Energy expenditure during daily activities as measured by two motion sensors in patients with COPD

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Summary

Background: In patients with chronic obstructive pulmonary disease (COPD), energy expenditure (EE) assessment during the performance of daily activities is not yet studied in depth. The aim of this study was to determine which daily activities are more demanding to patients with COPD and to compare the accuracy of EE estimation given by the pedometer Digiwalker SW701 (DW) and the multisensor SenseWear Armband (SAB).

Methods: Thirty-six patients with COPD (20 men; FEV_1 48 $\pm$ 15%predicted; BMI 25.7 $\pm$ 8 kg/m^2) were submitted to a modified version of the Glittre ADL-test, which included five activities performed for 1 min each: walking on the level, walking on the level carrying a backpack, walking up/downstairs, rising/sitting in chairs and moving objects in and out of a shelf. During the protocol subjects wore both devices concomitantly, and indirect calorimetry (IC) was simultaneously performed as the criterion method to assess EE.

Results: The most demanding daily activity for individuals with COPD was walking up/downstairs (4.9 $\pm$ 1.7 kcal *versus* 3.7 $\pm$ 1.4 to 4.2 $\pm$ 1.8 kcal for the other tasks; $p < 0.05$). EE estimation by the SAB did not show difference in comparison to IC for the sum of the five activities (SAB = 22.7$\pm$7 kcal *versus* IC = 21$\pm$8 kcal; $p > 0.05$), although overestimation was found in activities involving walking. DW showed significant EE underestimation in the sum of the activities (9.6 $\pm$ 4.3kcal; $p < 0.05$ *versus* IC) and for each activity.

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Conclusion: Walking up/downstairs was the most energy-demanding daily activity for patients with COPD. Furthermore, during daily activities, the multisensor showed adequate overall estimation of energy expenditure, as opposed to the pedometer.

Introduction

One of the most important aspects regarding the limitations imposed by the chronic obstructive pulmonary disease (COPD) is the limitation of the patients to perform their daily activities.[1] This functional limitation, which features physical inactivity in daily life[2,3] and high energy expenditure (EE) for simple activities,[4] has an important role in the morbid-mortality of this population.[5,6] However, there is still limited information concerning what kind of daily activity is more energy-demanding to patients with COPD.

Detailed and objective measurement of physical activities in daily life is now considered an essential outcome of the overall evaluation of patients with COPD, and assessment of EE and step counting (SC) are common methods when assessing this outcome. For EE assessment, literature usually recommends the doubly-labeled water method or indirect calorimetry.[7–9] For SC, direct observation and videotaping have been considered as reference methods.[10] However, these techniques are not easily available in everyday life because of their methodological complexity, limited practicality, and/or high cost. Instead, a variety of motion sensors have been recently used. Simple "step counters" or pedometers (*e.g.*, DigiWalker SW701, or DW) and advanced multisensors (*e.g.*, SenseWear Armband, or SAB) are among the most used motion sensors. Despite their technological differences, both of them quantify steps and estimate total EE, providing information from free living conditions and not just information derived from laboratory tests.

The SAB multisensor was validated in order to assess walking in patients with COPD.[11] Furthermore, Watz et al.[3] showed a comprehensive description of daily physical activity in patients with COPD by using EE assessment provided by the SAB, classifying patients as active, predominantly sedentary and very inactive. Recently, two studies confirmed that the SAB is useful to estimate walking EE of patients with COPD.[12,13] Moreover, Furlanetto et al[12] showed that, in patients with COPD, the DW pedometer was accurate for estimation of EE and SC only at a high walking speed (4.8 ± 0.8 km/h) during a treadmill protocol. However, there are no studies comparing SAB and DW during real life daily activities in patients with COPD.

Therefore, the aims of this study were: (1) to determine which daily activities are more energy-demanding to patients with COPD; and (2) to compare the accuracy of EE and SC estimation by SAB and DW during the performance of different daily activities.

Methods

Study design and subjects

In this cross-sectional observational study, 36 individuals (20 men) with clinically stable COPD (ratio of postbronchodilator forced expiratory volume in 1 s (FEV_1) to forced vital capacity <0.7)[1] were recruited from the outpatient Respiratory Physiotherapy clinic from Hospital Universitário Londrina (Brazil). No patient was long-term oxygen user. Individuals were excluded if they showed a co-morbid condition thought to compromise their mobility (*e.g.*, musculoskeletal problems) or had problems with adaptation to the devices used for assessment. The study was approved by the institution's Ethics and Research Committee, and all subjects signed a formal informed consent term.

Protocol

All subjects were submitted to an initial assessment of lung function (spirometry and maximal inspiratory and expiratory pressures [MIP and MEP, respectively]), functional exercise capacity (6-min walking test [6MWT]) and sensation of dyspnea (modified Medical Research Council scale [MRC]) as screening measures, or the most recent measurements were retrieved from the hospital records (less than 6 months). All patients were classified by two indexes: BODE[14] (body mass, obstruction, dyspnea and exercise capacity) and ADO[15] (age, dyspnea and obstruction).

On a second day, subjects were instructed to walk 10 steps in a straight line as in their daily walking for step size determination. Total distance was measured and divided by 10. Afterward, patients were submitted to a modified version of the Glittre ADL-test[16] (Fig. 1), which included five activities performed during 1 min each: walking on the level, walking on the level carrying a backpack (5 kg for men and 2.5 Kg for women), rising from a chair and sitting in another chair positioned 1 m apart, walking up/downstairs (stair with 9 steps, 15 cm high and 30 cm deep) and moving an object weighting 1 kg in and out of two shelves (it was moved from the top shelf [positioned at shoulder height] to the bottom shelf [positioned at waist height], down to the floor, back to the bottom shelf, to the top shelf again and so on). Activities were performed in random order, and time between activities was determined by the return of heart rate (HR) and oxygen consumption (VO_2) to resting values. During the protocol subjects wore both devices (DW and SAB) concomitantly, and indirect calorimetry (VO_{2000} AeroGraph, AeroSport) was simultaneously performed as the criterion method to assess EE. The indirect calorimetry equipment was calibrated before each test in accordance with manufacturer instructions. EE (in Kilocalories for standardization of units) was derived from VO_2 assessment (mL kg^{-1} min^{-1}). The exact beginning and ending of each activity were synchronized in all devices since there were at least 3 investigators during each test. Concomitantly, the protocol was videotaped by a digital camera (Sony CyberShot DSC-W120) as criterion method for SC. EE and SC estimated by both motion sensors were compared with the criteria