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Early Post-Discharge Predictors of Sedentary Behavior Following COPD Exacerbation: An Observational Study

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ABSTRACT

Patients hospitalized due to an exacerbation of chronic obstructive pulmonary disease (ECOPD) often exhibit increased sedentary behavior (SB), which may persist after discharge and negatively affect recovery. However, early determinants of SB during this period remain unclear. To identify the factors at hospital discharge that predict SB 30 days later in patients with ECOPD. This observational longitudinal study included patients hospitalized for ECOPD, assessed during the first week after discharge and reassessed 30 days later. Data collected included sociodemographic information (age, sex, name, telephone number, and address), anthropometric measurements (weight, height, and body mass index [BMI]), clinical history (previous hospitalizations, exacerbations, and smoking status), dyspnea (Medical Research Council scale, mMRC), health status (COPD Assessment Test, CAT), co-morbidities (Charlson Comorbidity Index), and exercise capacity (6-minute walk test, 6MWT). Physical activity and sedentary behavior—including SB, light (LPA), moderate (MPA), and vigorous (VPA) physical activity, step count, and sleep—were measured using a triaxial accelerometer worn for seven consecutive days. Accelerometer data were processed with ActiPASS software, and statistical analyses were performed in RStudio. Stepwise regression analysis was used to identify the discharge variables that could predict SB at 30 days. Forty-four patients (61% female; age 66 ± 8 years; FEV_1 53 ± 13%; Charlson 1 [1–2]; hospital stay 5 [3–6] days) were included. At discharge, median mMRC was 3 (2–3), CAT 21 ± 8, 6MWT 274 ± 102 m, steps/day 3,148, SB 619 ± 226 min/day, and LPA 216 min/day. At 30 days, SB was 615 ± 166 min/day. Dyspnea (mMRC) and LPA at discharge explained SB at 30 days (R^2 = 0.31, p < 0.001). Higher levels of dyspnea and lower levels of LPA during the first week after discharge are the significant predictors of SB 30 days after hospitalization for ECOPD.

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COPD; disease exacerbation; sedentary behavior; physical activity; physiotherapy

Introduction

Sedentary behavior (SB) involves prolonged activities performed in a sitting, reclining, or lying position, with energy expenditure <1.5 metabolic equivalents (METs) [1–3]. Physical activity (PA), according to the World Health Organization [4], is defined as any bodily movement that results in energy expenditure, considering intensity, duration, and frequency. It is recommended that adults, including those with chronic diseases, engage in at least 150 min of moderate-intensity PA or 75 min of vigorous-intensity PA per week. Although PA and SB are distinct concepts, they are directly related, as a reduction in PA tends to promote an increase in time spent on SB, reflecting the codependency of physical behaviors. When the time dedicated to one of these behaviors increases, the time dedicated to the others necessarily decreases and vice versa [1].

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During hospitalization for COPD exacerbation (ECOPD), a reduction in PA levels is observed, which may persist even after hospital discharge and contribute to physical deconditioning [5]. In this context, reducing PA after a COPD exacerbation may worsen the clinical prognosis, including an increased risk of rehospitalization [2]. Increasing moderate-to-vigorous physical activity (MVPA) is challenging for individuals with COPD, and even more so after ECOPD when dyspnea and exercise tolerance are more impaired [6]. Therefore, more attention is needed to reduce SB and promote light-intensity physical activity (LPA) during the post-hospitalization period.

In recent years, several studies have investigated the determinants of PA and SB patterns in individuals with COPD. However, most of these have concentrated on SB during the stable phase of the disease, with limited evidence addressing periods of exacerbation [7,8]. According to Tofoli et al. [8], in stable COPD, higher levels of SB are associated with greater dyspnea, fewer steps, and less time spent in light intensity PA. According to Borges et al. [9], who conducted a study in patients with COPD after a hospitalization for a COPD exacerbation, the percentage of time spent lying or sitting decreased after hospital discharge, from 86.7 ± 7.7% to 69.6 ± 16.1%. Despite these reductions, SB remained predominant among individuals with COPD after hospital discharge. Nevertheless, a gap remains in the literature regarding the identification of factors present at hospital discharge that may explain the physical behavior pattern of individuals with ECOPD 30 days after hospitalization, specifically regarding SB. Understanding these factors may contribute to future interventions and clinical management of the disease after an ECOPD.

Therefore, a gap remains in the literature regarding the identification of factors present at hospital discharge that may explain the physical behavior pattern of individuals with ECOPD 30 days after hospitalization, specifically regarding SB. Understanding these factors may contribute to future interventions and clinical management of the disease after an ECOPD.

Thus, the aim of this study was to identify predictor factors in the first week after hospital discharge that may explain SB in individuals with COPD 30 days after hospitalization due to an ECOPD. We hypothesize that SB 30 days after hospital discharge can be explained by the time spent in light physical activity (LPA) and the symptom of dyspnea reported in the first week after hospital discharge.

Methods

Study design, inclusion, and exclusion criteria

This was an observational longitudinal study conducted according to the STROBE guidelines [10] (Strengthening the Reporting of Observational Studies in Epidemiology). The study was approved by the Ethics Committees of the Federal University of São Carlos (CAAE: 67991323.0.0000.5504). Participants were recruited following episodes of ECOPD that occurred during hospitalization, at the time of discharge, at a public hospital of a medium and high complexities, providing specialized care for adults with chronic respiratory diseases, including acute exacerbations and chronic treatment, the University Hospital of the Federal University of São Carlos (UFSCar). Recruitment and screening were carried out in the hospital wards by trained researchers, through medical record review and in person interviews. Data were collected across all seasons, between July 2023 and March 2024.

Patients of both sexes, aged 40 to 80 years, diagnosed with ECOPD according to Global Initiative for Chronic Obstructive Lung Disease (GOLD) classification [11], and who agreed to participate in the study by signing the informed consent form, were included.

Exclusion criteria included patients with any severe condition that could hinder the assessments, such as dysfunction impairing mobility (e.g., osteoarthritis, fractures, or stroke sequelae), ongoing chemotherapy treatment, acute myocardial infarction within the last 6 months, neurological impairment, or associated pulmonary diseases. Additionally, participants with missing accelerometer data were excluded.

Procedures

At hospital discharge, participants underwent an in-person evaluation at the hospital. For those unable to be assessed on the same day, an in-person evaluation was scheduled at the hospital or at the

Physical Therapy Department of the Federal University of São Carlos (UFSCar) within 48 h after discharge. During this visit, sociodemographic (name, telephone number, address, age, and sex), anthropometric (weight, height, and body mass index [BMI]), and clinical data (history of hospitalizations, exacerbations, and smoking) were collected through a structured interview. Participants were classified as exacerbators according to the GOLD 2025 definition [11]. Pulmonary function, exercise capacity, dyspnea, and health status were also assessed.

At the end of the baseline assessment, each participant was fitted with a triaxial activPAL3™ accelerometer, on the mid-right thigh by a trained researcher. Participants were instructed to wear the device continuously, 24 h per day, for 7 consecutive days. For the 30-day reassessment, participants returned to the UFSCar Physical Therapy Department, where the accelerometer was refitted for a second 7-day monitoring period. After this period, the device was collected by a physical therapist.

Assessments

Sedentary behavior and physical activity variables

SB and PA data were monitored using a triaxial accelerometer (activPAL3™, PAL Technologies Ltd., Glasgow, UK), with a sampling frequency of 20 Hz. The device is small, portable, and validated for the measurement of SB and PA [12]. In each assessment, the device was used continuously for 7 consecutive days, with records considered valid if they were used for at least four days, with at least 8 hours of awake monitoring per day [13].

Data were processed using the ActiPASS software (version 2025.04), developed by Hettiarachchi P. and Johansson P., Sweden [14], which classifies time spent in different physical behaviors over a 24-hour period. Behaviors were categorized as follows: SB: Sitting or lying, LPA: Standing still, dynamic standing, and walking slow (<100 steps/min). Moderate-to-vigorous physical activity: Walking fast (≥100 steps/min), stair climbing, running, and cycling [15].

As participants were instructed to wear the activity monitor continuously for 24 hour per day, raw data included both awake and sleep periods. However, only the awake period was considered for the statistical analyses. Sleep time, as well as time spent in moderate physical activity (MPA) and vigorous physical activity (VPA), was retained for descriptive purposes to provide a more comprehensive characterization of 24-hour movement behaviors.

Pulmonary function

Pulmonary function was assessed by spirometry following the standardization documents of the American Thoracic Society/European Respiratory Society (ATS/ERS) [16,17]. Spirometry was performed post-bronchodilator, and the following parameters were collected: forced expiratory volume in the first second (FEV_1), forced vital capacity (FVC), and the FEV_1/FVC ratio, both in absolute values and as percentages of predicted values. Reference values proposed by Pereira et al. [18] for the Brazilian population were used.

Exercise capacity

Exercise capacity was assessed using the 6-minute walk test (6MWT), performed according to the recommendations of the European Respiratory Society and the American Thoracic Society [19]. Participants were instructed to walk a 30-meter distance. The reference values proposed for the Brazilian population were used [20].

Dyspnea

The Medical Research Council dyspnea scale (mMRC) was used to assess the perception of limitation caused by dyspnea in daily activities, and it has been validated for individuals with COPD [21]. The scale consists of five items, where the participant must select a value that best corresponds to their degree of limitation in daily life.

COPD assessment test

The impact of COPD on patients' well-being and daily life was assessed using the COPD Assessment Test (CAT), validated for the COPD population [22]. The CAT consists of eight questions evaluating symptoms such as cough, sputum production, chest tightness, breathlessness, limitations in daily activities, confidence to leave the house, sleep, and energy levels. Responses are scored from zero to five, and at the end of the test, the scores are summed, resulting in a total score ranging from 0 to 40 points. The higher the score, the greater the impact of the disease.

Sample size

The sample size calculation was performed using the G*Power software, version 3.1.9.7 [23] for the correlation data. Thus, a significance level of alpha = 0.05 and power 0.80 were used, with an effect size of 0.4. Therefore, a sample of 44 participants was estimated. Considering a 20% dropout, the total target sample was 53 participants.

Statistical analysis

Analyses were performed using R software version 4.4.1 (R Foundation for Statistical Computing, Vienna, Austria) and RStudio (Posit PBC, Boston, MA, USA). The normality of data distribution was assessed using the Shapiro–Wilk test. Variables with a normal distribution were presented as mean ± standard deviation, whereas non-normally distributed variables were expressed as median and interquartile range (25th–75th percentile). Between-time comparisons first week with 30 days were performed using the Wilcoxon test for non-normally distributed data. A significance level of $p < 0.05$ was adopted.

The correlations between SB at 30 days after hospital discharge and other variables were examined using Spearman correlation coefficients (ρ) for nonparametric data. The strength of the correlations was interpreted according to the following categories: $\rho = 0–0.40$ (weak), 0.41–0.75 (moderate to strong), and 0.76–1.00 (very strong) [24]. Variables that showed a significant correlation with SB ($p < 0.05$) and did not present multicollinearity ($\rho < 0.7$ between independent variables) were entered as candidates in a stepwise multiple linear regression model to identify the main factors associated with SB in individuals with ECOPD.

Given the sample size of 44 participants, a maximum of four independent variables could be included in the regression model without violating general statistical recommendations [25]. In the stepwise multiple linear regression model, only the variables mMRC and LPA were retained in the final model, identifying the main factors associated with SB in individuals with ECOPD.

Results

A total of 75 individuals were assessed for eligibility. Of these, 22 were excluded: 18 based on clinical exclusion criteria and 4 due to simple refusal to participate (participants who met all inclusion criteria but declined). Fifty-three participants were included and assessed at hospital discharge. After this assessment, five patients were excluded: invalid accelerometry data, missing questionnaire data, and death. At the 30-day follow-up, four additional participants were excluded: invalid accelerometry data, hospital readmission, and death. Therefore, the final sample comprised 44 individuals with ECOPD (Figure 1).

The characteristics of the final sample are presented in Table 1. Sixty-one per cent of the sample were female, the mean age was 66 ± 8 years, and the mean BMI was 24 ± 6.65 kg/m^2. The mean FEV_1/FVC ratio was 53 ± 13%, with a post-bronchodilator FEV_1 of 45 ± 15% of predicted. The median GOLD stage was 3 (25th–75th percentile of 2–3), with a predominance of GOLD classification B (62%), followed by classifications E (24%) and A (14%). The mean smoking history was 58 ± 36 pack-years. The median co-morbidities were 1 (1–2), and the length of hospital stay was 5 (3–6) days. A quarter of the sample (25%) was classified as an exacerbator according to the GOLD 2025 criteria. The

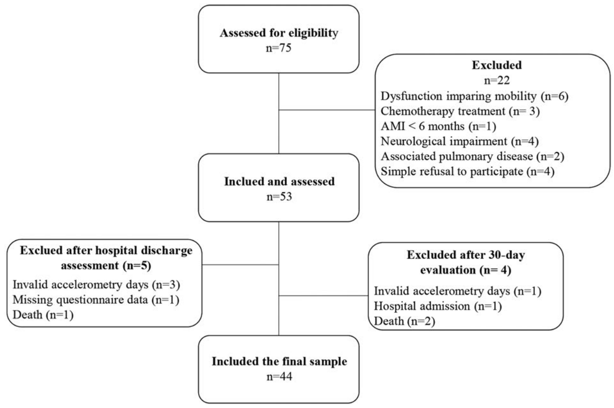

Figure 1. Flowchart of participants included in the study. AMI: acute myocardial infarction. Dysfunction impairing mobility includes conditions such as osteoarthritis, fractures, stroke sequelae, and balance disorders.

Table 1. Sample characteristics of the patients at first week after hospital discharge.

Variables	($n = 44$)
Sex, Female	27 (61%)
Age, years	66 ± 8
BMI, kg/m^2	24 ± 6.65
FEV_1/FVC ratio, %	53 ± 13
FEV_1 post-bronchodilator, %	45 ± 15
GOLD (1, 2, 3, 4)	3 (2–3)
GOLD classification, (%)	
A	6 (14%)
B	28 (62%)
E	10 (24%)
Smoking history (pack-years)	58 ± 36
Charlson index	1 (1–2)
Length of hospitalization (days)	5 (3–6)
Exacerbators, n (%)	11 (25%)
mMRC	3 (2–3)
CAT, score	21 ± 8
6MWT (meters)	274 ± 102
6MWT, % predicted	50 ± 19

Data presented as mean ± SD, median (IQR), or absolute value (percentage). BMI: body mass index; FEV_1: forced expiratory volume in the 1 s; FVC: forced vital capacity; GOLD: Global Initiative for Chronic Obstructive Lung Disease; Exacerbators: classification based on GOLD 2025 criteria; mMRC: Modified Medical Research Council Scale; CAT: COPD Assessment Test™; 6MWT: 6-Minute Walk Test.

Table 2. Characteristics of physical behaviors of the patients at first week and 30 days after hospital discharge.

Variables	First week	30 days	*p*-value
SB (min/day)	619 ± 226	615 ± 166	0.532
Step count (step/day)	3148 (1368–6288)	6118 (2665–8858)	<0.001*
LPA (min/day)	216 (113–370)	294 ± 153	0.020*
MPA (min/day)	16 (3–35)	31 [12.36; 51.14]	<0.001*
VPA (min/day)	2 (1–6)	4 (1.38–6.75)	0.498
Sleep (min/day)	536 (399–668)	522 ± 165	0.788

Data presented as mean ± SD or median (IQR). SB: sedentary behavior; LPA: light physical activity; MPA: moderate physical activity; VPA: vigorous physical activity. Wilcoxon test; $p < 0.05$*.

median mMRC score was 3 (2–3), and the mean CAT score was 21 ± 8 points. The mean 6MWT was 274 ± 102 meters, corresponding to 50 ± 19% of predicted.

Table 2 presents the characterization of patients' physical behaviors during the first week and 30 days after hospital discharge. In the first week, patients spent a mean of 619 ± 226 minutes per day in SB, had a median of 3,148 (1,368–6,288) steps per day and engaged in 216 (113–370) minutes per day of LPA. At 30 days, patients spent 615 ± 166 minute per day in SB, had a median of 6,118 (2,665–8,858) steps per day, and engaged in 294 ± 153 minutes per day of LPA. Time spent in MPA, VPA, and sleep was also included to provide a more comprehensive overview of 24-hour movement behaviors at both time points. Step count, LPA, and MPA showed significant increases over time, whereas SB, VPA, and sleep duration showed no significant changes.

Correlations between SB 30 days after hospital discharge and all studied variables are presented in Table 3. SB 30 days after hospital discharge showed a weak positive correlation with mMRC ($r = 0.33$), a weak negative correlation with predicted 6MWT ($r = -0.38$), a moderate-to-strong negative correlation with 6MWT in meters ($r = -0.41$), a moderate-to-strong positive correlation with step count ($r = 0.44$), and a moderate-to-strong negative correlation with time spent in LPA ($r = -0.50$). Figure 2 represents the association between time spent in LPA during the first week after hospital discharge and SB 30 days after hospital discharge due to ECOPD.

All variables that showed statistically significant correlations with SB 30 days after hospital discharge, including BMI, post-bronchodilator FEV_1, GOLD classification, co-morbidities, length of hospitalization, mMRC, CAT, 6MWT in meters and % predicted, daily step count, and time spent in LPA (Table 3), were initially considered for inclusion in a multiple linear regression model. Only those variables significantly associated with SB and without evidence of multicollinearity were retained for analysis. A stepwise multiple linear regression was then performed to identify the most relevant predictors of SB 30 days after hospital discharge.

The final model included only statistically significant variables, including two assessed in the first week after discharge: the mMRC and LPA. Together, these variables explained 31% of the variance in SB 30 days after hospital discharge (Table 4). Among them, time spent in LPA was the strongest

Table 3. Correlations between sedentary behavior at 30 days after hospital discharge and clinical and behavioral variables measured during the first week after discharge.

Variables	ρ	*p*-value
Sedentary behavior at 30 days		
BMI	0.27	0.072
FEV_1 post-bronchodilator	−0.22	0.148
GOLD classification (A, B, E)	0.12	0.409
Charlson index	0.19	0.204
Length of hospitalization	<0.001	0.950
mMRC	0.33	0.027
CAT	0.13	0.392
6MWT (meters)	−0.41	0.005
6MWT (% predicted)	−0.38	0.009
Step count (step//day)	0.44	0.002
LPA (min/day)	−0.50	<0.001

ρ: Greek rho letter; BMI: body mass index; FEV_1: forced expiratory volume in the 1 s post-bronchodilator; GOLD: Global Initiative for Chronic Obstructive Lung Disease; mMRC: Modified Medical Research Council dyspnea scale; CAT: Chronic Assessment Test; 6MWT: six-minute walk test; LPA: light physical activity. Spearman's rank correlation.

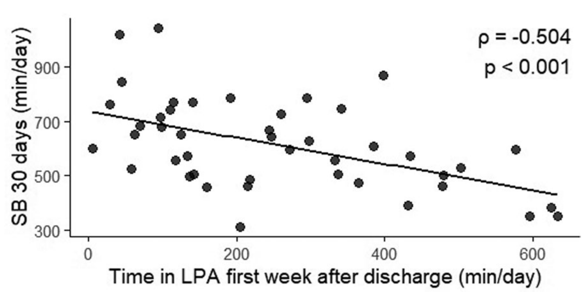

Figure 2. Daily time spent in sedentary behavior (SB) at 30 days after discharge and light physical activity (LPA) at first week after discharge in individuals with COPD.

Table 4. Multiple linear regression models predicting sedentary behavior at 30 days using independent variables measured during the first week after hospital discharge.

Variables	ΔR^2	B	CI95% LL	CI95% UL	*p*
SB at 30 days (min/day)					
mMRC	0.316	37.6	5.37	69.9	0.023
LPA	0.316	−0.45	−0.69	−0.21	0.001

Model: "Stepwise" method in RStudio 4.4.1. mMRC: Modified Medical Research Council Dyspnea Scale; LPA: Light Physical Activity; ΔR^2: Adjusted R-squared; B: Unstandardized regression coefficient; CI: Confidence Interval; LL: Lower Limit; UL: Upper Limit.

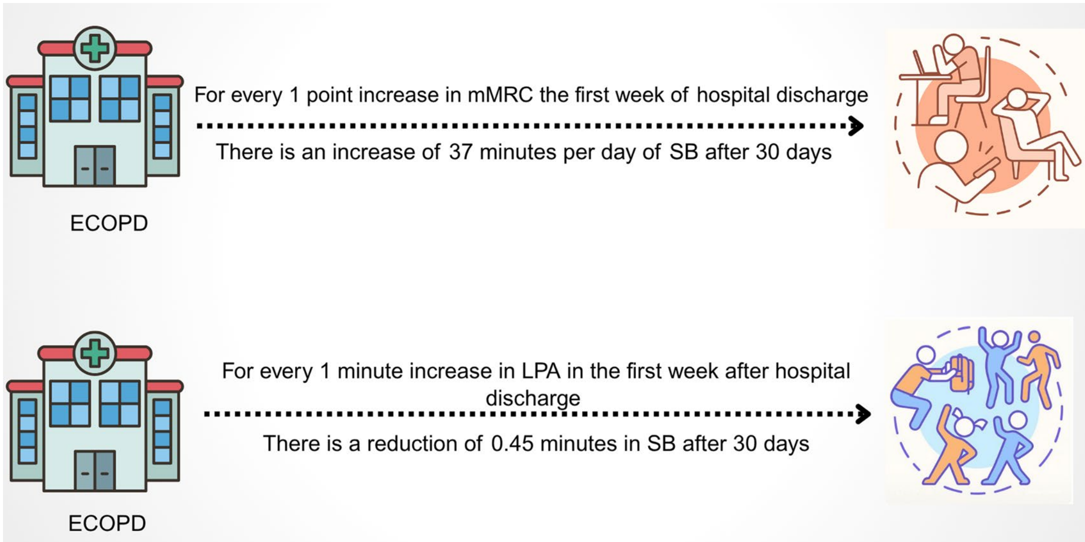

Figure 3. Schematic representation of the associations between clinical variables assessed in the first week after hospital discharge due to COPD exacerbation (ECOPD) and time in sedentary behavior (SB) after 30 days. mMRC: Modified Medical Research Council dyspnea scale; light physical activity (LPA).

predictor, highlighting its central role in explaining SB 30 days after hospital discharge. Figure 3 shows an infographic about the impact of mMRC and LPA assessed at the first week after hospital discharge of patients with ECOPD on SB 30 days after hospital discharge.

Discussion

The results of the present study indicate that SB 30 days after hospital discharge for ECOPD was associated with lower engagement in LPA during the first week after discharge. This finding suggests that LPA a week after hospital discharge plays a relevant role in determining SB 30 days after hospital discharge. Additionally, the mMRC score was also associated with SB, suggesting it may act as a barrier to engaging in daily physical activities.

Although a range of predictor factors, including clinical (FEV_1, length of hospitalization, CAT score, and GOLD classification), functional (6MWT), and physical behavior variables, were considered in the regression model, only LPA and dyspnea (assessed using the mMRC scale) were retained in the final model. These findings suggest that immediate functional and symptomatic factors may have a stronger association with SB after hospitalization compared to other clinical variables. Similar results were observed in the study by Tofoli et al. [8], which evaluated the patients with stable COPD and considered clinical variables such as the MRC scale (Medical Research Council), daily step count, daily time spent in LPA and MPA, the 6MWT, and body composition. However, their analysis assessed SB at a single moment, and only the MRC scale and LPA remained in their final regression model. In contrast, this study evaluated predictors during the first week after discharge in relation to SB at 30 days post-hospitalization.

The present findings reinforce that LPA measured during the first week after hospital discharge plays a key role as a determining variable of SB at 30 days. A moderate negative correlation was observed between LPA measured during the first week and SB at 30 days, suggesting that even small amounts of light movement (e.g., standing and walking slow) early after discharge may be relevant for interrupting inactivity patterns. These results align with findings reported by Cheng et al. [26], who identified a strong negative correlation between sedentary time and time spent in LPA, and by Tofoli et al. [8], who demonstrated that in individuals with stable COPD, sedentary time is strongly influenced by LPA, dyspnea, and step count. The multiple regression analysis conducted by these authors indicated that daily time spent in LPA was the main determinant of sedentary time [8].

Given the observed associations, early post-discharge interventions might consider promoting light movement, including simple daily activities such as slow walking or household tasks, which may be easier to integrate into patients' routines and could help reduce prolonged SB. According to Cavalheri et al. [27] and Hill et al. [28], increasing LPA may be a more realistic initial goal for these individuals, as functional limitations, dyspnea symptoms, and muscle mass loss are the important barriers to engaging in higher-intensity activities. Furthermore, promoting LPA that includes simple daily actions such as walking slowly or performing light household tasks may be more easily incorporated into patients' routines, facilitating the interruption of the inactivity cycle and preventing the progression of complications associated with SB.

Early evidence indicates that interventions promoting both incidental physical activity and home-based exercise are feasible and acceptable in this population [29]. This supports the implementation of simple, low-intensity LPA strategies immediately after discharge, which may be practical for patients and effective in reducing sedentary time, highlighting a potential pathway to improve functional recovery and long-term outcomes in individuals with COPD.

Dyspnea assessed in the first week after hospital discharge was also associated with SB 30 days after hospital discharge, indicating that the perception of respiratory effort shortly first week after discharge may have a prolonged effect on these individuals' willingness and functional capacity. This is consistent with the self-limiting behavior model common in COPD, and it can lead to activity avoidance, contributing to the increased SB and physical deconditioning [30].

These findings therefore highlight the importance of early intervention strategies focused on increasing LPA and managing dyspnea, especially in the period following hospitalization for an exacerbation. Promoting LPA may be fundamental to reducing SB and potentially improving long-term health outcomes in individuals with COPD.

This study has some limitations that should be considered. Environmental factors and barriers, such as social and family support, that may influence SB and physical activity were not investigated. In addition, no analysis of physical activity according to the seasons was performed. The relatively small sample size is another limitation, which may reduce statistical power and restrict the generalizability of the findings to the broader population of patients with COPD. Additionally, approximately 29% of the initial sample was excluded due to missing data, which may have introduced selection bias. However, the participants excluded had similar baseline demographic and clinical characteristics compared to those included in the final sample. Despite these limitations, this study contributes valuable insights into the physical behavior of patients with COPD in the early period after hospitalization, an understudied and clinically relevant phase of the disease.

Future studies with larger samples and the evaluation of additional potential factors could provide a more comprehensive understanding of the multiple factors influencing this post hospitalization period.

Conclusion

The findings suggestthat higher levels of dyspnea and lower levels of LPA during the first week after hospital discharge are significant predictors of SB 30 days after hospital discharge for ECOPD.

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Author contributions

Maria Gabriela Colucci, Joana Patrícia dos Santos Cruz, Luiz Augusto Brusaca, and Valéria Amorim Pires Di Lorenzo contributed to conception planning, interpretation of evidence, drafting of preliminary, and definitive versions. Débora Mayumi de Oliveira Kawakami, Gustavo Henrique Guimarães Araujo, Manuela Karloh, and Renata Gonçalves Mendes contributed to support in data interpretation, manuscript revision of preliminary and final manuscript versions.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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