Brazilian Journal of Physical Therapy 2020;24(3):264–272

abrapg·ft
Associação Brasileira de Pesquisa e Pós-Graduação em Fisioterapia

Brazilian Journal of Physical Therapy

https://www.journals.elsevier.com/brazilian-journal-of-physical-therapy

ORIGINAL RESEARCH

The London Chest Activity of Daily Living scale cut-off point to discriminate functional status in patients with chronic obstructive pulmonary disease

Aline Almeida Gulart[a,b], **Anelise Bauer Munari**[a,b], **Suelen Roberta Klein**[a,b], **Raysa Silva Venâncio**[a,c], **Hellen Fontão Alexandre**[a,c], **Anamaria Fleig Mayer**[a,b,c,*]

[a] *Center for Assistance, Teaching and Research in Pulmonary Rehabilitation (NuReab), Universidade do Estado de Santa Catarina (UDESC), Florianópolis, Santa Catarina, Brazil*
[b] *Human Movement Sciences Graduate Program, Centro de Ciências da Saúde e do Esporte (CEFID), Universidade do Estado de Santa Catarina (UDESC), Florianópolis, Santa Catarina, Brazil*
[c] *Physical Therapy Graduate Program, Centro de Ciências da Saúde e do Esporte (CEFID), Universidade do Estado de Santa Catarina (UDESC), Florianópolis, Santa Catarina, Brazil*

Received 3 August 2018; received in revised form 12 February 2019; accepted 18 March 2019
Available online 26 March 2019

KEYWORDS
Chronic obstructive pulmonary disease;
Activities of daily living;
Exercise;
Rehabilitation;
Interpretability;
Outcome assessment (health care).

Abstract
Objective: To determine the cut-off point for the London Chest Activity of Daily Living scale in order to better discriminate functional status. Secondarily, to determine which of the scores (total or %total) is better associated with clinical outcomes of a pulmonary rehabilitation program.
Methods: Sixty-one patients with chronic obstructive pulmonary disease performed the following tests: spirometry; Chronic Obstructive Pulmonary Disease Assessment Test; Saint George's Respiratory Questionnaire; modified Medical Research Council, the body-mass index, airflow obstruction, dyspnea, and exercise capacity index; six-minute walk test; physical activity in daily life assessment and London Chest Activity of Daily Living scale. Thirty-eight patients were evaluated pre- and post-pulmonary rehabilitation . The cut-off point was determined using the receiver operating characteristic curve with six-minute walk test (cut-off point: 82%pred), modified Medical Research Council (cut-off point: 2), level of physical (in)activity (cut-off point: 80 min per day in physical activity $\geq$3 metabolic equivalent of task) and presence/absence of severe physical inactivity (cut-off point: 4580 steps per day) as anchors.
Results: A cut-off point found for all anchors was 28%: modified Medical Research Council [sensitivity = 83%; specificity = 72%; area under the curve = 0.80]; level of physical (in)activity [sensitivity = 65%; specificity = 59%; area under the curve = 0.67] and classification of severe physical inactivity [sensitivity = 70%; specificity = 62%; area under the curve = 0.70]. The patients who scored $\leq$28% in %total score of London Chest Activity of Daily Living had lower modified Medical Research Council , Chronic Obstructive Pulmonary Disease Assessment Test,

* Corresponding author at: Núcleo de Assistência, Ensino e Pesquisa em Reabilitação Pulmonar (NuReab), UDESC, Rua Pascoal Simone 358, CEP 88080-350, Florianópolis, Santa Catarina, Brazil.
E-mail: anamaria.mayer@udesc.br (A.F. Mayer).

https://doi.org/10.1016/j.bjpt.2019.03.002

Saint George's Respiratory Questionnaire, body-mass index, airflow obstruction, dyspnea and exercise capacity index and sitting time than who scored >28%, and higher forced expiratory volume in the first second, time in physical activity ≥3 metabolic equivalent of task, steps per day and six-minute walk distance. The %total score of London Chest Activity of Daily Living correlated better with clinical outcomes than the total score.
Conclusions: The cut-off point of 28% is sensitive and specific to distinguish the functional status in patients with chronic obstructive pulmonary disease. The %total score of the London Chest Activity of Daily Living reflects better outcomes of chronic obstructive pulmonary disease when compared to total score.

Introduction

In patients with chronic obstructive pulmonary disease (COPD), the impaired functional status is related to the increased risk of exacerbations, hospitalizations and death.[1,2] Improving the functional status is one of the main objectives of Pulmonary Rehabilitation Programs (PRP) and, therefore, its evaluation is essential.[3] It is recommended the choose of instruments with well-established measurement properties[4] and which have interpretability criteria, as the cut-off point that discriminates patients with better or worse outcome.[4–6] Similarly, the easy applicability and low cost are important features to be considered when choosing an instrument for use in clinical practice, which can be obtained by using questionnaires and scales.[4,7]

The London Chest Activity of Daily Living scale (LCADL) is valid and reliable to assess the functional limitation in patients with COPD due to dyspnea,[8,9] as well as being responsive to changes with PRP.[10] The scale has four domains distributed into 15 items with each item scored from 0 to 5, and higher scores mean greater functional limitation. From the summation of the scores, a total score ($LCADL_{total}$) is obtained, and the larger the score is, the greater the patient's functional limitation.[11] However, the items with a ''0'' score (i.e. activities that the patients have never performed because they never had to do the activity or consider it irrelevant) can reduce $LCADL_{total}$, overestimating their functional status.[8] The percentage of the total score ($LCADL_{\%total}$) was created to establish a more reliable and sensitive measure, disregarding the activities with score ''0''.[8] Although previous studies have shown that $LCADL_{\%total}$ correlated better than $LCADL_{total}$ with body-mass index, airflow obstruction dyspnea and exercise capacity index (BODE), forced expiratory volume in the first second, six-minute walk test (6MWT), modified Medical Research Council (mMRC) scale and Glittre Activity of Daily Living-test,[8,11,12] it is not known whether this association also occurs with other important outcomes, such as health status, health-related quality of life and level of physical activity in daily life (PADL).

Simon et al.[12] proposed a cut-off point of 50% for LCADL using the BODE index as the anchor. However, although the BODE includes instruments that evaluate constructs related to functional status, this index raises the risk of death. Therefore, there is still no cut-off point for $LCADL_{\%total}$ capable of discriminating functional status of patients with COPD. Also, only the $LCADL_{total}$ provides minimal detectable change.[13] However, the interpretation of improvement of functional status post-PRP using $LCADL_{total}$ may not be reliable, but no papers have been found to confirm it.

Therefore, the study's primary objective was to determine the cut-off point for $LCADL_{\%total}$ in order to better discriminate functional status. Second, to determine which of the scores (total or %total) was more closely associated with lung function, dyspnea, health-related quality of life, health status, functional status, and PADL level, as well as better reflecting the change in functional status and other outcomes in COPD; and third, to analyze the agreement between $LCADL_{total}$ and $LCADL_{\%total}$ in the interpretation of PRP effects on the functional status of patients with COPD.

Methods

This study was cross-sectional, approved by the Human Research Ethics Committee of the Universidade do Estado de Santa Catarina (UDESC), Florianópolis, Santa Catarina, Brazil (CAAE: 80831117.5.0000.0118). Patients with COPD, referred to the Center for Assistance, Teaching and Research in Pulmonary Rehabilitation (NuReab), with clinical diagnosis of COPD and the Global Initiative for Chronic Obstructive Lung Disease classification II-IV[1]; ages 40–80 years; with clinical stability in the last month before the initiation of the protocol; and those with optimized medication participated in the study. The exclusion criteria were: exacerbation of COPD during the protocol; associated disabling diseases and other respiratory conditions; hospitalization in the 12 weeks before the initiation of the protocol; participation in PRP over the past six months; and active smoking or stopped for less than six months prior to this study. A subgroup who completed the PRP was included in the analysis of the improvement in functional status interpretation. The exclusion criteria for this analysis were: conditions other than COPD that might compromise the physical training progression; interruption of PRP for any reason; and severe exacerbation of COPD. All patients signed a consent form.

The evaluation protocol was composed of four days. In the first day, spirometry was performed and the COPD Assessment Test, Saint George's Respiratory Questionnaire,

mMRC and LCADL were completed. On the second day, the 6MWT was performed and on the third and fourth day, the PADL was monitored.

The EasyOne portable spirometer (NDD Medical Technologies®, Switzerland) was used for spirometry, with calibration checked before each evaluation. The American Throracic Society/European Respiratory Society[14] recommendations and the reference equations for the Brazilian population were used.[15]

Health status was assessed using the COPD Assessment Test. For the analysis, the total score was considered and the higher the score, the greater the impact of COPD on the patient's health status.[16] To evaluate the quality of life-related to respiratory disease, Saint George's Respiratory Questionnaire was used.[17] The total score and the score in each domain were considered for the analyses and the higher the score, the worse the quality of life.[17] The mMRC was applied to evaluate the dyspnea on exertion and the higher the score, the worse the dyspnea . Patients were divided into two groups: mMRC <2 and mMRC ≥2.[1]

Two 6MWT were performed on the same day as recommended,[18] with a minimum interval of 30 min between tests. The best values for the distance in meters and percentage of predicted (%pred)[19] were considered for the analyses. Patients were categorized as abnormal (<82 %pred) and normal (≥82 %pred) functional capacity.[20]

The patients used a triaxial accelerometer (DynaPort MiniMod, McRoberts BV, The Netherlands) by 12 h of two consecutive days, starting after awakening.[21] The mean of two days was used for analysis. The time spent in PADL <1.5 METs[22] ≥8.5 h/day[23] was considered sedentary. The level of physical (in)activity was classified based on an 80 min/day cut-off point in PADL ≥3 METs.[24] For the classification of severe physical inactivity, the number of steps per day (<4580 steps/day)[25] was considered. The data was read and processed using the MiRA2 software (McRoberts BV, The Netherlands).

The BODE index was calculated to identify the risk of death.[26]

London Chest Activity of Daily Living scale (LCADL)

The LCADL evaluates the limitation to perform activities of daily living by dyspnea[8,9] and looks at four domains: self-care, domestic, physical and leisure. It is composed of 15 items, which are scored by the patient as follows: 0 (I do not perform this activity because I never had to do it or it is irrelevant), 1 (I do not feel any breathless when performing this activity), 2 (I feel moderate breathless when performing this activity), 3 (I feel a lot of breathless in doing this activity), 4 (I cannot perform this activity due to breathless and I have no one who can do the activity for me) or 5 (I cannot perform this activity anymore and I need someone to do it for me or help me because of breathless). The $LCADL_{total}$ and $LCADL_{\%total}$[27] were used for the analyses.

Pulmonary Rehabilitation Program (PRP)

A subgroup of patients participated in a PRP of 24 sessions based on physical training and education, three times a week, as recommended by American Thoracic Society/European Respiratory Society.[3] The program included continuous aerobic treadmill training (30 min with intensity determined by the modified Borg scale[28] between 4 and 6) and localized training for upper limbs using free weights or elastic bands (two sets, lasting 2 min of each modified diagonal of the proprioceptive neuromuscular facilitation method) and lower limbs (quadriceps and triceps sural) using free weights and/or the extensor chair (2 sets of 10 repetitions) and global stretch training (30 s for each muscle group). Immediately post-PRP, the patients were reassessed using the COPD Assessment Test, the Saint George's Respiratory Questionnaire, the mMRC, the 6MWT, the PADL and the LCADL.

Statistical analysis

The sample size was calculated using the MedCalc software 17.1 and an area under the curve of 0.70[5] was expected. With a bidirectional alpha of 0.05 and 80% power, a sample size of 60 patients was estimated.

The SPSS Statistics 20.0 software was used for data processing. A significance level of 5% was adopted. The Shapiro–Wilk test was used to analyze the data distribution. The Spearman correlation coefficient was adopted to verify if there was any correlation of $LCADL_{total}$ and $LCADL_{\%total}$ with other variables. The correlation coefficient was classified as: weak ($r \geq 0.3$), moderate ($r \geq 0.50$), strong ($r \geq 0.70$) and perfect ($r = 1$).[29] Also, patients were compared for $LCADL_{total}$ and $LCADL_{\%total}$ in pre-PRP, based on the following values for 6MWT (≥82 and <82 %pred),[20] mMRC (<2 and ≥2), physical (in)activity (≥80 and <80 min/day in PADL ≥3 METs)[24] and severe physical inactivity (≥4580 and <4580 steps/day)[25] using the Mann–Whitney *U* test.

Determination of a cut-off point for LCADL

The variables related to functional status were used as anchors to determine the cut-off point for $LCADL_{\%total}$, which achieved the following criteria: (1) correlation ≥0.3 with $LCADL_{\%total}$; and (2) classifications capable of distinguishing patients in relation to $LCADL_{\%total}$. The most sensitive and specific cut-off point in the $LCADL_{\%total}$ that discriminated the patients functional status was determined using the receiver operating characteristic curve[5] with the following four anchors: 6MWT, mMRC, level of physical (in)activity and presence/absence of severe physical inactivity. The area under the curve was calculated for each anchor. To verify whether these classifications were associated with the classification based on the cut-off point found for the $LCADL_{\%total}$, the Chi-square was used. The associations strength was demonstrated by Cramer's V coefficient. Considering the cut-off point found in the receiver operating characteristic curve, the patients were classified into two groups and compared for the following variables: PADL, 6MWT, mMRC, Saint George's Respiratory Questionnaire, COPD Assessment Test and BODE, using the Mann–Whitney *U* test.

Table 1 Anthropometric characteristics, pulmonary function, functional status, severity of dyspnea, health status, quality of life and physical activities in daily life of the sample.

Variables	Mean ± SD ($n = 61$)	LCADL ≤ 28%Mean ± SD ($n = 25$)	LCADL > 28%Mean ± SD ($n = 36$)	*p-value*
Age (years)	65.5 ± 8.76	66.3 ± 8.93	65.0 ± 8.72	0.70
Body weight (kg)	72.7 ± 15.1	72.2 ± 14.2	73.1 ± 15.9	0.85
Heigth (m)	1.67 ± 0.09	1.68 ± 0.09	1.66 ± 0.09	0.59
BMI (kg/m^2)	26.0 ± 4.80	25.4 ± 4.32	26.5 ± 5.12	0.45
FEV_1/FVC	0.44 ± 0.09	0.47 ± 0.09	0.41 ± 0.09	0.01
FEV_1 (L)	1.06 ± 0.44	1.26 ± 0.37	0.93 ± 0.44	0.001
FEV_1 (%pred)	34.9 ± 13.3	40.3 ± 11.5	31.2 ± 13.5	0.004
FVC (L)	2.39 ± 0.77	2.63 ± 0.76	2.22 ± 0.74	0.02
FVC (%pred)	62.0 ± 17.0	66.9 ± 15.4	58.5 ± 17.4	0.06
6MWT (m)	430 ± 96.3	467 ± 91.1	404 ± 92.2	0.01
6MWT (%pred)	74.7 ± 16.1	80.2 ± 14.6	70.9 ± 16.2	0.04
mMRC[a]	1 [2]	1 [0]	2 [2]	<0.001
CAT (total)	17.3 ± 8.06	11.0 ± 5.45	21.6 ± 6.60	<0.001
$SGRQ_{symptoms}$	39.4 ± 22.4	25.5 ± 16.8	49.1 ± 20.9	<0.001
$SGRQ_{activity}$	66.5 ± 21.0	48.5 ± 14.5	79.0 ± 14.8	<0.001
$SGRQ_{impact}$	38.4 ± 21.3	21.0 ± 12.3	50.5 ± 17.5	<0.001
$SGRQ_{total}$	47.2 ± 19.6	30.1 ± 10.6	59.0 ± 15.3	<0.001
BODE index (score)	3.54 ± 1.87	2.64 ± 1.25	4.17 ± 1.98	0.001
Time sitting (min)	383 ± 104	351 ± 101	406 ± 101	0.045
Time lying (min)	105 ± 105	115 ± 119	97.7 ± 94.8	0.69
Time standing (min)	140 ± 54.9	144 ± 64.5	137 ± 48.0	0.94
Time walking (min)	68.5 ± 38.2	71.1 ± 34.8	66.7 ± 40.8	0.36
Steps	5273 ± 2726	6236 ± 2771	4605 ± 2521	0.02
Time in activities <1.5 MET (min)	583 ± 68.4	568 ± 67.3	593 ± 68.2	0.15
Time in activities ≥3 METs (min)	84.1 ± 41.2	95.1 ± 40.7	76.4 ± 40.3	0.046

SD, standard deviation; $LCADL_{total}$, total score ofLondon Chest Activity of Daily Living; $LCADL_{\%total}$, percentage total score of London Chest Activity of Daily Living; kg, kilograms; m, meters; BMI, body mass index; FEV_1, forced expiratory volume in the first second; L, liters; %pred, percentage of predicted; FVC, forced vital capacity; 6MWT, six-minute walk test; mMRC, modified Medical Research Council scale; CAT, COPD Assessment Test; SGRQ, Saint George's Respiratory Questionnaire; min, minute; MET, metabolic equivalent of tasks.

[a] Results are presented as median [interquartile range].

Interpretation of change in functional status post-PRP

The Wilcoxon test was used to compare $LCADL_{total}$ and $LCADL_{\%total}$ between pre-PRP and post-PRP moments. The patients were classified according the change in functional status, using $LCADL_{total}$ and $LCADL_{\%total}$: without changes (post-PRP − pre-PRP = 0), worsening (post-PRP > pre-PRP) and improvement (post-PRP < pre-PRP). The agreement between $LCADL_{total}$ and $LCADL_{\%total}$ for change in functional status was tested using Kappa agreement analysis and interpreted as previously described.[30] Also, a qualitative and descriptive analysis of changes in $LCADL_{total}$ and $LCADL_{\%total}$ post-PRP was performed.

Results

There were 66 patients potentially eligible. Five were excluded due to COPD exacerbation during the protocol. Thus, 61 patients (47 men) completed the study. Ten patients presented moderate impairment of pulmonary function, 28 severe and 23 very severe impairment. According to the BODE classification, 22 patients were classified in the quartile I, 22 in the quartile II, 12 in the quartile III and five in the quartile IV. The sample characteristics are described in Table 1.

Forty-four patients reported a ''0'' score for at least one of the LCADL items. The $LCADL_{\%total}$ had higher correlation coefficients than $LCADL_{total}$ for the most of the variables tested. Also, only the $LCADL_{\%total}$ correlated with the PADL level variables (Table 2).

Patients with mMRC ≥2 presented higher $LCADL_{total}$ [mean difference: 9.48 (95%CI: 3.46–15.5); $p = 0.002$] and $LCADL_{\%total}$ [mean difference: 14.7% (95%CI: 7.67–21.8%); $p < 0.001$] when compared to patients with mMRC <2. The $LCADL_{total}$ score did not differ between active and inactive patients [mean difference: 4.64 (95%CI: −1.29 to 10.6); $p = 0.26$], while $LCADL_{\%total}$ was higher for inactive patients [mean difference: 8.02% (95%CI: 0.76–15.3%); $p = 0.03$]. Patients with severe physical inactivity presented higher $LCADL_{total}$ [mean difference: 6.46 (95%CI: 0.40–12.9), $p = 0.04$] and $LCADL_{\%total}$ [mean difference: 10.1% (95%CI 2.33–17.9%); $p = 0.007$] than those without severe physical inactivity. When comparing patients with normal and abnormal functional capacity, there was no difference in $LCADL_{total}$ [mean difference: 5.77 (95%CI: −0.75 to 12.3); $p = 0.28$] and $LCADL_{\%total}$ [mean difference: 8.93% (95%CI: 0.96–16.9%); $p = 0.12$] (Table 3).

Table 2 Correlations between $LCADL_{total}$ and $LCADL_{\%total}$ and pulmonary function, health status, quality of life, dyspnea, functional status, physical activities in daily life and mortality index.

Variables	$LCADL_{total}$		$LCADL_{\%total}$	
	r	*p-value*	*r*	*p-value*
FEV_1/FVC	−0.28	0.03	−0.43	0.001
FEV_1 (L)	−0.44	<0.001	−0.52	<0.001
FEV_1 (%pred)	−0.32	0.01	−0.49	<0.001
FVC (L)	−0.35	0.005	−0.35	0.006
FVC (%pred)	−0.20	0.13	−0.30	0.02
CAT (total)	0.66	<0.001	0.77	<0.001
$SGRQ_{symptoms}$	0.56	<0.001	0.62	<0.001
$SGRQ_{activity}$	0.68	<0.001	0.84	<0.001
$SGRQ_{impact}$	0.62	<0.001	0.79	<0.001
$SGRQ_{total}$	0.68	<0.001	0.85	<0.001
mMRC	0.49	<0.001	0.62	<0.001
6MWT (m)	−0.31	0.01	−0.43	0.001
6MWT (%pred)	−0.24	0.06	−0.38	0.002
Time sitting (min)	0.18	0.16	0.32	0.01
Time lying (min)	−0.01	0.95	−0.06	0.66
Time standing (min)	0.01	0.98	−0.01	0.98
Time walking (min)	−0.12	0.35	−0.29	0.02
Steps	−0.25	0.05	−0.39	0.002
Time in activities <1.5 MET (min)	0.06	0.62	0.26	0.04
Time in activities ≥3 METs (min)	−0.21	0.10	−0.36	0.004
BODE index (score)	0.37	0.004	0.57	<0.001

$LCADL_{total}$, total score of London Chest Activity of Daily Living; $LCADL_{\%total}$, percentage total score of London Chest Activity of Daily Living; FEV_1, forced expiratory volume in first second; FVC, forced vital capacity; L, liters; %pred, percentage of predicted; m, meters; CAT, COPD Assessment Test; SGRQ, Saint George's Respiratory Questionnaire; mMRC, modified Medical Research Council scale; 6MWT, six-minute walk test; min, minute; MET, metabolic equivalent of task.

Table 3 Comparison of $LCADL_{\%total}$ and $LCADL_{total}$ between groups: mMRC < and ≥ 2, 6MWT < and ≥ 82 %pred, time in activities ≥3 METs < and ≥ 80 min, and steps/day < and ≥ 4850.

Variables	$LCADL_{\%total}$ Mean ± SD	Mean difference[a] (95%CI)	*p*-value	$LCADL_{total}$ Mean ± SD	Mean difference (95%CI)	*p*-value
mMRC						
≥2	43.2 ± 16.9	14.7	<0.001	27.4 ± 14.5	9.48	
<2	28.5 ± 8.68	(7.67–21.8)		18.0 ± 7.12	(3.46–15.5)	0.002
6MWT						
≥82%pred	29.5 ± 7.37	8.93		18.6 ± 6.48	5.77	
<82%pred	38.4 ± 17.0	(0.96–16.9)	0.12	24.37 ± 13.8	(−0.75–12.3)	0.28
Time in activities ≥3 METs						
≥80 min/day	31.1 ± 11.5	8.02	0.03	19.9 ± 9.24	4.64	0.26
<80 min/day	39.1 ± 16.7	(0.76–15.3)		24.5 ± 13.9	(−1.29–10.6)	
Severe inactivity						
≥4580 steps/day	31.1 ± 11.6	10.1		19.6 ± 9.51	6.46	
<4580 steps/day	41.1 ± 17.1	(2.33–17.9)	0.04	26.1 ± 14.2	(0.40–12.9)	0.007

$LCADL_{total}$, total score of London Chest Activity of Daily Living; $LCADL_{\%total}$, percentage total score of London Chest Activity of Daily Living; SD, standard deviation; CI, confidence interval; mMRC, modified Medical Research Council scale; 6MWT, six-minute walk test; %pred, percentage of predicted; MET, metabolic equivalent of tasks; min, minute.

[a] Mean difference between mMRC, time in activities ≥3 METs, steps/day and 6MWT classifications.

Determination of a cut-off point for LCADL

The receiver operating characteristic curve (Fig. 1) showed a cut-off point of 28% for the $LCADL_{\%total}$ for all 4 anchors: mMRC, 6MWT, classification of severe physical inactivity and level of physical (in)activity.

The classification of functional status according to the cut-off point found ($LCADL_{\%total}$ ≤28% and >28%) was

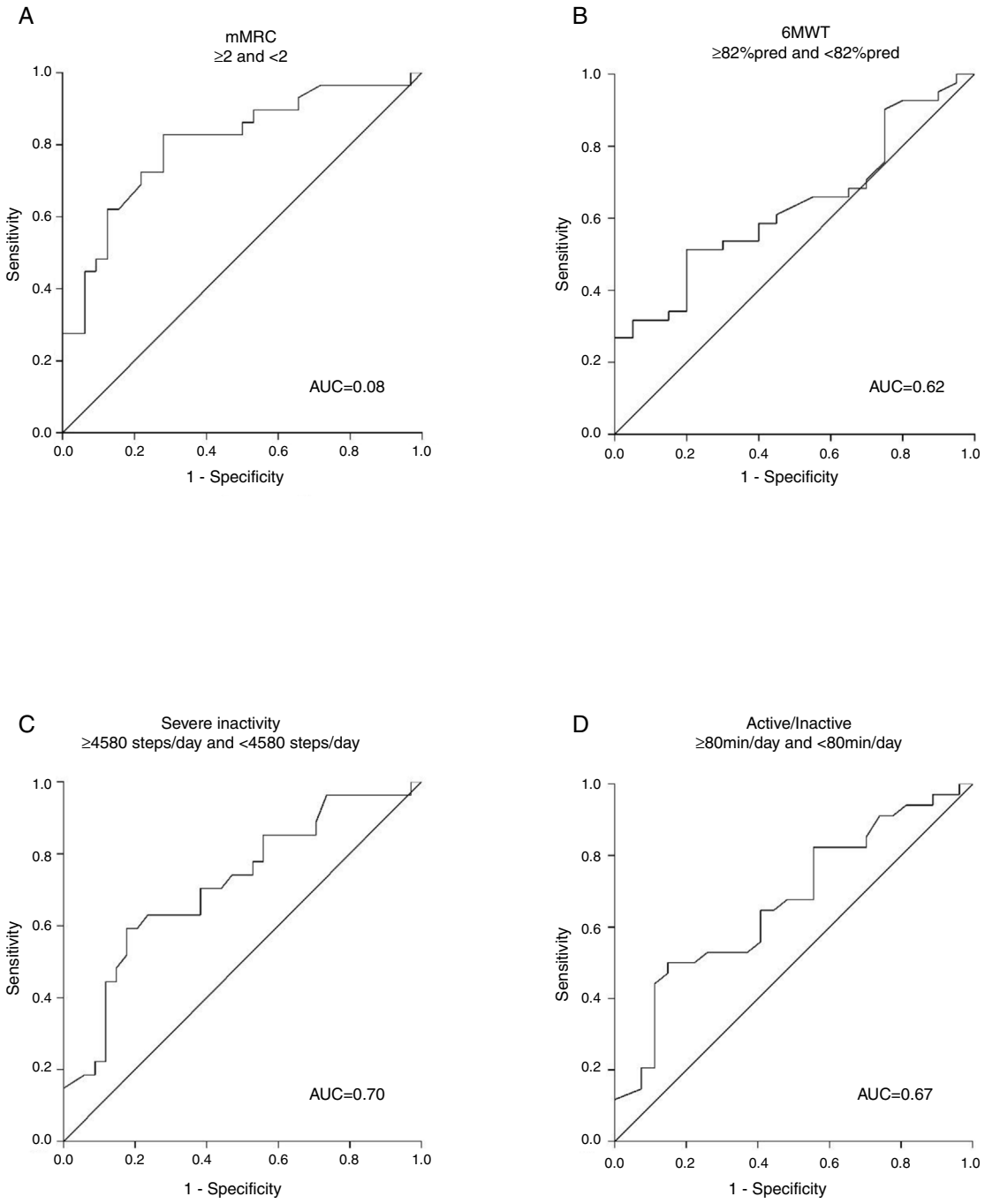

Figure 1 Receiver operating characteristic curves for the percentage of the total score of London Chest Activity of Daily Living ($LCADL_{\%total}$) cut-off point to discriminate the functional status of patients with COPD. (A) Modified Medical Research Council Scale (mMRC) ≥2 and <2: cut-off point = 28%; sensitivity = 83%; specificity = 72%; area under the curve (AUC) = 0.80 (95%CI: 0.69–0.91); $p < 0.001$. (B) Six-minute walk test (6MWT) ≥82%pred and <82%pred: cut-off point = 28%; sensitivity = 58%; specificity = 60%; AUC = 0.62 (95%CI: 0.48–0.76); $p = 0.13$. (C) ≥4580 steps/day and <4580 steps/day: cut-off point = 28%; sensitivity = 70%; specificity = 62%; AUC = 0.70 (95%CI: 0.57–0.84); $p = 0.007$. (D) Time ≥80 min/day and <80 min/day in physical activities ≥3 METs: cut-off point = 28%; sensitivity = 65%; specificity = 59%; AUC = 0.67 (95%CI: 0.53–0.80); $p = 0.03$.

associated with the mMRC (<2 and ≥2, Cramer's $V = 0.46$, $p < 0.001$) and severe physical inactivity (≥4580 and <4580 steps, Cramer's $V = 0.27$, $p = 0.03$) classifications.

There was no statistically significant difference with regards to anthropometric variables between the patients who scored ≤28% and >28% in the $LCADL_{\%total}$. Those who scored ≤28% in $LCADL_{\%total}$ had lower scores on mMRC, COPD Assessment Test, Saint George's Respiratory Questionnaire (total score and domains) and BODE index score when compared to patients who scored >28%. Also, they presented

higher forced expiratory volume in the first second in percentage of predicted, shorter sitting time, longer time in PADL $\geq$3 METs, greater number of steps and walked longer distance during the 6MWT (Table 1).

Interpretation of changes in functional status post-PRP

From 61 patients included in present study, nine presented some condition other than COPD that compromised the training progression, nine presented severe exacerbation during the PRP or the post-PRP evaluations and five did not completed the PRP because they withdrew from the program. Therefore, 38 patients (27 men; 63 $\pm$ 9 years, body mass index: 26.1 $\pm$ 5.31 kg/m^2 and forced expiratory volume in the first second: 39.1 $\pm$ 13.1%pred) completed PRP and entered into the analyses. There was no statistically significant difference in the $LCADL_{total}$ and $LCADL_{\%total}$ between pre-PRP and post-PRP moments [median = 17 (25–75% IQR: 15–22) vs. 17 (25–75% IQR: 14–21); $p = 0.08$ and median = 28.4% (25–75% IQR: 23.9–33.7%) vs. 27.1% (25–75% IQR: 23–34.9%); $p = 0.18$, respectively]. The changes in $LCADL_{total}$ and $LCADL_{\%total}$ were correlated with the change in COPD Assessment Test ($r = 0.33$; $p = 0.04$ for both), in the impact domain ($r = 0.44$; $p = 0.006$ and $r = 0.53$; $p = 0.001$, respectively) and in the Saint George's Respiratory Questionnaire total score ($r = 0.42$; $p = 0.009$ and $r = 0.51$; $p = 0.001$, respectively). Only the change in $LCADL_{\%total}$ correlated with the change in time in PADL <1.5MET ($r = 0.38$; $p = 0.03$). The changes in the other variables did not correlate with changes in $LCADL_{total}$ and $LCADL_{\%total}$.

There was almost perfect agreement between $LCADL_{total}$ and $LCADL_{\%total}$ for the PRP functional effects interpretation (Kappa = 0.81; $p < 0.001$). Twenty-three patients reduced $LCADL_{total}$ and 20 patients reduced $LCADL_{\%total}$ post-PRP. One patient who did not have changes in $LCADL_{tota}$, did have increased $LCADL_{\%total}$. Two patients who showed reduced $LCADL_{total}$ also had increased $LCADL_{\%total}$ while one patient who increased $LCADL_{total}$, had reduced $LCADL_{\%total}$. The frequency of a ''0'' score being reported was different between pre- and post-PRP when there was disagreement between the $LCADL_{total}$ and $LCADL_{\%total}$ on interpretation of changes in functional status post-PRP. Fifteen patients who had reported a ''0'' score for some item(s) of LCADL pre-PRP, reported a score $\geq$1 in them post-PRP. Also, 17 patients reported a ''0'' score for LCADL items post-PRP that had reported a score $\geq$1 pre-PRP.

Discussion

The present study was the first to identify a cut-off point to allow the LCADL scale to be interpreted relative to impairment of functional status. The results demonstrated that the cut-off point of 28% was sensitive and specific to enable discrimination the functional status of patients with COPD. Patients with $LCADL_{\%total}$ >28% had worse pulmonary function, dyspnea, health-related quality of life and health status, shorter time in PADL $\geq$3 METs and number of steps, longer sitting time and higher risk of death according to the BODE index when compared to patients with $LCADL_{\%total}$ $\leq$28%. Based on this information, health professionals will be able to use LCADL as a tool to better target treatment strategies. Also, this cut-off point may be useful in studies that focus on assessing more severe patients.

The LCADL cut-off point for discriminating the functional status of patients with COPD was determined only for $LCADL_{\%total}$ because the results of the present and previous studies[8,11,12] showed that the ''0'' score items could make the scale interpretation using $LCADL_{total}$ unreliable. In this study, $LCADL_{\%total}$ showed a stronger correlation with BODE, forced expiratory volume in the first second, 6MWT, and mMRC than $LCADL_{total}$, similarly to previous studies[8,11,12] as well as with Saint George's Respiratory Questionnaire and COPD Assessment Test. Also, the post-PRP change in the $LCADL_{\%total}$ showed higher correlations with the change in the Saint George's Respiratory Questionnaire than $LCADL_{total}$. Only the $LCADL_{\%total}$ correlated with variables that reflect the PADL level, as the change in time in PADL <1.5MET. This is a very interesting result, since sedentary behavior can increase the risk of death in COPD patients[23] and reducing sedentary lifestyle is a focus of PRP.[3]

Another finding that reinforces the $LCADL_{\%total}$ use as opposed to $LCADL_{total}$ was that a large number of the patients presented a ''0'' score for some item(s) at both pre-PRP and post-PRP moments. Also, in spite of the high agreement between $LCADL_{\%total}$ and $LCADL_{total}$ in demonstrating whether there was improvement, worsening or absence of changes in functional status post-PRP, it was noted that in many situations, a reduction in $LCADL_{total}$ could have been caused when the patient stopped performing activities that he/she did before the PRP (i.e., because he/she started to report a ''0'' score for items that had reported score $\geq$1). The opposite may also have been responsible for an increase in $LCADL_{total}$ post-PRP in some patients, which was not effectively related to worsening of functional status since the patient could perform the activities post-PRP (score $\geq$1) that he did not perform in pre-PRP (''0'' score) and experienced dyspnea. These situations reduced the agreement between $LCADL_{total}$ and $LCADL_{\%total}$ and could lead to a misinterpretation of the amount of improvement following the PRP, as well as confounding the interpretation of the magnitude of the interventions effect, increasing or reducing it. Thus, the $LCADL_{\%total}$ use could solve these problems because it disregards the items scored as ''0'' and leads to a more reliable interpretation of results. Therefore, although $LCADL_{total}$ presented with a minimal detectable change,[13] its use may significantly impair the interpretation of the PRP effects on functional status. Future studies should develop a minimal important difference for $LCADL_{\%total}$ since this is fundamental for this instrument use in clinical practice. Because most of patients reported a ''0'' score for at least one of the LCADL items before PRP, it may have also reduced the scale responsiveness, since it reduced the possible items to improve post-PRP. This may explain why there was no improvement in the LCADL scores post-PRP. Besides, the subjectivity and the misinterpretation which can occur when scales are used may have interfered in this outcome.

A cut-off point for discriminating patients with worse or better outcomes is also an important interpretation criteria. The instruments used as anchors in the present study having cut-off points that allowed their well-established criteria[1,24,25] and being outcomes capable of reflect the risk of death in patients with COPD.[31,32] All the receiver

operating characteristic curve analyses found the cut-off point of 28%, which was able to discriminate patients in the pulmonary function, dyspnea, health status, quality of life, PADL level, and risk of death. Also, an association was found between the classification of functional status by the $LCADL_{\%total}$ cut-off point and the mMRC and severe physical inactivity classifications. However, these associations were weak probably because all of the instruments evaluated different constructs related to functional status. These outcomes are complementary to one another and are strongly associated with the prognosis of COPD.[2,26,32–36] Another factor that reinforces the $LCADL_{\%total}$ cut-off point use is that the differences between the groups presented higher values than the minimal important difference of the Saint George's Respiratory Questionnaire,[37] the COPD Assessment Test,[38] the 6MWT[18] and the number of steps.[39] Therefore, the 28% cut-off point for LCADL has clinically relevant discriminatory power.[40]

The lack of significance in the receiver operating characteristic curve analysis using the 6MWT as the anchor can be considered a limitation of the study. A type II error may have ocurred since the *p*-value was borderline. However, the sample size was based on a previous sample calculation and the cut-off point by the other anchors showed satisfactory area under the curve values, sensitivity and specificity. Some analysis may have presented low statistical power, especially for the subgroups, since a sample estimation was not conducted for this purpose.

Conclusions

It is recommended that clinicians use the cut-off point of 28% for $LCADL_{\%total}$ to distinguish the functional status of patients with COPD. This cut-off point is capable of differentiating patients in relation to dyspnea, health status, quality of life, PADL and potential risk of death. The $LCADL_{\%total}$ reflects better outcomes of COPD than $LCADL_{total}$, which could compromise the interpretation of the PRP effects on functional status.

Conflicts of interest

The authors declare no conflicts of interest.

References

1. GOLD. *Global Initiative for Chronic Obstructive Lung Disease*; 2018.
2. Gimeno-Santos E, Frei A, Steurer-Stey C, et al. Determinants and outcomes of physical activity in patients with COPD: a systematic review. *Thorax*. 2014;69(8):731–739.
3. Spruit MA, Singh SJ, Garvey C, et al. American Thoracic Society/European Respiratory Society statement on pulmonary rehabilitation. *Am J Respir Crit Care Med*. 2013;188:e64.
4. Kocks JW, Asijee GM, Tsiligianni IG, et al. Functional status measurement in COPD: a review of available methods and their feasibility in primary care. *Prim Care Respir J*. 2011;20(3):269–275.
5. Hajian-Tilaki K. Receiver operating characteristic (ROC) curve analysis for medical diagnostic test evaluation. *Caspian J Intern Med*. 2013;4(2):627–635.
6. Mokkink LB, Terwee CB, Patrick DL, et al. The COSMIN study reached international consensus on taxonomy, terminology, and definitions of measurement properties for health-related patient-reported outcomes. *J Clin Epidemiol*. 2010;63(7):737–745.
7. Pitta F, Troosters T, Probst VS, et al. Quantifying physical activity in daily life with questionnaires and motion sensors in COPD. *Eur Respir J*. 2006;27(5):1040–1055.
8. Carpes MF, Mayer AF, Simon KM, et al. The brazilian portuguese version of the London Chest Activity of Daily Living scale for use in patients with chronic obstructive pulmonary disease. *J Bras Pneumol*. 2008;34(3):143–151.
9. Garrod R, Bestall JC, Paul EA, et al. Development and validation of a standardized measure of activity of daily living in patients with severe COPD: the London Chest Activity of Daily Living scale (LCADL). *Respir Med*. 2000;94(6):589–596.
10. Garrod R, Paul EA, Wedzicha JA. An evaluation of the reliability and sensitivity of the London Chest Activity of Daily Living Scale (LCADL). *Respir Med*. 2002;96(9):725–730.
11. Gulart A, Santos K, Munari A, et al. Relationship between the functional capacity and perception of limitation on activities of daily life of patients with COPD. *Fisioterapia e Pesquisa*. 2015;22(2).
12. Simon KM, Carpes MF, Correa KS, et al. Relationship between daily living activities (ADL) limitation and the BODE index in patients with chronic obstructive pulmonary disease. *Rev Bras Fisioter*. 2011;15(3):212–218.
13. Bisca GW, Proenca M, Salomao A, et al. Minimal detectable change of the London chest activity of daily living scale in patients with COPD. *J Cardiopulm Rehabil Prev*. 2014;34(3):213–216.
14. Miller MR, Hankinson J, Brusasco V, et al. Standardisation of spirometry. *Eur Respir J*. 2005;26(2):319–338.
15. Pereira CA, Sato T, Rodrigues SC. New reference values for forced spirometry in white adults in Brazil. *J Bras Pneumol*. 2007;33(4):397–406.
16. Jones PW, Harding G, Berry P, et al. Development and first validation of the COPD Assessment Test. *Eur Respir J*. 2009;34(3):648–654.
17. Sousa TC, Jardim JR, Jones P. Validation of the Saint George's Respiratory Questionnaire in patients with chronic obstructive pulmonary disease in Brazil. *J Pneumol*. 2000;26(3):119–128 [in Portuguese].
18. Holland AE, Spruit MA, Troosters T, et al. An official European Respiratory Society/American Thoracic Society technical standard: field walking tests in chronic respiratory disease. *Eur Respir J*. 2014;44(6):1428–1446.
19. Britto RR, Probst VS, de Andrade AF, et al. Reference equations for the six-minute walk distance based on a Brazilian multicenter study. *Braz J Phys Ther*. 2013;17(6):556–563.
20. Troosters T, Gosselink R, Decramer M. Six minute walking distance in healthy elderly subjects. *Eur Respir J*. 1999;14(2):270–274.
21. Pitta F, Troosters T, Spruit MA, et al. Characteristics of physical activities in daily life in chronic obstructive pulmonary disease. *Am J Respir Crit Care Med*. 2005;171(9):972–977.
22. Hill K, Gardiner PA, Cavalheri V, et al. Physical activity and sedentary behaviour: applying lessons to chronic obstructive pulmonary disease. *Intern Med J*. 2015;45(5):474–482.
23. Furlanetto KC, Donaria L, Schneider LP, et al. Sedentary behavior is an independent predictor of mortality in subjects with COPD. *Respir Care*. 2017;62(5):579–587.
24. van Remoortel H, Camillo CA, Langer D, et al. Moderate intense physical activity depends on selected Metabolic Equivalent of Task (MET) cut-off and type of data analysis. *PLoS ONE*. 2013;8(12):e84365.
25. Depew ZS, Novotny PJ, Benzo RP. How many steps are enough to avoid severe physical inactivity in patients

with chronic obstructive pulmonary disease? *Respirology*. 2012;17(6):1026–1027.
26. Celli BR, Cote CG, Marin JM, et al. The body-mass index, airflow obstruction, dyspnea, and exercise capacity index in chronic obstructive pulmonary disease. *N Engl J Med*. 2004;350(10):1005–1012.
27. Carpes MF, Mayer AF, Simon KM, et al. The Brazilian Portuguese version of the London Chest Activity of Daily Living scale for use in patients with chronic obstructive pulmonary disease. *J Bras Pneumol*. 2008;34(3):143–151 [in Portuguese].
28. Borg GA. Psychophysical bases of perceived exertion. *Med Sci Sports Exerc*. 1982;14(5):377–381.
29. Rumsey D. *Statistics for Dummies*. 2nd ed; 2016.
30. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics*. 1977;33(1):159–174.
31. Waschki B, Kirsten A, Holz O, et al. Physical activity is the strongest predictor of all-cause mortality in patients with COPD: a prospective cohort study. *Chest*. 2011;140(2):331–342.
32. Casanova C, Marin JM, Martinez-Gonzalez C, et al. Differential Effect of Modified Medical Research Council Dyspnea, COPD Assessment Test, and Clinical COPD Questionnaire for Symptoms Evaluation Within the New GOLD Staging and Mortality in COPD. *Chest*. 2015;148(1):159–168.
33. Garcia-Sidro P, Naval E, Martinez Rivera C, et al. The CAT (COPD Assessment Test) questionnaire as a predictor of the evolution of severe COPD exacerbations. *Respir Med*. 2015;109(12):1546–1552.
34. Pasquale MK, Xu Y, Baker CL, et al. COPD exacerbations associated with the modified Medical Research Council scale and COPD assessment test among Humana Medicare members. *Int J Chron Obstruct Pulmon Dis*. 2016;11:111–121.
35. Carone M, Antoniu S, Baiardi P, et al. Predictors of mortality in patients with COPD and chronic respiratory failure: the Quality-of-Life Evaluation and Survival Study (QuESS): a three-year study. *COPD*. 2016;13(2):130–138.
36. Yorgancioglu A, Havlucu Y, Celik P, et al. Relation between quality of life and morbidity and mortality in COPD patients: two-year follow-up study. *COPD*. 2010;7(4):248–253.
37. Schunemann HJ, Griffith L, Jaeschke R, et al. Evaluation of the minimal important difference for the feeling thermometer and the St. George's Respiratory Questionnaire in patients with chronic airflow obstruction. *J Clin Epidemiol*. 2003;56(12):1170–1176.
38. Kon SS, Canavan JL, Jones SE, et al. Minimum clinically important difference for the COPD Assessment Test: a prospective analysis. *Lancet Respir Med*. 2014;2(3):195–203.
39. Demeyer H, Burtin C, Hornikx M, et al. The minimal important difference in physical activity in patients with COPD. *PLoS ONE*. 2016;11(4):e0154587.
40. Kiley JP, Sri Ram J, Croxton TL, et al. Challenges associated with estimating minimal clinically important differences in COPD-the NHLBI perspective. *COPD*. 2005;2(1):43–46.