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LETTER TO THE EDITOR

Use of automatic 6-minute walking test recording system in patients with chronic respiratory diseases

KEYWORDS
6MWT;
Distance sensors;
Biological signals;
COPD;
Interstitial lung disease;
Pulmonary hypertension

To the editor:

Physical capacity tests are used for the diagnosis, prognosis and monitoring of chronic respiratory diseases (CRD), such as Chronic Obstructive Pulmonary Disease (COPD) or Pulmonary Hypertension (PH).[1] Among these tests, the most widely used is the 6-minute walking test (6MWT).[2] Additionally, the guidelines highlight the need to continuously record biological signals, particularly oxygen saturation (SpO_2), which has been shown to be a prognostic marker in CRD.[2]

Technological advances have made available new solutions that improve monitoring and testing, including the 6MWT.[3] By applying off-the-shelf technology, including the internet of things (IoT), edge computing and wireless communications, the required biological signals can be automated and recorded in a more user-friendly and reliable way, thus meeting recommendations precisely.[4] Our objective was to determine the reliability and agreement in capturing the SpO_2 and heart rate (HR) data of an automated 6MWT recording system in patients with COPD or PH, in comparison with that manually recorded by a technician.

We conducted a cross-sectional study of patients with a COPD or PH diagnosis followed at the Hospital Clínic in Barcelona, Spain, between October 2022 and March 2023. Ethics committee approval was obtained, and all patients signed informed consent forms. The inclusion criteria were patients older than 18 years and diagnosis of COPD or PH. Exclusion criteria were the presence of locomotor or cognitive impairment and any pre-existing condition limiting the ability to perform at test. Anthropometric characteristics, pulmonary diagnostics, and lung function parameters were collected. The main outcomes were SpO_2 and HR during the 6MWT.

The 6MWT was conducted indoors in a flat, straight, 30-metre walking corridor.[2] The modified Borg scale (0−10) was used to measure dyspnoea and fatigue.[5] A finger oximeter (Nonin WristOx 3130, Plymouth, USA) was used to record SpO_2 and HR. We collected patients' data for an analysis corresponding to 8 data points (baseline, final and every minute during the test).

The 6MWT automatic data collection system consists of a non-commercial prototype designed in a doughnut shape for placement in any type of cone. To record subjects` counterclockwise turns around the cone, it uses sensors that detect movement and send data to a tablet with an ad-hoc application. Simultaneously, the application records HR and SpO_2 biological signals that are acquired at 1 Hz frequency though the finger oximeter. First, the technician must set up the scenario, place sensors over the cones and attach the pulse oximeter to the patient. Meanwhile, the two sensors and the pulse oximeter are paired to the application. The test starts counting the elapsed time when the patient turns around the cone. Then, each time the patient turns around a checkpoint, a card will appear in the application, displaying the tests elapsed time, the time difference from the previous card, the checkpoint number, the SpO_2, and the HR. At the end of the test, the system automatically computes the extra meters walked from the last checkpoint and asks the patient again about dyspnoea and fatigue. When the test is finished, all raw data obtained from the pulse oximeter in all test stages (including the initial rest and the final recuperation) are uploaded, highlighting the checkpoint data. It is accessible to anyone with the required authorisation. A trained technician manually recorded the biological signals in an ad-hoc form. As in the automatic system, the variables were recorded each time the patient passed through one of the cones.

Using the method of Walter et al.[6] based on an estimate using the intraclass correlation coefficient (ICC), at least 40 individuals are necessary, considering an acceptable reliability of p0 = 0.60 and an expected reliability of p1 = 0.80, with a power of 90 % and a level of significance of 5 %, due to the nature and characteristics of the study, a loss of 5 % of the sample is assumed. All data are expressed as means, standard deviations (SD) or medians at the 25th and 75th percentile depending on the distribution. The distribution was analysed using the Shapiro-Wilk test. Differences between

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Table 1 Descriptive data of the included patients.

Variable	N = 45	
Sex, M/F	9/36	
Age, years	58 ± 15	
Weight, Kg	68 ± 15	
Height, cm	164 ± 9	
BMI, Kg/m^2	25.0 ± 4.9	
Diagnosis		
PH	27 (60.0 %)	
COPD	18 (40,0 %)	
Pulmonary function	**COPD**	**PH**
FEV_1, % ref	50 ± 14	84 ± 17
FVC, % ref	82 ± 17	93 ± 14
FEV_1/FVC, %	45 ± 10	71 ± 10
DL_{CO}, % ref	57 ± 18	57 ± 16
K_{CO}, % ref	60 ± 15	65 ± 19
Six-minute walking test		
Distance walked, metres	493 ± 121	
Dyspnoea baseline, Borg	1 (0-2)	
Dyspnoea at the end, Borg	3 (2-4)	
Fatigue baseline, Borg	1 (0-1)	
Fatigue at the end, Borg	2 (1-3)	
*Heart rate**		
Manual system baseline, beat/min	85 ± 17	
Automatic system baseline, beat/min	85 ± 18	
Manual system at the end, beat/min	116 ± 19	
Automatic system at the end, beat/min	112 ± 21	
*Oxygen saturation**		
Manual system baseline, %	96.4 ± 1.6	
Automatic system baseline, %	96.3 ± 1.6	
Manual system at the end, %	89.4 ± 7.2	
Automatic system at the end, %	89.3 ± 6.8	

Values are expressed as the mean ± SD if data are normally distributed or as the median (P25−P75) if the data distribution is skewed. *The difference between both systems > 0.05. Definition of abbreviations: BMI: Body mass index; PH: Pulmonary hypertension; COPD: Chronic obstructive pulmonary disease; FEV_1: Forced expiratory volume in the first second; FVC: Forced vital capacity; DL_{CO}: Diffusing capacity for carbon monoxide; K_{CO}: Carbon monoxide transfer coefficient.

data were evaluated using Student's t-test for normally distributed variables or a Mann−Whitney U test for nonparametric variables. The ICC and Bland−Altman plots were used to evaluate the agreement between both systems. All statistical analyses were performed with the SPSS Version 25.0 package (SPSS, Chicago, IL, USA).

We recruited 45 patients (36 [80 %] women; 58 ± 15 years). The baseline characteristics of the patients are presented in Table 1. Regarding the 6MWT, the mean distance walked (in the manual and automatic registry) was 493 ± 121 m. The ICC for the HR was 0.894 (0.863−0.918) and for SpO_2, it was 0.955 (0.941−0.965). The Bland-Altman plot showed that 94.2 % of the HR data and 94.2 % of the SpO_2 data were within the limits of agreement (Fig. 1).

The automatic system can acquire biological signals at a frequency of 1 Hz, thus providing much more information during the performance of the 6 MWT. In contrast, when it is manually recorded, biological signals usually cannot be collected due to the limitations of technicians who first need to pay attention to patients' safety.

Finally, to date, automatic recording systems have been developed that mainly focus on remote evaluation or the recording of biomechanical gait parameters.[3] The proposed system, unlike those previously published, focuses on the recording of biological signals in respiratory patients, especially SpO_2, which predict mortality and exacerbation.[7,8]

In conclusion, using an automated recording system based on distance sensors and the transmission of biological signals is reliable and shows excellent agreement with the manual registration system for the clinical registration of SpO_2 and HR during the 6MWT in patients with CRD.

Conflict of interest

The authors declare to have no conflict of interest.

CRediT authorship contribution statement

R. Torres-Castro: Formal analysis, Methodology, Writing − original draft, Writing − review & editing. **H. Pascual:** Formal analysis, Methodology, Writing − review & editing. **A. Alonso:** Conceptualization, Formal analysis, Methodology, Writing − review & editing. **E. Gimeno-Santos:** Methodology, Writing − review & editing. **J.A. Barberà:** Formal

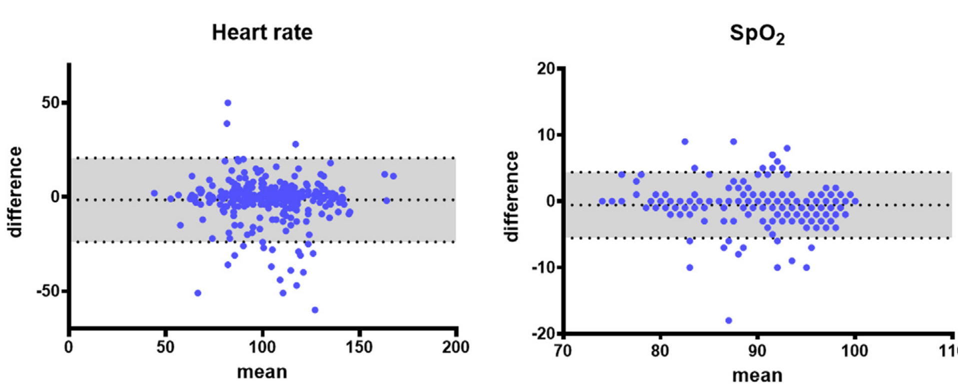

Fig. 1 Bland-Altman plots for biological signals.

analysis, Methodology, Writing − review & editing. **J. Bigorra:** Writing − review & editing. **J. Batlle:** Conceptualization, Writing − review & editing. **X. Masip-Bruin:** Conceptualization, Formal analysis, Methodology, Writing − review & editing. **I. Blanco:** Conceptualization, Formal analysis, Writing − original draft, Writing − review & editing.

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