Development, Validity and Reliability of the Londrina Activities of Daily Living Protocol for Subjects With COPD

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BACKGROUND: To avoid symptoms, patients with COPD may reduce the amount of activities of daily living (ADL). Therefore, the aim of the present study was to develop a standardized protocol to evaluate ADL performance in subjects with COPD (Londrina ADL protocol) and to assess the validity and reliability of the protocol in this population. METHODS: The Londrina ADL protocol was created based on activities included in previous studies aimed at investigating outcomes from ADL. Activities were included in the protocol because they could represent other activities of similar patterns and because they could be actually performed, not simulated. Twenty subjects with COPD (12 men, 70 ± 7 y old, FEV_1 = 54 ± 15% predicted) wore 2 motion sensors while performing the protocol 4 times, 2 of them wearing a portable gas analyzer. Subjects were also submitted to assessments of lung function, functional exercise capacity, functional status, impact on health status, and physical activity in daily life. RESULTS: The Londrina ADL protocol comprised of 5 activities representing ADL, involving upper limbs, lower limbs, and trunk movements. Londrina ADL protocol duration presented high values of intraclass correlation coefficient, even using a mask for gas analysis (intraclass correlation coefficient >0.90, $P < .001$). Intensity of movement during the protocol performance was highly correlated to intensity of movement in daily life ($r = 0.71$). The protocol duration was correlated with functional status and impact on health status variables from questionnaires ($0.36 \leq r \leq 0.59$). There was also correlation between functional exercise capacity and the protocol duration ($r = -0.64$). CONCLUSIONS: The Londrina ADL protocol was a valid and reliable protocol to evaluate ADL performance in subjects with COPD. It is a protocol that can be used in clinical practice and in future studies to investigate ADL outcomes, including those studies that require gas analysis and the wearing of a mask. *Key words: COPD; activities of daily living; aging; motor activity; chronic limitation of activity; symptoms and signs.* [Respir Care 2017;62(3):288–297. © 2017 Daedalus Enterprises]

Introduction

Dyspnea and fatigue are the most common symptoms reported by patients with COPD,[1] a progressive disease with pulmonary and extrapulmonary manifestations.[2] Therefore, patients involve themselves in a negative spiral, reducing participation in physical activities, intending to avoid symptoms.[3] However, the less they perform physical activities, the more they worsen their physical conditioning and symptoms.[4] This vicious cycle affects even simple features, such as activities of daily living (ADL).[4]

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ADL are activities related to the subject's routine and are generally linked to domestic tasks, personal care, leisure, and work-related activities. As a consequence of increased symptoms, patients reduce the amount of ADL, leading to a reduction in quality of life, which is associated with limitations to perform ADL.[5] Considering the impact of a limited ADL performance on the daily life of patients with COPD, the adequate evaluation of ADL performance is relevant for clinical practice in this population.

A term often used to describe the level of ADL impairment and performance is "functional status."[6] The most common instruments available to evaluate ADL and functional status are questionnaires. Some examples of questionnaires in widespread use for these purposes, validated for use in patients with COPD, are the pulmonary functional status and dyspnea questionnaire, modified version (PFSDQ-M)[7,8] and the London chest activity of daily living questionnaire (LCADL).[9,10] In these questionnaires, patients report to which degree symptoms interfere on their ADL performance. Although it is very important to know how patients perceive their own ADL performance and limitations, an objective assessment of this outcome can provide complementary information.

The Glittre ADL test is a protocol developed to assess functional status in patients with COPD. For this, patients have to perform 4 different activities (rising up from sitting position, walking, moving up and down an interposed 2-step staircase, and organizing objects on shelves) through a 10-m corridor, going back and forth 5 times along the corridor. The protocol has to be performed as fast as possible, and the time spent to complete it is the test's main outcome.[11] However, the Glittre ADL test does not include an in-depth and objective assessment of problematic activities involving the upper limbs, which are often limited in patients with COPD.[12] Furthermore, it was shown that the Glittre ADL test induces a higher oxygen uptake than the 6-min walk test (6MWT),[13] an exercise capacity test. Moreover, since the Glittre ADL test is performed as fast as possible and not at the usual ADL pace, it correlates more strongly with the 6MWT (a test in which the instruction is to walk as far as possible in 6 min) than with functional status questionnaires.[11] Since it is known that the 6MWT frequently makes patients with COPD achieve their near-maximal sustainable intensity during the test,[14] it is questionable to associate the Glittre ADL test with a real-life ADL representation; instead, it should more likely be associated with a test of functional exercise capacity.

In an Asian study,[15] the psychometric properties of an ADL protocol, the monitored functional task evaluation, were investigated in subjects with COPD. However, this protocol is described as "symptom-limited," since the effort intensity during performance of activities is monitored and limited to 70% of maximum heart rate.[15] Therefore, the monitored functional task evaluation jeopardizes the possibility of investigating the real performance of patients, since they will not freely execute the activities as they do in daily life but will rather perform them according to the limit imposed by the protocol.

Another gap in the literature is that when researchers want to investigate any outcome coming from or associated with ADL (eg, dynamic hyperinflation, S_{pO_2}, or energy expenditure), it is common to create their own ADL protocols specifically for their studies.[16-22] This leads to a lack of standardization in the objective assessment of ADL in patients with COPD. Furthermore, almost all of these protocols did not have their psychometric properties evaluated. Obviously, this is a scenario that imposes a methodological bias in scientific investigations, hindering comparisons between different studies.

Considering the limitations in the assessment of ADL performance in patients with COPD identified in the literature, the development of a laboratory-based protocol that in fact reflects ADL performed at the patients' usual speed, which is reliable and objectively assesses ADL performance, would be useful to standardize the assessment of ADL performance and contribute to the in-depth evaluation of patients with COPD. For these reasons, we propose a new protocol of objective ADL assessment in subjects with COPD, which is intended to counteract the disadvantages of the available tools: the Londrina ADL protocol. After creating the protocol, the present study

QUICK LOOK

Current knowledge

Dyspnea and fatigue are the most common symptoms reported by patients with COPD. As a consequence of increased symptoms, patients reduce the amount of activities of daily living (ADL). Considering the impact of a limited ADL performance on the daily life of patients with COPD, it is relevant for clinical practice to be able to evaluate ADL performance in a standardized way in this population.

What this paper contributes to our knowledge

The Londrina ADL protocol was shown to be a valid and reliable test, even when subjects were using a mask for gas analysis. It is a protocol that can be used in clinical practice and in scientific studies to investigate ADL outcomes, including those studies that require gas analysis and the wearing of a mask. Therefore, by creating the Londrina ADL protocol and investigating its validity and reliability, the present study contributes the possibility of having a standardized method for assessment of ADL performance in subjects with COPD.

Table 1. Activities Included in Activities of Daily Living Protocols of Previous Studies

Authors	Year	Activities of Daily Living Included
Fong et al[15]	2001	Walking on level ground for a fixed distance; standing up from a chair and then sitting down; lifting a 3-kg weight load from waist level to a higher level and then returning the weight back to waist level; walking on level ground for a fixed distance while carrying in each hand a load of 3 kg; rising up and down on a step.
Velloso et al[21]	2003	Sweeping the floor; erasing a blackboard; lifting pots weighing 0.5, 1.0, 2.0, 3.0, 4.0, and 5.0 kg from waist level to above the head and putting them down again on a surface at that level; screwing in and out a bulb from sockets placed at the height of the eyes.
Skumlien et al[11]	2005	Rising from a seated position; walking; moving up and down an interposed 2-step staircase; repositioning cartons weighing 1 kg in shelves. All activities were performed by subjects carrying a backpack containing 2.5 kg (women) or 5.0 kg (men).
Hill et al[23]	2008	Standing up from a chair and carrying 2 grocery bags, each filled with 10 items (410 g each) to a bench, before stacking the items onto a shelf 15 cm above shoulder height.
Lahaije et al[24]	2010	Vacuum cleaning; carrying weight during walking (4–5 kg); showering; putting on socks and shoes; getting dressed; (un)loading washing machine; climbing stairs; dish washing; hanging up laundry; window cleaning; wiping terrace/cleaning floor; cleaning cupboard; gardening; peeling potatoes.
Sant'Anna et al[19]	2012	Sitting on a chair and rising; climbing up and down a step; lying down on a bed and then rising; dressing and removing a shirt.
Pessoa et al[25]	2012	Picking up weights of 0.5, 1, 2, 3, 4, and 5 kg from a waist-high surface and positioning them on a shelf located above the head.
Vaes et al[26]	2012	Putting on 2 socks (sitting in chair), 2 shoes (sitting in chair), and a vest (standing); folding 8 towels (standing); putting away groceries (6 cans of beans of 400 g each) in a cupboard (standing and walking); washing 4 dishes, 4 cups, and 4 saucers (standing); sweeping the floor.
Castro et al[27]	2012	Walking up and down stairs and up and down a ramp; sweeping and mopping.
Lahaije et al[18]	2013	Vacuum cleaning; sweeping floor; stair climbing; carrying bags; changing beds; dish washing; window cleaning; hanging laundry; digging garden; putting on shoes; cleaning cupboards; walking with the dog; emptying dishwasher.
Castro et al[17]	2013	Brushing teeth; washing face; combing hair; simulating bathing; putting on and taking off clothes and shoes; sweeping the floor; storing pots weighting 1.5 kg in upper and lower shelves; washing dishes; writing on a sheet of paper; answering the phone without any arm support; opening and closing drawers; moving paper sheets from one side to the other of a desk; walking up and down a flight of stairs; walking up and down a ramp; walking along a 25-m corridor carrying 2.5 kg in both hands and 5.0 kg in one hand for another.
Velloso et al[28]	2013	Teeth brushing; face washing; hair combing; taking shirt off; putting shirt on; putting shoes on; taking shoes off; shaving for men; waxing for women.
Rutten et al[29]	2014	Putting on shoes, socks, and a coat; folding up 16 towels and placing them in a basket; placing 12 cans (400 g) in a shopping basket; washing 8 plates, 8 cups, and 8 saucers and placing them in a plate rack; sweeping plastic blocks with a broom.
Barusso et al[30]	2015	Getting out of bed; putting on shoes; making the bed; showering; lifting and lowering containers on a shelf above the shoulder girdle; and raising and lowering pots on a shelf below the pelvic girdle.
Silva et al[16]	2015	Walking down a corridor carrying a bag weighing 5 kg; going up and down a 10-step staircase; walking on a treadmill with 5% inclination; putting shoes on and taking them off; lifting pots (1, 2, and 3 kg) from a table to the highest position over the subject's head, using both arms, and then bringing the pots back to the table; simulating taking a shower.

then investigated the validity and reliability of the new protocol in this population.

Methods

For the development of a new protocol for the assessment of ADL performance in subjects with COPD, bibliographic research was done to find studies that applied different ADL protocols in this population. Based on these studies, the ADL included in those protocols were registered, and the most prevalent ADL were verified. Table 1 shows these studies and the ADL included in each one. After that, meetings with the authors of the present study were undertaken to discuss the ADL included in the previous studies. Those meetings had the objective of determining the activities that should be prioritized for inclusion in the new ADL protocol. The criteria used to select the activities to be included in the new protocol were: activities that could make the protocol simple and feasible; activities that involved the utilization of upper and lower limbs and trunk flexion/inclination; activities that reproduced what is commonly performed in the day-to-day rou-

tines of most people; activities that could be performed in the most realistic way that was possible, avoiding simulations (ie, avoid pretending one is having a shower, sweeping the floor, shaving, etc). It is important to highlight that each activity included in the Londrina ADL protocol does not necessarily represent the intention to evaluate subjects' performance in that specific activity, but also in activities with similar movements to that activity. In other words, when an activity such as hanging clothes on a clothesline was included, the objective was not necessarily to evaluate subject performance only during hanging clothes on a clothesline, since several subjects do not actually perform this activity in daily life. Actually, the objective was to evaluate subjects' performance during an activity that includes upper-limb movement above the head associated with trunk movement in the standing position. Finally, before investigating psychometric properties of the new protocol, we applied it in a sample of young healthy adults and subjects with COPD to identify practical limitations of the protocol and to correct them. The new protocol was named Londrina ADL protocol because it was created in the Laboratory of Research in Respiratory Physiotherapy of the State University of Londrina, Brazil.

For the analysis of the protocol's criterion validity and reliability, 20 subjects with COPD were included. As inclusion criteria, they presented with a diagnosis of COPD according to the Global Initiative for Chronic Obstructive Lung Disease criteria,[2] clinical stability (at least 3 months without severe exacerbation of the disease), absence of neuromuscular or skeletal disorders that could impair ADL performance, and not having basal P_{aO_2} and S_{pO_2} values consistent with an indication of long-term oxygen therapy ($P_{aO_2} \leq 55$ mm Hg or $S_{aO_2} < 88\%$). Patients were excluded if they were not able to execute the proposed evaluations. This research was approved by the ethics committee of the State University of Londrina, Brazil (approval 031/2013), and all participants provided informed consent.

Assessments were done at 3 times. On the first visit to the laboratory, subjects had their anthropometric data collected and were submitted to arterial blood gas analysis and assessment of lung function by spirometry,[31,32] impact on health status by the COPD assessment test,[33] and functional status by the LCADL[9,10] and the PFSDQ-M.[7,8] On the second visit, subjects performed the Londrina ADL protocol 4 times, with sufficient intervals to recover basal S_{pO_2}, heart rate, and perceived effort (modified Borg scale).[34] Two of these protocol performances occurred with subjects wearing a portable gas analyzer (Oxycon mobile device, CareFusion, San Diego, California),[35] registering the oxygen consumption ($\dot{V}_{O_2}$). The portable gas analyzer weighs around 1 kg and requires wearing a face mask. The order of testing (with and without the portable gas analyzer) was randomized. During all protocol performances, S_{pO_2}, heart rate, energy expenditure (SenseWear armband, Body Media, Pittsburgh, Pennsylvania),[36] and intensity of movement (DynaPort Move Monitor, McRoberts, Den Haag, The Netherlands)[37] were registered. Before and after the protocol, dyspnea and fatigue sensation were also assessed by the modified Borg scale.[34] Each subject was asked to perform each activity at the usual pace at which he/she would perform it in real life, and the main outcome registered from the Londrina ADL protocol was the time spent by subjects to perform the protocol (ie, the Londrina ADL protocol duration), verified using a simple stopwatch. After performing the 4 protocols, subjects reported the degree of difficulty in performing each protocol by a Likert scale. This scale ranged from 0 to 10, where 0 represents not difficult at all and 10 represents too much difficulty. On the third visit, subjects were submitted to functional exercise capacity evaluation by the 6MWT[38] and received the 2 activity monitors (SenseWear armband and DynaPort Move Monitor). Subjects wore these devices during 2 consecutive weekdays, 24 h/d. The main outcomes from the activity monitors were the total energy expenditure by the SenseWear armband and the movement intensity from the DynaPort Move Monitor.

Sample Size Calculation

The intensity of movement during daily life, an outcome registered objectively by physical activity monitoring, was selected as the main variable to verify the validity of the Londrina ADL protocol as representing subjects' real ADL performance. A sample of 14 subjects would be necessary to find a correlation of at least 0.70 between movement intensity during the Londrina ADL protocol and movement intensity during daily life, considering $\alpha = .05$ and $\beta = 0.80$. The calculation was done using BioStat 3.0 software (AnalystSoft, Walnut, California). Although movement intensity was the main outcome to evaluate the protocol's validity, other variables were also included in the study methodology, with the objective to have a more in-depth analysis of the new protocol.

Statistical Analysis

Data distribution was analyzed by the Shapiro-Wilk test. According to normality in data distribution, data were expressed as mean and SD or median and interquartile range; correlations between outcomes were verified using Pearson or Spearman coefficients; and comparisons were done using a paired Student *t* test or Wilcoxon test. Reproducibility and agreement of the Londrina ADL protocol were verified using the 2-way mixed, single-measure, intraclass correlation coefficient (ICC) and Bland-Altman plots, respectively. Statistical significance was set at $P < .05$. The analysis was performed using SPSS 20.0 (SPSS, Chicago,

Illinois) and GraphPad Prism 6.0 (GraphPad Software, La Jolla, California).

Results

Five activities were included in the Londrina ADL protocol, including activities that involved upper limbs, lower limbs, and trunk flexion/inclination/rotation. It was also possible to include activities that could be fully and realistically performed, without pretending or simulating. Additionally, all the activities included are relatively simple to organize from the logistical point of view.

During the application of the protocol in 3 healthy young adults and 3 subjects with COPD to identify limitations in the protocol, some original characteristics of the protocol were adapted. For example, it was realized that some subjects used only one hand to perform some upper-limb activities to avoid other body movements (such as trunk movement). Therefore, for standardization purposes, we included the instruction of "moving objects with both hands." The order of the activities during the protocol was also adapted until reaching the final sequence because, in the beginning, the order of the activities was causing too much upper-limb fatigue among the subjects with COPD, leading to a need for frequent rest intervals. The final version of the Londrina ADL protocol is described below.

The protocol is composed of 5 activities and organized in stations inside a room. The room must include enough space to allow for the required distances between the stations (6.5 × 5.0 m is enough). The positions of the activity stations and the distance between them are shown in Figure 1. The sequence of the stations is as follows.

(1) Objects on the table. The subject sits on a chair in front of a table with a drawn line separating it into 2 halves (left and right). A table of 1.2 m (length) × 0.6 m (width) was used, but small variations in its dimensions are allowed, since activity dynamics is preserved. The subject must have the possibility of performing not only upper-limb movements but also trunk movements. However, trunk movements are not mandatory. The subject will use his own movement dynamics. The table has 10 objects above it (4 objects of 250 g, 4 objects of 500 g, and 2 objects of 1 kg), all together on the left half of the table. The subject takes the objects, one by one, with both hands and puts them all on the right half of the table. After that, subject returns all of the objects in the same way to the left side of the table again. There is no standardized order for object positioning. This activity was chosen to represent activities that involve upper-limb movements in the sitting position.

2) Walking with bags. The subject walks over a 6-m line, 3 consecutive times (back and forth, totaling 18 m), carrying 2 bags, one in each hand. Inside the bags, there are loads representing 10% of the subject's body weight, 5% in each bag. This activity was chosen to represent activities that involve carrying loads while walking, inside the home or in the street.

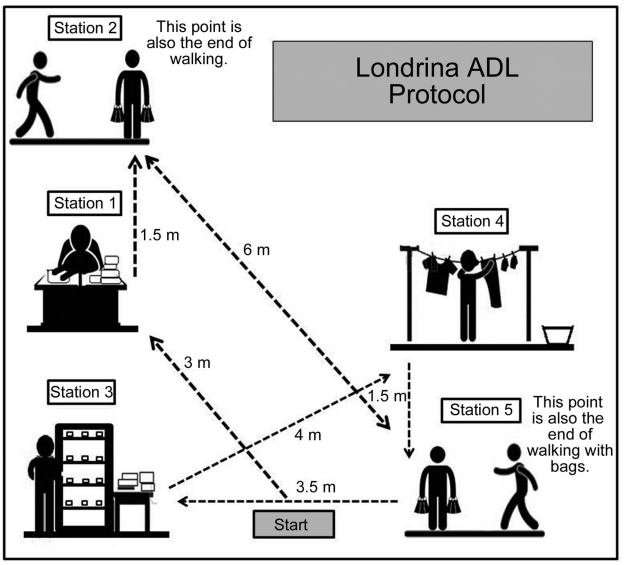

Fig. 1. Positioning of activity stations in the Londrina activities of daily living (ADL) protocol. The subject is initially positioned at the start area. He/she walks to station 1 to perform the established activity (objects on the table). Finishing activity 1, the subject walks to station 2 (beginning of walking with bags), where he/she takes the 2 bags positioned on the floor, already containing the predetermined load, and begins walking, carrying one bag in each hand. This walking occurs in the 6-m line, 3 consecutive times. In other words, the subject walks to the end of the 6-m line, turns around, walks back to the first position, turns around, and walks once again to the end of the 6-m line, finalizing the activity on the point identified as the end of walking with bags (the same as station 5). At this point, the subject leaves the bags on the floor and walks to station 3 (shelves) to perform this activity. After this activity is concluded, the subject walks to station 4 (clothesline) and, after this activity is concluded, goes to station 5 (beginning of walking) to start walking again through the 6-m line 3 consecutive times, this time without the bags. The protocol is finalized at the point identified as the end of walking. More details about the protocol can be found in the text.

3) Shelves. The subject stands in front of 4 shelves, one above the other (distributed at different levels, from a height near to knees to above the head), with a table beside them. On the table, there are 12 objects (4 objects of 250 g, 4 objects of 500 g, 2 objects of 1 kg, and 2 objects of 2 kg). The subject takes the 12 objects, one by one, with both hands and puts them on the shelves. The subject organizes the objects on the shelves in such a way that 3 objects are placed on each shelf but with no standardized positioning order regarding which object should be placed on each shelf. When all of the objects are placed on the shelves, the subject returns the objects again to the table, one by one, with both hands. This activity was chosen to represent unsupported upper-limb activities associated with trunk movement in the standing position.

Table 2. Subject Characteristics

Characteristics	Values
Male/female sex, *n*	12/8
Age, mean ± SD y	70 ± 7
BMI, mean ± SD kg/m^2	26 ± 5
FEV_1, mean ± SD % predicted	54 ± 15
6MWD, mean ± SD m	504 ± 83
6MWD, median (IQR) % predicted	95 (66–104)
P_{aO_2}, median (IQR) mm Hg	76 (64–80)

N = 20.
BMI = body mass index
6MWD = 6-min walk distance
IQR = interquartile range

Table 3. Values Obtained From the Assessment Battery

Variables	Values
Londrina ADL protocol	
Duration, median (IQR) s	378 (354–426)
Duration with mask, mean ± s	420 ± 18
Peak $\dot{V}_{O_2}$, mean ± mL/kg/min	14 ± 2
Movement intensity, mean ± m/s^2	1.7 ± 0.3
Difficulty, median (IQR)	3.8 (1–4)
Energy expenditure, median (IQR) cal	18 (14–29)
Baseline S_{pO_2}, median (IQR) %	93.6 (90.6–94.6)
Baseline heart rate, mean ± beats/min	84.3 ± 10.4
Baseline Borg dyspnea, median (IQR)	0 (0–1)
Baseline Borg fatigue lower limbs, median (IQR)	0 (0–1)
Baseline Borg fatigue upper limbs, median (IQR)	0 (0–1)
Final S_{pO_2}, mean ± %	91.9 ± 3.2
Final heart rate, median (IQR) beats/min	90.5 (83.2–97.7)
Final Borg dyspnea, median (IQR)	2 (0.5–3)
Final Borg fatigue lower limbs, median (IQR)	1 (0–3)
Final Borg fatigue upper limbs, median (IQR)	1 (0–2)
Physical activity in daily life	
Movement intensity, mean ± m/s^2	1.6 ± 0.3
Energy expenditure, mean ± cal	2,034.2 ± 456.6
LCADL, median (IQR) points	
Health care	5 (4–7.5)
Domestic	6 (2.5–9.7)
Physical activity	5 (3–5.7)
Leisure	3.5 (3–4.7)
Total	18 (16–23.7)
PFSDQ-M, median (IQR) points	
Dyspnea	7 (2.7–17)
Fatigue	5 (3.2–11.7)
Activities	8 (3.2–21.2)

ADL = activities of daily living
IQR = interquartile range
Peak $\dot{V}_{O_2}$ = peak oxygen consumption
LCADL = London chest activity of daily living scale
PFSDQ-M = pulmonary functional status and dyspnea questionnaire, modified version

4) Clothesline. The subject stands in front of a clothesline, positioned at eye level. There is a bowl/basket on the ground, next to the subject, containing 10 items of clothing. Clothes should be dry and of different sizes for adults, ranging from 80 to 442 g (median weight of the items is 122 g). Small variations in the clothes weight are allowed. Subject takes the items, one by one, with both hands and hangs them on the clothesline. After hanging all of the items, the subject returns them to inside the bowl/basket again, taking them one by one and with both hands. There is no standardized order for positioning of clothes on the clothesline or in the bowl/basket. This activity was chosen to represent unsupported upper-limb activities in the standing position, with more intense trunk movements and, eventually, squatting (movement pattern is chosen by the subject).

5) Walking. The subject walks back and forth again on the same 6-m line described in activity 2, 3 consecutive times, but without carrying the bags. This activity was chosen to represent walking in daily life.

As mentioned previously, the subject is asked to perform the activities at the usual pace in which he/she would perform them in real life. Between the activity stations, the subject also walks at the usual pace. Before the subject starts to perform the protocol, the evaluator demonstrates the activities in the order in which they will be performed, explaining how they have to be performed. The instructions given to the subject are: "Perform these activities as if you were doing them at home, in your usual day-by-day pace. You are allowed to stop to rest if you feel it is necessary. Do not worry about the order of the activities, because we will give you instructions along the protocol." After completing one activity, the subject is reminded of the next; however, no encouragement is given during the protocol.

For the criterion validity and reliability analysis, 20 subjects with COPD were included in the study. Characteristics of the participants are given in Table 2, and the values obtained from the assessment battery are shown in Table 3. All subjects were in the registers of the research laboratory as currently involved, previously involved, or interested in being involved in a pulmonary rehabilitation program.

Results described in Table 4 concern the protocol's reliability when the subjects were not wearing the portable gas analyzer. The reliability of the Londrina ADL protocol duration is also shown in Figure 2A. There was no difference in duration between test 1 and test 2 (378 [interquartile range 354–426] vs 372 [336–420] s, $P = .10$). Moreover, Figure 2B illustrates the reliability of the reported difficulty in the 2 protocols performed.

Even while using a gas analyzer mask, the protocol duration was reproducible (ICC = 0.97, 95% CI 0.93–0.99, $P < .001$), presenting a quite small difference between test

Table 4. Reliability Values of Londrina ADL Protocol Outcomes

Variables	ICC	95% CI	*P*
Duration	0.90	0.74–0.96	<.001
Difficulty	0.96	0.90–0.98	<.001
Energy expenditure	0.83	0.57–0.93	<.001
Baseline S_{pO_2}	0.89	0.71–0.96	<.001
Baseline heart rate	0.90	0.74–0.96	<.001
Baseline Borg dyspnea	0.95	0.88–0.98	<.001
Baseline Borg fatigue lower limbs	0.95	0.87–0.98	<.001
Baseline Borg fatigue upper limbs	0.88	0.70–0.95	<.001
Final S_{pO_2}	0.84	0.60–0.94	<.001
Final heart rate	0.86	0.65–0.95	<.001
Final Borg dyspnea	0.92	0.81–0.97	<.001
Final Borg fatigue lower limbs	0.83	0.56–0.93	<.001
Final Borg fatigue upper limbs	0.84	0.60–0.94	<.001

ICC = intraclass correlation coefficient

1 and test 2 (420 ± 18 s vs 396 ± 18 s, $P = .02$). From the protocols performed using the portable gas analyzer, peak $\dot{V}_{O_2}$ during the protocol was obtained, and it was also shown to be reproducible (ICC = 0.89, 95% CI 0.53–0.98, $P = .002$). There was no difference in peak $\dot{V}_{O_2}$ between test 1 and test 2 (14 ± 0.63 vs 13 ± 0.64 $mL \cdot kg^{-1} \cdot min^{-1}$, $P = .70$).

Londrina ADL protocol duration was reproducible between protocols performed with and without a mask for gas analysis, presenting ICC = 0.94, 95% CI 0.85–0.98, $P < .001$ (Fig. 2C). However, as expected, the energy expenditure and the difficulty reported by subjects showed lower reproducibility between protocols performed with and without the mask (ICC = 0.73, 95% CI 0.29–0.90, $P = .005$ and ICC = 0.70, 95% CI 0.21–0.88, $P = .008$, respectively).

For correlation analysis, the first protocol performance without the gas analysis was used, since it was reproducible. The subject's movement intensity during the protocol performance was well correlated with the subject's movement intensity during locomotion in daily life (r = 0.71, $P = .001$) (Fig. 3). Correlations between the protocol duration and other outcomes are described in Table 5. There was no correlation between the protocol duration and lung function outcomes.

The questionnaire domain that best correlated with the difficulty reported by subjects regarding the protocol performance was fatigue from the PFSDQ-M (r = 0.53, $P = .01$), but the same protocol outcome was also correlated with dyspnea and activities from the PFSDQ-M and physical activity and total score from the LCADL (r = 0.38, 0.33, 0.38, and 0.33, respectively, $P = .01$ for all). Reported difficulty, differently from duration, was correlated with absolute FEV_1 (r = 0.43, $P = .040$) but was not correlated with the walking distance in the 6MWT (r = 0.12, $P = .60$).

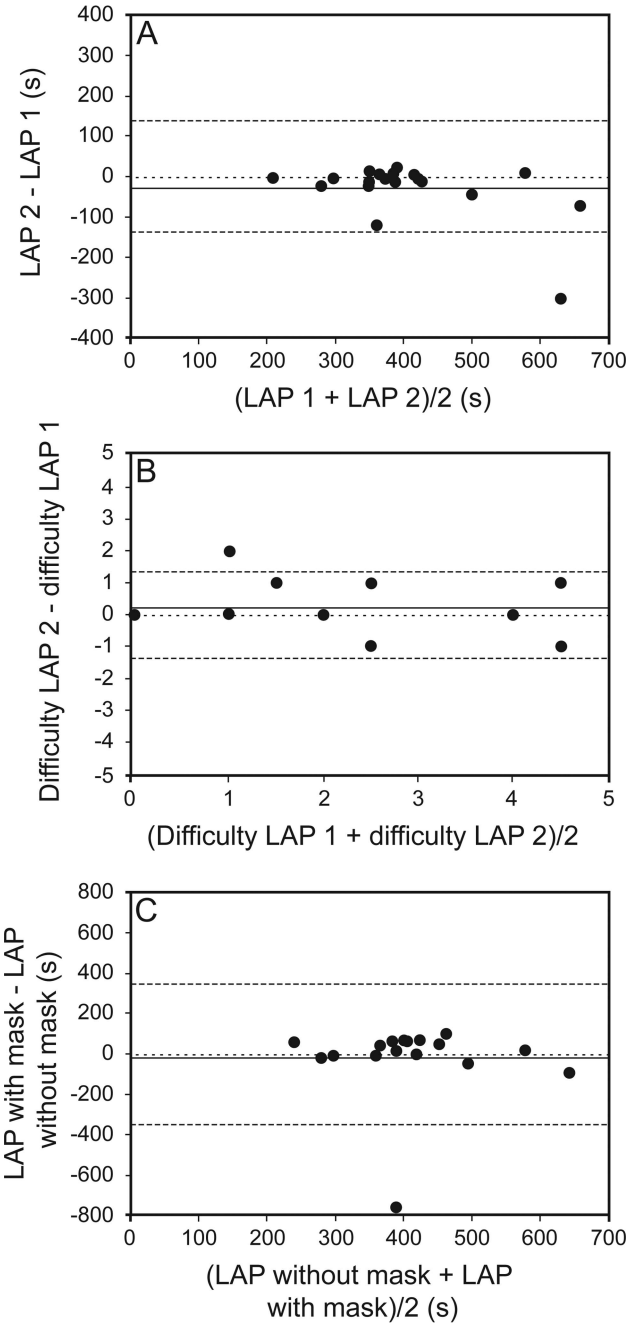

Fig. 2. Bland-Altman plots showing agreement between the Londrina activities of daily living protocol outcomes in the first and second tests. A: Londrina activities of daily living protocol (LAP) duration in the first and second tests; B: reported LAP difficulty in the first and second tests; C: LAP duration performed with and without a mask for gas analysis. The center lines show the mean difference, and the upper and lower dotted lines denote the upper and lower limits, respectively.

Relative peak $\dot{V}_{O_2}$ achieved during the protocol performance was correlated with movement intensity (r = 0.62,

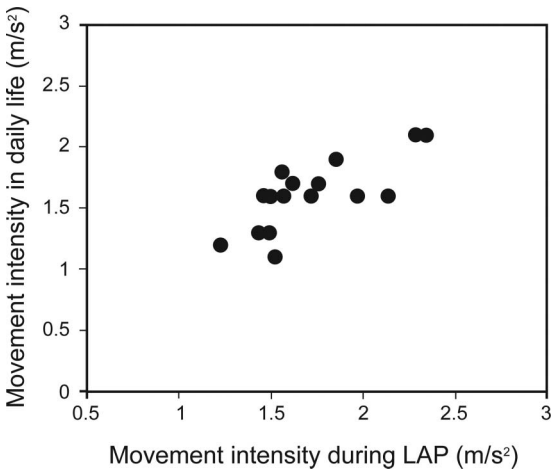

Fig. 3. Correlation between movement intensity during the Londrina activities of daily living protocol (LAP) and movement intensity during daily life (Pearson coefficient).

Table 5. Correlations With Londrina Activities of Daily Life Protocol Duration: Spearman Coefficient

Variables	r	*P*
CAT	0.41	.041
LCADL		
Health care	0.59	<.001
Physical activity	0.44	.004
Total score	0.48	.031
PFSDQ-M		
Dyspnea	0.48	.006
Fatigue	0.36	.02
Activities	0.47	.01
6MWD, % predicted	−0.64	<.001

CAT = COPD assessment test
LCADL = London chest activity of daily living questionnaire
PFSDQ-M = pulmonary functional status and dyspnea questionnaire, modified version
6MWD = 6-min walk distance

$P = .02$) and, consequently, inversely correlated with protocol duration ($r = -0.42$, $P = .01$). Peak $\dot{V}_{O_2}$ was very modestly correlated with 6MWT performance ($r = 0.30$, $P = .01$). No other correlations were found with relative peak $\dot{V}_{O_2}$. Finally, there was no correlation between the energy expenditure in daily life and the energy expenditure during the protocol performance ($r = -0.19$, $P = .40$).

Discussion

This study presents a new protocol developed to evaluate ADL performance in subjects with COPD, the Londrina ADL protocol. It provides the possibility of having a standardized method to assess different outcomes during the performance of ADL in this population. The Londrina ADL protocol is a reliable test, since it has shown high test-retest ICC values. This high reproducibility suggests that the protocol can be performed only once, even if a mask for gas analysis is being used to obtain further outcomes. This is a very useful finding, because studies have shown that dynamic hyperinflation plays a role in ADL performance,[20,39] and for measuring dynamic hyperinflation, a mask may be necessary. The protocol has been shown not to be jeopardized by the use of a face mask. However, researchers should remember that using a mask makes the protocol more energy-consuming and difficult for subjects with COPD. Considering that mean protocol duration is around 7 min, the whole protocol can be applied in 10–15 min (including the initial explanation for subjects). The above mentioned characteristics associated with the simplicity of the protocol, using simple objects and structure, make the protocol a feasible option for the assessment of ADL performance in subjects with COPD.

The Londrina ADL protocol is valid because there was correlation between movement intensity in daily life and movement intensity during the protocol. This indicates that it represents the subject's real life and also the subject's performance during ADL as it happens in real daily life. This was possibly achieved because the instructions given to the subjects were to perform the activities at their usual pace, as they do in their homes on a daily basis. The intensity of movement recorded by the DynaPort Move Monitor is based on acceleration. This is an interesting outcome, because walking speed is associated with survival in the elderly according to a study by Studenski et al,[40] which showed that the lower the walking speed, the lower the survival in this population.[40] Even with the correlation between movement intensity at home and during the protocol performance, there was no correlation between energy expenditure in these 2 situations. A hypothesis to explain these findings is that the protocol duration, for practical reasons, was substantially shorter than the duration of daily life evaluation by the motion sensors.

Moreover, the Londrina ADL protocol is correlated with widely used functional status questionnaires and even with a questionnaire that investigates disease impact on health. Although correlations between the protocol and questionnaires are moderate, these are important results. The main protocol outcome (duration) is an objective outcome, and questionnaires present subjective outcomes, since they are based on subjects' memory and feeling about their experiences in daily life. Thus, an expectation of high correlations between these instruments would not be realistic. It could be expected, therefore, that the Likert scale of difficulty for the protocol performance correlated better with the questionnaires. This was not the case, probably due to differences in design and recall period between instruments.

Although the Londrina ADL protocol was correlated with the 6MWT, an important outcome to characterize functional capacity, this correlation was less intense in comparison with other ADL protocols available in the literature.[11] The Glittre ADL test is highly correlated with the 6MWT, possibly because of the test design, which stimulates subjects to walk as fast as possible (the instruction given to patients for the 6MWT is to walk as far as possible in 6 min). Taking into account that the 6MWT represents the functional exercise capacity[38] and the Londrina ADL protocol represents functional performance, a high correlation between these tests was not expected, since they investigate different concepts.[41] The results also suggest that the Londrina ADL protocol is more representative of ADL performance than the above mentioned tests. According to Kocks et al,[42] an indication of the limitations that patients experience in daily life (functional performance) can be more informative for clinical management than functional capacity alone, both composing the functional status concept. The functional capacity is defined as "one's maximum potential to perform activities." On the other hand, functional performance is "the physical, psychological, social, occupational and spiritual activities people actually do in the normal course of their lives to meet basic needs."[41]

There are several studies in the literature that aimed at investigating outcomes derived from ADL.[16-22] To accomplish this goal, authors commonly create ADL protocols specifically for their studies. However, almost all of these protocols did not have their psychometric properties evaluated. Therefore, it is not possible to affirm that they represent subjects' real ADL performance. Another problem is that each study having its own protocol hinders comparisons between studies. By developing and describing the Londrina ADL protocol's psychometric properties, we expect to provide a valid, standardized, simple, and useful tool to be used in clinical studies, without the limitations of other protocols (ie, little involvement of the upper limbs, ADL performed at the maximum and not the usual speed, and predetermined limitation of the performance).

Besides the relatively small sample size appearing to represent a more fit group of subjects, a limitation of the present study is that an accepted standard method for the analysis of the Londrina ADL protocol validity was not used. However, to the best of our knowledge, an accepted standard measure for ADL performance does not exist. Therefore, the option was to use an activity monitor to objectively detect whether subjects performed ADL in the new laboratory-based protocol at the same intensity with which they performed their ADL at home. In addition, questionnaires that are widely known as providing an evaluation of functional status related to ADL performance were also used in the analysis.

Conclusions

The Londrina ADL protocol is a simple, valid, and reliable protocol to evaluate ADL performance in subjects with COPD. It is a protocol that can be used in clinical practice and in future studies to investigate ADL outcomes, including those studies that require gas analysis and the wearing of a mask. Future studies are welcome to investigate the Londrina ADL protocol's responsiveness to interventions, reference values, and minimal important difference.

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