Functional Status of Patients with COPD Assessed by London Chest Activity of Daily Living Scale: Gender Association and Validity of a Cutoff Point

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Abstract

Purpose Whether the difference in the impact of chronic obstructive pulmonary disease (COPD) on the functional status of men and women stems from clinical distinctions or to the measuring instrument used is unclear. Like most instruments for assessing functional limitation in COPD, the interpretation of the results of the London Chest Activity of Daily Living (LCADL) scale is limited because a lack of a valid cutoff point to this scale. For that, this study sought to compare the functional status between men and women with COPD; and propose a cutoff point for LCADL capable of discriminating the prognosis of these individuals.

Methods A sample of 138 subjects with moderate–severe COPD was evaluated by the LCADL. The percentage of the individual maximum score was used to obtain a cutoff point capable of discriminating patients with the worse prognosis according to the BODE Index. The cutoff point was also tested in an independent sample ($n = 70$).

Results Regarding the total score, domestic and leisure domains of the LCADL, men had better scores than women ($P \leq 0.01$). The cutoff point found was 37% (area under the curve = 0.70, 95% confidence interval = 0.60–0.80, sensitivity = 0.55 and specificity = 0.74). Individuals who scored $\geq 37\%$ had a worse prognosis and level of physical activities of daily living than those who scored below ($P \leq 0.02$).

Conclusion When evaluated by the LCADL, men and women with COPD present difference in the functional status. The established cutoff point (37%) adequately discriminates individuals regarding the prognosis, contributing to improve the interpretation capacity of the LCADL.

Keywords Chronic obstructive pulmonary disease · Activities of daily living · Symptom assessment · Surveys and questionnaires

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Introduction

Clinical and physiological differences of chronic obstructive pulmonary disease (COPD) between men and women are extensively studied. Women with COPD are known to be younger and have lighter smoking habits than men with the same diagnosis, although women are more susceptible to tobacco lesions [1]. These differences are prominent in women due to their anatomical and physiological particularities, like narrower and more hyperresponsive bronchial structures [1, 2]. However, when considering gender comparisons about extrapulmonary manifestations of COPD, like functional limitations (i.e., the individual capacity to

perform the activities of daily living), few studies address this issue and present conflicting results [3–5].

The composition of the available assessment instruments of functional status may lead to an evaluation bias, which may be related to conflicting results. The London Chest Activity of Daily Living (LCADL) scale is widely used in people with COPD; composed of four domains. During the development process of the LCADL, some activities which presented association with gender were not included in its final version [6]. However, some factors that may lead to gender assessment bias should be considered: first, the largest domain of the LCADL is composed by domestic activities; and the fact that, around the world, domestic activities are culturally performed by women [7]. In the most commonly used of the LCADL scores, i.e., the total score, each single activity must be scored, and even when an individual does not perform any activity it is scored as zero. Thus, lower scores do not necessarily represent milder functional limitation; in this case it simply means that the individual does not perform some activities [8].

To minimize this bias, Carpes et al. proposed a score that disregards non-performed activities and calculates each patient's maximum score [9]. Thus, a percentage of the maximum score corresponding to the score reached by the individual is calculated. Despite this, it is not known if both scores (total and percentage) are influenced by gender. The LCADL is a validated [6], reproducible and responsive scale [10], having minimal clinical difference [8] and being widely used in COPD, however, another problem identified is the difficulty to interpret the results. The LCADL presents correlation with important clinical variables [9, 11, 12], but no valid cutoff point to discriminate a preserved or impaired functional status patients with COPD has been described yet.

Considering the hypothesis that the LCADL total score may overestimate the functionality of men in relation to women, and considering that establishing a cutoff related to clinically important outcomes for COPD would improve the scale's interpretation, the objectives of this study were: to compare the functional status assessed by LCADL, and verify if there is association between a smaller score in each activity and the participant's gender; to propose and validate a cutoff point capable of discriminating the functional status of men and women with COPD about the clinical prognosis.

Methods

Sample and Study Design

A retrospective cross-sectional study was conducted with data of patients with COPD recruited during the initial evaluation of an exercise training program. Data collection occurred from July 2006 to July 2017. The inclusion criteria

were: COPD diagnosis [13], no infections and exacerbations within the last 3 months prior the program; no severe osteoarticular and cardiac comorbidities that interfered in the exercise training protocol. Participants were excluded if they did not complete the primary outcomes evaluations for any reason.

Initially, the convenience sample was composed by 208 patients. After that, according to previously calculated sample size (more details in "Statistical Analysis" section) patients were randomized into two independent samples: sample 1 used to develop a cutoff point to the best LCADL percentage score; and sample 2 used to test and validate the cutoff point established in the first analyses.

Primary Outcomes

Functional Status

Functional status was assessed by the LCADL [6, 11], applied as an interview. The scale identifies the dyspnea limitation when performing the ADL and is composed by four domains: self-care (four items), domestic (six items), physical (two items) and leisure (three items). Each activity is scored as follows: 0 ("I wouldn't do anyway"), 1 ("I do not get breathless"), 2 ("I get moderately breathless"), 3 ("I get very breathless"), 4 ("I can't do this anymore"), and 5 ("Someone else does it for me"). The individual score of each activity; the domain's scores; and the total score were considered. The total score was calculated by two way: (1) total score—the sum of all domains (0–75 points) and (2) percentage score—being firstly calculated a maximum individual score, disregarding five points of maximum score (75 points) to each activity that scored 0 (not performed); following, the percentage was calculated, corresponding to the score of the individual's responses [9]. Higher values indicate greater limitation [6].

Prognosis Index

The BODE index (body mass index [BMI], airflow obstruction, dyspnea and exercise) [14] was calculated and used as the base to develop a cutoff point for the LCADL. This index classify the patients clinical prognosis, and was chosen because it is a predictor of all-cause mortality in patients with COPD and because the variables included influence an individual's functional status [12, 14, 15]. Patients can be classified in four quartiles: I (0–2 points), II (3–4 points), III (5–6 points) and IV (7–10 points) [14].

The variables analyzed were: BMI (kg/m^2); lung function (spirometry) [16, 17], dyspnea (modified Medical Research Council scale [mMRC]) [18]; and exercise capacity (6-min walk test [6MWT]) [19–21].

Secondary Outcome

Physical Activity in Daily Life

To characterize the sample and validate the cutoff, the level of physical activity in daily life (PADL) was assessed for two consecutive working days by the SenseWear® armband monitor (Body Media, USA) [22–24]. The analyzed variables were: sedentary time (time spent in activities below 1.5 metabolic equivalents [SED < 1.5METs]), duration of physical activity in activities above 3 METs (PAD > 3METs) and steps per day.

Statistical Analysis

The software used was the SPSS 21.0 (SPSS Inc., USA). Normality data distribution was evaluated using the Kolmogorov–Smirnov test. The results were described as mean (standard deviation) or 95% confidence interval (95%CI) or median (interquartile range 25–75%). The comparisons between gender were performed using unpaired Student's t test or Mann–Whitney test. The Chi-square test was done to compare the proportions. The association between gender and functional status was tested by Goodman and Kruskal's gamma [25], considering the score of each LCADL activity (from 0 to 5 points) and the gender (men:0 and women:1). Following, a receiver operation characteristics (ROC) curve with area under the curve (AUC) and Youden's Index were used to verify the discriminative capacity and determine the best cutoff point from the LCADL (percentage score) to discriminate patients with the worse prognosis (i.e., BODE ≥ 5 points) [14]. Significance level was set at $P < 0.05$.

The sample size calculated (MedCalc Software 17.1, Belgium) was 138 patients, expecting to find a 0.70 AUC, considering a 0.05 bilateral alpha value and a 99% power [26].

Results

Regarding the participants, 208 individuals were included initially and all finished the study protocol. According to the sample size calculation, 138 patients were randomized into sample 1 which presented a similar gender proportion (men: 51% and women: 49%), including in general elderly (67 ± 9 years), with moderate–severe COPD (forced expiratory volume in first second [FEV$_1$] 47 ± 17 %predicted) and overweight (BMI 26 ± 6 kg/m^2). In addition, presented preserved exercise capacity (6MWT 447 ± 84 m, 84 ± 16 %predicted) and some degree of dyspnea limitation (mMRC 3 [1–3] points), with mild to moderate BODE Index (3 [2–5] points).

Gender comparisons showed that men with COPD present better functional status than women in both scores (total and percentage), despite being similar in demographics, anthropometrics and clinical characteristics (Table 1). Interestingly, the positive and statistical significant associations showed that men are more susceptible to not perform all domestic activities (i.e., scored 0 in these activities) than women, as shown in Table 2 and Fig. 1. In addition, more men do not live alone than women (Table 1) and, among those who scored 0 in one or more activity (60 men and 22 women), there were also more men than women who do not live alone (93% vs 73%, $P = 0.0002$, respectively).

ROC curve analyses identified 37% of the LCADL score as the best cutoff point to discriminate the worse prognosis in COPD (AUC: 0.70 [95%CI 0.6–0.8]), sensibility: 0.56 and specificity: 0.74) (Fig. 2).

Further, the cutoff point validity was tested in an independent sample composed by 70 subjects with COPD, with similar characteristics to the sample (57% men, 67 ± 7 years,

Table 1 Comparison between male and female patients with COPD in sample 1

	Men (n = 71)	Women (n = 67)	P
Age (years)	68 ± 10	65 ± 7	0.07
Not living alone (%)	93	76	0.001
BMI (kg/m^2)	26 ± 6	27 ± 5	0.61
BODE (I/II/III/IV) (n)	33/18/16/4	26/23/16/2	0.57
FEV$_1$ (%pred)	45 ± 17	50 ± 16	0.11
6MWT (m)	467 [390–515]	445 [412–490]	0.12
6MWT (%pred)	82 [71–93]	86 [80–97]	0.07
mMRC (pts)	2 [1–3]	3 [2–3]	0.13
Steps per day[a]	4095 [2502–7686]	4532 [2887–6347]	0.63
PAD > 3METs[a] (min)	50 [21–109]	33 [9–74]	0.05
SED < 1.5METs[a] (min)	503 [427–599]	482 [345–589]	0.30
LCADL (pts)			
Self-care	5 [4–7]	5 [4–8]	0.82
Domestic	4 [2–7]	10 [7–15]	< 0.001
Physical	4 [3–5]	4 [3–5]	0.96
Leisure	4 [3–5]	5 [4–6]	0.01
Total	17 [13–22]	24 [19–34]	< 0.001
Percentage score (%)	29 [24–37]	36 [26–47]	0.03

Data express in absolute frequency, mean (SD) or median [IQR 25–75%]

BMI body mass index, *BODE* BODE index, *FEV$_1$* forced expiratory volume in the first second, *6MWT* six-minute walk test, *mMRC* modified medical research council, *PAD* physical activity duration in activities above 3METs, *SED < 1.5* sedentary time in activities below 1.5METs, *LCADL* London Chest Activity of Daily Living

[a]Data for 127 patients

Table 2 Association between the score of each activity of LCADL scale and gender

LCADL domains	Y for each score					
	0	1	2	3	4	5
Self-care domain						
Drying	−1.0	−0.009	0.059	−0.130	−1.0	1.0
Dressing uper body	−0.029	0.254	−0.079	−1.0*	–	–
Putting shoes/socks on	−0.029	−0.048	−0.016	0.226	−0.533	−0.029
Washing hair	−0.029	−0.100	0.232	−0.293	−1.0	1.0
Domestic domain						
Make beds	0.946*	−0.112	−0.440*	−0.602	–	–
Change sheets	0.945*	−0.229	−0.654*	−0.602	–	−0.545
Wash windows/curtains	0.868*	−0.611*	−0.397	−0.699	−1,0*	−0.753*
Clean/dusting	0.916*	−0.412*	−0.491*	−0.381	−0.533	−0.782*
Wash up	0.910*	−0.681*	0.042	−0.029	–	−0.366
Vacuuming/sweeping	0.866*	0.271	−0.618*	−0.254	−1.0	−0.389
Physical domain						
Walking up stairs	0.313	−0.299	0.275	−0.015	−1.0	–
Bending	−0.366	0.063	−0.203	0.266	–	–
Leisure domain						
Walking in home	0.313	0.167	−0.234	−0.029	–	–
Going out socially	1.0	0.414*	−0.248	−0.264	−1.0*	1.0
Talking	−0.029	0.281	−0.278	−0.030	–	–

Men = 1; women = 0; Y: Goodman and Kruskal's Gamma, "–" insufficient data for analysis, *significant associations $P \leq 0.04$

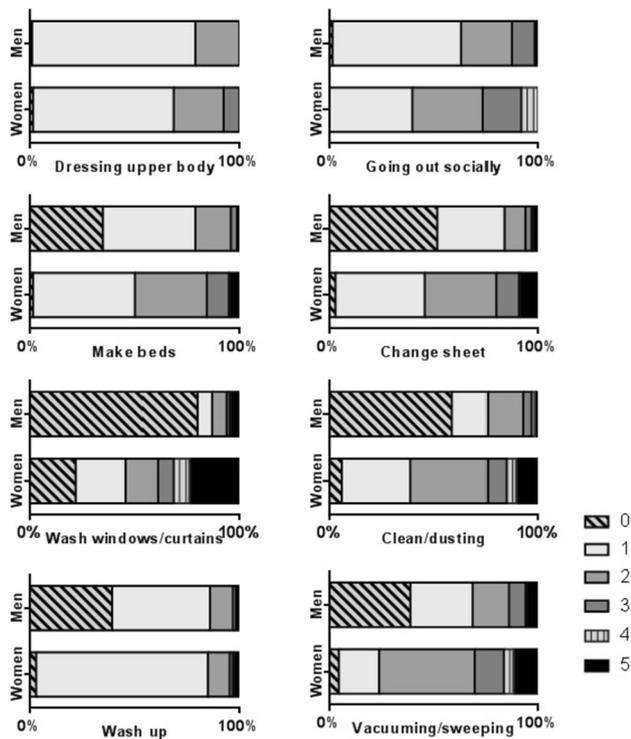Positive associations imply that men can be scores the punctuation

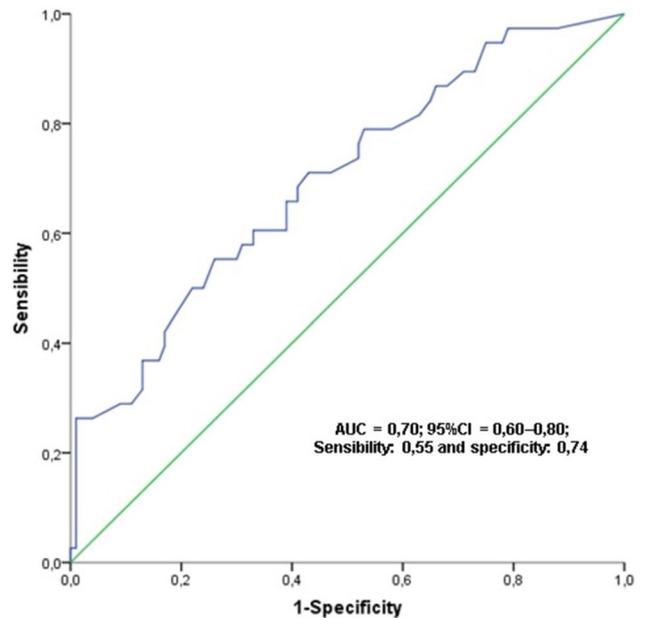**Fig. 1** Difference in proportion between men and women scores in activities of LCADL that had gender association

Fig. 2 ROC curve to identify the best cutoff point in percentage score of LCADL to discriminate better or worse prognosis in patients with COPD

AUC = 0,70; 95%CI = 0,60–0,80; Sensibility: 0,55 and specificity: 0,74

BMI 27 [22–30] kg/m^2; FEV$_1$ 45 ± 5 %predicted, 6MWT 449 ± 82 m, $P \geq 0.32$ for all). By separating the sample into two groups according to the cutoff point, subjects who scored ≥ 37% (i.e., impaired functional status) obtained a higher BODE index classification (5 [4–7] points vs 2 [1–4] points), in addition to a larger proportion of subjects classified in the III or IV quartiles than subjects classified below the cutoff (46% vs 16%). Further, the patients with impaired functional status presented worse pulmonary function, exercise capacity, PADL (steps per day) and greater dyspnea when compared to the others (FEV$_1$ 37 ± 12 %predicted; 6MWT 414 ± 97 m and 74 ± 23 %predicted; 3781 [1366–7075] steps, mMRC 3 [3–3] vs FEV$_1$ 50 ± 15 %predicted; 6MWT 470 ± 63 m and 88 ± 12 %predicted; 5478 [3750–8600] steps, mMRC 2 [1–3] $P \leq 0.02$ for all, respectively).

Regarding gender, Table 3 shows the comparison between them according the cutoff classification sub-analysis. Also expected, previously clinical differences described between subjects classified below or above the cutoff remained. However, there was no specific difference in the domestic score between men with preserved functional status or not

($P > 0.05$). This proves that the differences detected by the cutoff point are not influenced by the instrument error.

Discussion

These findings confirmed the hypothesis that the LCADL overestimates the functional status of men with COPD in relation to women with the same diagnosis. Furthermore, the association between men and scoring zero in the domestic domain shows that most men with COPD do not perform such activities. Therefore, gender potentially causes bias to the interpretation of functional status assessed by the LCADL. However, it is worth emphasizing that the gender difference was maintained even when using the percentage score, further confirming an existing clinical difference in the functional status of men and women with COPD.

The association between gender and the activities included in the LCADL was discussed in the paper of Garrod and colleagues [6]. Although, three activities were not included in the LCADL final version because they were associated with gender (moving the furniture, shaving and

Table 3 Discriminative capacity of LCDAL cutoff point according the gender

	LCADL < 37% (n = 44)		LCADL ≥ 37% (n = 26)		P^*	$P^†$
	Men (n = 28)	Women (n = 16)	Men (n = 12)	Women (n = 14)		
Age (years)	69 ± 7	63 ± 8	65 ± 8	68 ± 4	0.06	0.09
Not living alone (%)	89	50	100	71	<0.001	0.002
BMI (kg/m^2)	27 ± 5	29 ± 7	26 ± 5	27 ± 7	0.56	0.47
GOLD (I/II/III/IV) (n)	0/14/9/5	0/10/6/0	0/0/5/7	0/4/9/1	0.005	0.13
BODE (I/II/III/IV) (n)	15/8/5/0	9/5/2/0	0/6/3/3	2/6/2/4	0.002	0.04
FVC (%pred)	66 [56–81]	73 ± 17	51 [41–55]	73 ± 22	0.005	0.99
FEV$_1$ (%pred)	47 ± 16	55 ± 13	31 ± 10	42 ± 11	0.002	0.02
FEV$_1$/FVC (%)	52 ± 11	60 ± 8	45 ± 13	48 ± 15	0.09	0.01
6MWT (m)	475 [410–521]	480 ± 65	449 [362–507]	406 ± 99	0.25	0.02
6MWT (%pred)	85 ± 11	95 ± 12	68 ± 27	81 ± 18	0.008	0.01
mMRC (pts)	2 [1–3]	3 [1–3]	3 [3–4]	3 [2–3]	0.001	0.12
Steps per day‡	5761 ± 3268	7548 [4173–8775]	4999 ± 3745	2197 [1328–5804]	0.53	0.03
PAD > 3METs (min)‡	52 [13–162]	51 ± 37	38 [18–82]	41 ± 38	0.67	0.52
SED <1.5METs (min)‡	463 ± 234	487 [389–638]	524 ± 219	508 [416–605]	0.45	0.61
LCADL (pts)						
Self-care	5 [4–6]	5 [4–5]	8 [6–9]	8 [5–9]	<0.001	0.002
Domestic	5 [2–7]	6 [6–9]	7 [2–11]	16 [12–19]	0.33	<0.001
Physical	3 [3–4]	3 [3–4]	5 [4–5]	6 [4–6]	0.003	<0.001
Leisure	3 [3–4]	3 [3–4]	7 [5–7]	5 [4–6]	<0.001	0.003
Total	17 [14–20]	19 [15–23]	26 [22–29]	31 [29–40]	<0.001	<0.001

Data express in absolute frequency, mean (SD) or median [IQR 25–75%]

BMI body mass index, *GOLD* Global Initiative for Chronic Lung Disease, *BODE* BODE index, *FEV$_1$* forced expiratory volume in the first second, *FVC* forced vital capacity, *6MWT* six-minute walk test, *mMRC* modified medical research council, *PAD* physical activity duration in activities above 3METs, *SED < 1.5* sedentary time in activities below 1.5METs, *LCADL* London Chest Activity of Daily Living scale

*Comparisons between men, †comparisons between women, ‡data for 63 subjects

brushing the hair), the present results showed that other activities also demonstrated this association. Specifically, the domestic domain may influence the results interpretation when not considering the patient's gender, as was questioned by Bisca et al. [8]. Because men are more likely to score 0 in all domestic activities, concurrently, women score higher in these activities, and in the activities "dressing upper body" and "getting out socially" (Table 2 and Fig. 1).

The higher functional limitation in domestic activities for women was previously shown by Skumlien et al. [27], using the Pulmonary Function Status and Dyspnea Questionnaire (PFSDQ) (4.8 ± 2.2 points vs 3.9 ± 2.6 points, respectively, $P < 0.05$). However, only 3% men classify the PFSDQ activities as "never performed" versus 6% women. This difference can be explained, partially, by the higher discriminative capacity of the PFSDQ for the greater diversity of activities than LCADL (79 vs 15 activities, respectively). Additionally, the LCADL domestic domain corresponds to 40% of all activities, being extensively associated with gender.

Further, the sociocultural division of housework over the years can be another reason to explain the association between these activities and gender [7, 28]. Previous studies showed that women spend more time performing domestic activities than men, which increases in married women. Noteworthy, this cultural pattern is maintained over the years in most countries around the world [28–30].

Trying to reduce the risk of overestimating the functional status in subjects that do not perform some LCADL activities, Carpes et al. [9] proposed the percentage score, however, this score was not tested for gender. According to the present results, when this score was used, men presented better functional status than women; however, the difference between them was lower than in total score. Therefore, although these differences can be partially explained by the evaluation instrument used, these findings reaffirm that there are clinical differences between gender [1, 4] and must be considered in the evaluation and treatment proposal to the functional limitations of the COPD population.

Men with COPD are known to have greater muscle mass and strength, better exercise capacity, to be less susceptible to tobacco damage and to have less hyperresponsive lung structures than women [1, 31]. Additionally, Guenette et al. [32] showed that the mechanical restrictions inherent to women with COPD (like greater dynamic hyperinflation) limited the minute volume increase during exercise and even in activities that required a lower work rate, causing a greater dyspnea sensation; this can also explain this study's findings.

Although the LCADL was developed almost two decades ago, the interpretation of its results remains limited. Simon et al. [33] proposed a 50% cutoff of the scale to discriminate patients with COPD classified in BODE IV. However, this cutoff point was not validated, limiting its use; further, have a reduced clinical applicability, only discriminating subjects

with higher disease severity, since the intervention focus on this group of patients is usually to adapt and maintain function, and not the return to habitual activities. Therefore, the cutoff point established in this study (37%) is the first valid cutoff to classify the functional limitation and discriminate the functional status in subjects with COPD. The percentage score was chosen to develop this cutoff because previous studies showed better correlation with this score and functional tests (6MWT and Glittre-ADL test) than the LCADL total score [9, 11, 12].

When the cutoff was tested in an independent sample, subjects with ≥ 37% (non-preserved functional status) had worse clinical characteristics according to the BODE index variables, as expected. Additionally, they had lower PADL in steps per day than patients with preserved functional status. It is already known that steps per day is a strong predictor of mortality in COPD, and is the most sensitive physical activity outcome to detect improvement after pulmonary rehabilitation in patients with COPD [34, 35]. These results can help explaining why steps per day was the only physical activity variable that differed between groups, since a cutoff point developed using mortality as anchor would be more likely to distinguish variables related to mortality. Moreover, walking is a basic activity involved in most daily activities performed by individuals and in the activities described in the LCADL.

Despite the fact that participants in the present sample had relatively preserved functional capacity differing from most European COPD populations, the authors believe that these results can be extrapolated. Although the cutoff point established was based on the BODE index which includes the 6MWT, the external validity of our results is maintained once the other three variables included in the index were on average similar to studies with non-Brazilian samples. In spite of the sensibility being moderate, the cutoff presented a higher capacity to identify subjects who do not have functional limitations. Further, the cutoff is valid to identifying functional limitations in patients with COPD independently of gender. Therefore, the clinical applicability of the cutoff is increased, as well as the interpretation of the LCADL findings.

An interesting finding of the present study deserves an indepth discussion. The majority of participants who scored 0 in some LCADL items are male (60 vs 22, male and female, respectively). Among them, independently of the gender, the largest number do not live alone (men 93% and women 73%). This suggests that not living alone can influence them to avoid performing some activities because there is someone else to perform these activities for them. Therefore, living alone or not may influence the functional status of patients with COPD when the total score of the LCADL was taken into account. On the other hand, when patients are classified according the cutoff point, all male patients

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with impaired functional status (i.e. score ≥ 37%) do not live alone (Table 3). This finding confirms that the cutoff point is capable to discriminate the true functional status of the patients, without the influence of not living alone and therefore scoring zero because of that.

Despite the novelty and clinical relevance of this study, the fact that only small part of the sample had mild COPD must be considered a limitation because extrapolating the results for this population becomes harder. Unfortunately, these patients are underdiagnosed in most countries, and consequently, not referred to pulmonary rehabilitation [13]. Further studies are necessary to investigate the responsiveness of the established cutoff point after a rehabilitation program.

In conclusion, men and women with COPD presented significant differences in functional status when assessed by the LCADL. Furthermore, the results of this evaluation can be overestimated in men when considering the total score, since gender was associated with some LCADL activities. Finally, it was established a 37% cutoff point for the LCADL, capable to discriminating subjects according to the prognosis, exercise capacity, pulmonary function, dyspnea and PADL. Finally, the LCADL interpretation capacity could be increased using the established reference value and can be useful in the clinical and scientific practice. Thus, professionals will be able to translate evaluation findings into to useful clinical information, allowing individualized interventions for patients with COPD.

Compliance with Ethical Standards

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