral neck BMD³¹.

This study found no other correlations between PADL and nutritional status variables. Pitta *et al.*², studying the PADL of COPD patients, also found no correlation between BMI and monitored standing or walking time. In turn Monteiro *et al.*³² found that monitored time spent in at least moderate-intensity activities correlated with body weight, BMI, and FM, but not with FFM. Likewise, Waschki *et al.*³³ found that patients with sustained physical inactivity for 3 years had greater FFM decrease than patients with some level of physical activity, regardless of FEV₁.

Assessment of body composition can be performed by direct (dissection of cadavers), indirect (hydrostatic weighing, DEXA), and doubly indirect (anthropometry and bioelectrical impedance analysis) methods. In this context DEXA - method used in this study - has the potential to provide overall and regional assessment of body composition in terms of fat, lean, and bone masses²⁰. Many studies that set

out to analyze body composition did so based only on data obtained from simple BMI calculation. Although BMI is the most commonly used indicator, it does not provide clear information about the distribution of lean mass or fat-free mass.

Patients were not classified based on the presence of emphysema (lean look and significant weight loss) or chronic bronchitis (obese or without marked weight loss) since it is often difficult to distinguish these overlapping phenotypes. Furthermore, the small percentage of malnourished patients may be explained by the fact that only three of them were female, and COPD women have a higher prevalence of nutritional depletion than their male counterparts³. Nutritional and functional impairments begin early in this population. COPD patients reduce their physical activity early, before the onset of breathlessness³⁴. Additionally, even older symptomatic smokers who do not meet the diagnostic criteria for COPD present nutritional deficits³⁵.

The patients' nutritional and functional characteristics may have compromised the strength of the study correlations. The relationship between nutritional status and functional status measured by TGlitter may be more evident in patients with greater functional impairment since the test appears to be less discriminatory in patients with fewer limitations in ADL. The study power was calculated based on the correlation coefficient (r) of LCADL total score with FFM and LM ($r=-0.50$ for both). With the present sample and $\alpha=0.010$, the power to detect the relationship between functional and nutritional limitations was 80%.

In despite of its strengths, some limitations of this study should be made clear. Although the sample size was sufficient, a relatively small number of patients, especially women, were included in the study. This prevented gender comparisons, even though it was not the aim of this study. In spite of this, the results were consistent and thereby, seem to be representative

for this group. The statistical power for the analysis was 80%.

This appears to be the first study to investigate the relationship between nutritional and functional statuses using specific tools validated for COPD for assessing limitations in ADL. The understanding of this relationship can guide interdisciplinary therapeutic approaches that aim to improve those two outcomes, such as pulmonary rehabilitation, optimizing COPD prognosis.

In summary, in patients with moderate to very severe COPD, nutritional status variables reflecting muscle mass correlate with variables of self-reported limitations in ADL. Bone Mineral Content correlates with the daily time patients spend lying, reflecting the impact of inactive positions on their nutritional status. Further studies are needed to investigate the relationship between nutritional and functional statuses in COPD patients with greater nutritional depletion and functional limitations.

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Received: December 9, 2015

Final version: May 18, 2016

Approved: June 17, 2016