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Physical Activity and Hospitalization for Exacerbation of COPD*

Fabio Pitta, PhD; Thierry Troosters, PhD; Vanessa S. Probst, PhD; Martijn A. Spruit, PhD; Marc Decramer, PhD; and Rik Gosselink, PhD, PT

Background: **Acute exacerbations (AEs) have a negative impact on various aspects of the progression of COPD, but objective and detailed data on the impact of hospitalizations for an AE on physical activity are not available.**

Objective and measurements: **We aimed to investigate physical activity using an activity monitor (DynaPort; McRoberts; the Hague, the Netherlands), pulmonary function, muscle force, 6-min walking distance, and arterial blood gas levels in 17 patients (mean age, 69 ± 9 years [± SD]; body mass index, 24 ± 5 kg/m^2) at the beginning and end of a hospitalization period for an AE and 1 month after discharge.**

Results: **Time spent on weight-bearing activities (walking and standing) was markedly low both at day 2 and day 7 of hospitalization (median, 7%; interquartile range [IQR], 3 to 18% of the time during the day; and median, 9%; IQR, 7 to 21%, respectively) and 1 month after discharge (median, 19% [IQR, 10 to 34%]; Friedman test, $p = 0.13$). Time spent on weight-bearing activities was positively correlated to quadriceps force at the end of the hospitalization period ($r = 0.47$; $p = 0.048$). Patients with hospitalization for an AE in the previous year had an even lower activity level when compared to those without a recent hospitalization. In addition, patients with a lower activity level at 1 month after discharge were more likely to be readmitted in the following year.**

Conclusions: **Patients with COPD are markedly inactive during and after hospitalization for an AE. Efforts to enhance physical activity should be among the aims of the disease management during and following the AE periods.** ***(CHEST 2006; 129:536–544)***

Key words: accelerometer; acute exacerbation; COPD; hospitalization; physical activity

Abbreviations: 6MWD = 6-min walking distance; AE = acute exacerbation; BODE = body mass, airflow obstruction, dyspnea, and exercise capacity; IQR = interquartile range; Pɪmax = maximal inspiratory pressure

Several studies have shown that acute exacerbations (AEs) have a negative impact on health-related quality of life,[1] pulmonary function,[2] utilization of health-care resources,[3] and survival[4] of patients with COPD. Therefore, an appropriate treatment of AE is considered an important aspect in the management of the disease.[5]

Spruit et al[6] found significantly reduced skeletal muscle strength in hospitalized patients during an AE of COPD when compared to those with stable disease. Moreover, quadriceps muscle force was further reduced during the hospital stay and was only partially recovered 3 months after discharge from the hospital. This reduction in muscle force is likely for a combination of factors, such as steroid treatment[7,8] and changes in the metabolic, nutrition, and

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inflammatory status at the time of the AE.[9–11] Since physical inactivity, especially bed rest, has potentially harmful effects such as muscle atrophy,[12,13] a reduced physical activity level could also be a factor linked to the reduction in muscle force observed during hospitalization for an AE of COPD.

It has been shown that stable COPD patients are markedly inactive in their daily lives, with the majority of the day spent sitting or lying down.[14] In addition, by asking patients to report their activity level in diary cards, Donaldson et al[15] recently showed that time spent outdoors declines over time and deteriorates acutely during exacerbations in COPD patients. This study[15] provided evidence that the occurrence of an AE in COPD patients could further reduce the time spent in weight-bearing activities (walking and standing). However, time spent outdoors does not necessarily mean time spent physically active (time spent sitting in a place other than home, or the patient going outside with the use of a wheelchair). Furthermore, only a small portion of the exacerbations reported in that study[15] resulted in hospitalization. In addition, the quantification of physical activity in the study by Donaldson et al[15] was based on patients' self-reports, which might suffer from inaccuracy when compared to objective assessment.[16] Currently, objective data on the impact of hospitalization for AE on usual physical activities in these patients are not available. An objective, reliable, and detailed analysis of physical activities may provide a new insight on the characteristics of the reduction of physical activity during and after hospitalization for an AE in COPD patients. Furthermore, it may provide further rationale to design recovery programs after severe AEs of COPD.

The present study was designed to investigate objectively how inactive COPD patients are during and after a hospital admission for AEs by assessing them using a highly accurate activity monitor.[16] In addition, we aimed to investigate whether patients with other episodes of hospitalization for an AE in the last year have slower recovery in terms of physical activities in daily life when compared to patients without hospitalization for an AE in the last year. Finally, we investigated whether patients with low activity level during and after hospitalization for an AE are more likely to be readmitted in the following year. Preliminary results of this study have been previously reported in the form of abstracts.[17,18]

Materials and Methods

Study Design

Assessment of physical activities was performed on day 2 and day 7 of the hospitalization period and 1 month after discharge from the hospital. Pulmonary function,[19] maximal inspiratory pressure (PImax) and maximal expiratory pressure,[20] quadriceps force,[7] fat-free mass (by bioimpedance), and arterial blood gas levels were measured on day 3 and day 8 of hospitalization and 1 month after discharge from the hospital (on a different day than the assessment of physical activities). A 6-min walking distance (6MWD) test[21] was performed on day 8 of hospitalization and 1 month after discharge from the hospital. The BODE (body mass index, airflow obstruction, dyspnea, and exercise capacity) index,[22] was also calculated at these two time points as a composite estimate of disease severity and a predictor of mortality risk. All methods and equipment, except for the assessment of physical activities, are described elsewhere.[14] All tests were performed by respiratory physiotherapists and pulmonary function technicians who were not involved in the study.

Patients

Twenty-four consecutive patients with COPD (FEV_1/FVC ratio $< 70\%$) were initially included. These patients consulted the emergency department because of deterioration in their respiratory status[23] in the period between November 2002 and July 2003. The decision to admit patients to the respiratory infirmary (ward) due to an AE was made by the attending chest physician, who was not familiar with the present study protocol. After admission to the hospital, patients were asked to partake in the study in case they fulfilled the following inclusion criteria: diagnosis of COPD according to established criteria (Global Initiative for Chronic Obstructive Lung Disease classes II to IV),[5] and absence of other disabling pathologic conditions that could potentially influence on physical activity performance, such as cerebrovascular diseases, rheumatism, and arthritis. Consenting patients gave oral and written informed consent to participate in the study. According to the classification of Anthonisen et al,[23] 9 patients had a type 1 exacerbation, 10 patients had a type 2 exacerbation, and 5 patients had a type 3 exacerbation. In this classification, exacerbations are defined in terms of symptoms. The occurrence of increased dyspnea, sputum volume, and sputum purulence is defined as type 1 exacerbation. Type 2 is characterized by the presence of two of these symptoms. Type 3 is defined as occurring when one of the symptoms is present, in addition to at least one of the following findings: upper respiratory infection, fever without other cause, increased wheezing, cough, respiratory rate, or heart rate.

Patients were included in the clinical pathway for COPD exacerbation used in the University Hospital Gasthuisberg, Leuven, Belgium. According to this clinical pathway, it is required that patients hospitalized due to an AE of COPD remain 10 days in the hospital in order to receive standardized medication and care. Following the pathway, the patients were discharged 10 days after hospital admission except for three patients who remained longer than the pathway requires because they were judged to be too ill to be discharged at the tenth day: 1 patient stayed in the hospital for 20 days, 1 patient stayed for 26 days (both patients were discharged according to the stabilization of their clinical condition), and a third patient died on the fifteenth day of hospitalization. All patients received oral methylprednisolone, 32 mg/d for 7 days, followed by 24 mg/d for 3 days. Additionally, patients received short-acting bronchodilators four times a day for 7 days, followed by two times a day for 3 days. A subsequent reduction in medication depended on the patient's status. Antibiotics were administered to nine patients with an infectious exacerbation. According to the routine investigation in the University Hospital Gasthuisberg, exacerbations were judged to be infectious based on three criteria: presence of fever, increase in C-reactive protein levels, and results of the sputum culture.[24,25] Patients did not receive any kind of physical training

until the assessments were done at 1 month after discharge. The ethics committee of the University Hospitals Leuven granted approval for this longitudinal study.

Information concerning the occurrence of hospitalization for an AE 1 year before or 1 year after inclusion in the present study were collected from the electronic database of the hospital. No patient was hospitalized in another center than the University Hospital Gasthuisberg during this period.

Assessment of Physical Activities

Physical activities were assessed using an accelerometer-based activity monitor (DynaPort; McRoberts; the Hague, the Netherlands), which was recently validated for patients with COPD.[16] In brief, when compared to video recordings (the "gold standard,") the activity monitor measured accurately time spent walking, cycling, standing, sitting, and lying in long-term assessments, as well as the intensity at which walking is performed. In the present study, walking time and standing time were summed together as time spent in weight-bearing activities (or active time). The device is calibrated individually to take into account each patient's body characteristics (such as height, and size of the abdomen). Technical details of the device can be found elsewhere.[16] Assessments were performed during 12 h per day, starting at 08:30 AM. Assessments after 1 month of discharge and in the stable group were performed on a weekday at the patients' home, also during 12 h, starting at 8:30 AM. Assessments were performed only on weekdays to avoid bias, *ie*, potential differences in physical activities between week days and weekend days.[26]

Statistical Analysis

Due to the sample size, nonparametric statistic tests were used. Changes during hospital stay and 1 month afterwards were analyzed using the Friedman test (repeated measures). When the p value was < 0.05, a *post hoc* test was performed (Dunn test). Correlations were analyzed with the Spearman coefficient. The level of significance was set at $p \leq 0.05$.

Results

Six patients dropped out during the hospitalization period: one patient with a mild exacerbation was discharged on the third day of hospitalization, three patients with very severe exacerbations required intensive care, and two patients refused to continue the tests for personal reasons. As previously mentioned, one patient died of respiratory insufficiency in the fifteenth day of hospitalization. The final analysis was therefore performed with 17 patients (16 men; median age, 69 years; interquartile range [IQR], 60 to 78 years).

Four patients (24%) died within 1 year after discharge, all of them for respiratory complications. The only difference between the 5 patients who died within 1 year and the other 13 patients was a higher BODE index at day 8 of hospitalization (median, 8 [IQR, 8 to 9]; vs median, 5 [IQR, 3 to 8], respectively; $p = 0.05$), with the same trend at 1 month after discharge (median, 7 [IQR, 6 to 8]; vs median, 4 [IQR, 3 to 7], respectively; $p = 0.16$).

Clinical Results

Clinical characteristics are summarized in Table 1. During the hospitalization period, quadriceps force

Table 1—*Clinical Characteristics of COPD Patients at Day 3 and at Day 7 of Hospitalization for an AE, and 1 Month After Discharge From the Hospital

Characteristics	Day 3 AE	Day 8 AE	1 mo After AE
Body mass index, kg/m^2	25 (22–26)	25 (19–27)	25 (20–26)
Fat-free mass, % of body mass	70 (66–72)	70 (63–74)	69 (64–74)
FEV_1, % predicted	29 (20–48)	28 (23–55)	34 (25–59)§
FVC, % predicted	66 (53–83)	71 (60–101)	80 (62–90)‖
FRC, % predicted	151 (121–162)	157 (131–174)	151 (120–161)
TLC, % predicted	108 (91–122)	112 (99–116)	112(93–122)
DLCO, % predicted	32 (20–76)	36 (20–86)	34 (19–82)
QF, % predicted	72 (62–78)	64 (52–76)†	70 (55–78)
QF, Newton meters	98 (79–126)	90 (67–109)†	94 (63–126)
PImax, % predicted	77 (54–91)	70 (58–93)	80 (66–91)§
PEmax, % predicted	79 (61–120)	82 (72–107)	86 (65–102)
6MWD, % predicted		43 (23–58)	52 (41–69)‡
6MWD, m		268 (155–352)	332 (261–443)‡
PaO_2, mm Hg	57 (48–67)	59 (54–65)	67 (59–73)‖
$PaCO_2$, mm Hg	39 (34–46)	39 (37–44)	43 (36–46)

*Data are expressed as median (IQR). Analysis of quadriceps force was performed with 15 patients because in 2 patients it was not possible to perform this assessment at the beginning of the hospitalization. Anthropometric data (body mass index) and assessment of fat-free mass could not be obtained in one patient at day 3, one (different) patient at day 8, and three patients at 1 month (different patients than the one missing on day 3 and the one missing on day 8). FRC = functional residual capacity; TLC = total lung capacity; DLCO = carbon monoxide diffusion capacity; QF = isometric quadriceps force; PEmax = maximum expiratory pressure.

†$p < 0.05$ vs day 3 AE.

‡$p = 0.01$ vs day 8 AE.

§$p \geq 0.05$ to $p < 0.1$ vs day 8 AE.

‖$p \geq 0.05$ to $p < 0.1$ vs day 3 and day 8 AE.

decreased significantly (median, − 5% of the predicted value [IQR, − 1 to − 12%]; p = 0.04). No other variables changed significantly during the hospitalization period. After 1 month of recovery at home, the 6MWD increased when compared to the end of the hospitalization period (median increase of 73 m [IQR, 27 to 149 m]; p = 0.01). In addition, FEV_1, FVC, PImax, and PaO_2 showed a strong tendency to increase over this period of time (Table 1).

Physical Activity During and After Hospitalization

Results from activity monitoring are shown in Figures 1, 2. Figure 1 shows that walking time was markedly low at day 2 of hospitalization and did not change significantly at day 7. One month after discharge, walking time increased significantly when compared to day 2 and day 7 of hospitalization ($p < 0.01$ and $p < 0.05$, respectively). However, assessment at 1 month after discharge showed still markedly low values when compared to those observed in stable COPD patients.[14] Figure 2 shows that standing time was markedly low at day 2 and day 7, with no significant improvement after 1 month (Friedman test, p = 0.26). It also shows that most of the time during both day 2 and day 7 of hospitalization was spent sitting or lying down, and there was no significant decrease after 1 month (Friedman test, p = 0.22 for sitting time and p = 0.31 for lying time). Median time spent on weight-bearing activities was 7% (IQR, 3 to 18%) of the time during day 2, 9% (IQR, 7 to 21%) of the time during day 7, and 19% (IQR, 10 to 34%) of the time during the assessment day at 1 month after discharge (Friedman test, p = 0.13).

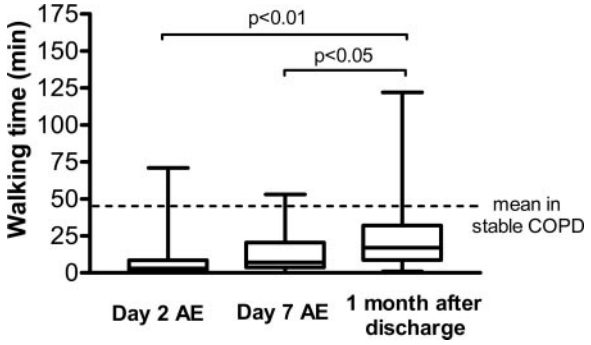

FIGURE 1. Time spent walking during the day by COPD patients hospitalized for an AE and 1 month after discharge. Data are shown as box plots (each box is composed by the 25% percentile, the lower extremity of the box; the median, the central line of the box; and the 75% percentile, the upper extremity of the box). The minimum and maximum values are also depicted and correspond to the lines outside each box. The dotted line corresponds to the mean time spent on walking time in daily life by COPD patients in stable condition.[14]

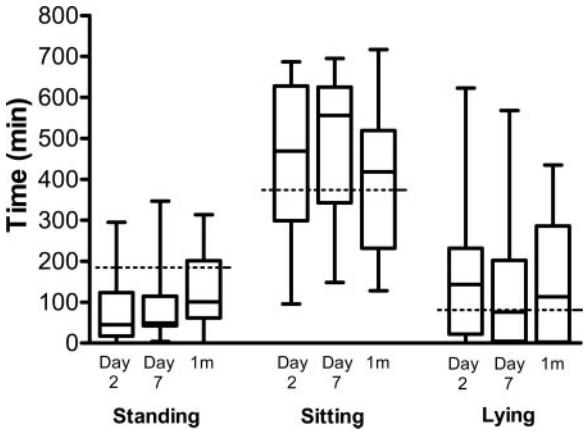

FIGURE 2. Time spent standing, sitting, and lying during the day by COPD patients hospitalized for an AE and 1 month after discharge. Data are shown as box plots (description is given in Fig 1 legend). The dotted lines correspond to the mean time spent in each activity by COPD patients in stable condition.[14]

Movement intensity during walking at day 2 of hospitalization was 1.4 m/s^2 (IQR, 1.2 to 1.5 m/s^2) and improved slightly but significantly to 1.5 m/s^2 (IQR, 1.4 to 1.9 m/s^2) at day 7 ($p < 0.05$). One month after discharge, median movement intensity during walking was 1.6 m/s^2 (IQR, 1.4 to 1.9 m/s^2) [$p < 0.01$ vs day 2, but not significantly different than day 7]. However, assessment at 1 month after discharge showed still markedly low values when compared to those observed in stable COPD patients (1.8 ± 0.3 m/s^2) [mean ± SD].[14] Patients with infectious exacerbation (n = 10) did not show any difference in physical activities when compared to patients with noninfectious exacerbation (n = 7).

Correlation Between Inactivity and Quadriceps Weakness

Time spent in weight-bearing activities (or active time) was positively correlated to quadriceps force at day 8 of the hospitalization period ($r = 0.47$; p = 0.048) [Fig 3]. In addition, reduction in quadriceps force during hospitalization was significantly correlated to less improvement in walking time after 1 month ($r = 0.58$; p = 0.03).

Impact of Frequent Hospitalizations

Patients with one or more hospitalizations for an AE in the year before inclusion in the present study (n = 9) showed lower walking time at 1 month when compared to patients (n = 8) without an AE in the previous year (median, 9 min/d [IQR, 4 to 18 min/d]; vs median, 26 min/d [IQR, 14 to 56 min/d]; p = 0.03). At the beginning of the hospitalization period, there were no differences in clinical charac-

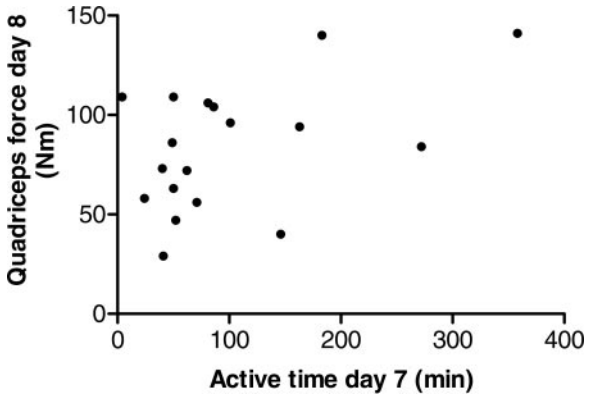

FIGURE 3. Relationship between active time (or time spent on weight-bearing activities; *ie*, walking time plus standing time) on day 7 and quadriceps force on day 8 of hospitalization for an AE in COPD patients ($r = 0.47$; $p = 0.048$). Nm = Newton meters.

teristics between patients with or without hospitalization in the previous year.

Patients readmitted to the hospital for another AE in the year following discharge (n = 11) had significantly lower walking time at 1 month when compared to patients (n = 6) who were not readmitted (median, 12 min/d [IQR, 9 to 27 min/d]; vs 30 min/d [IQR, 21 to 100 min/d]; p = 0.03) [Fig 4]. Concerning clinical characteristics, the 6MWD at day 8 of hospitalization tended to be lower in patients who were readmitted (median, 200 m [IQR, 155 to 298 m]; vs median, 351 [IQR, 164 to 520 m]; p = 0.12). No other differences in clinical characteristics were found. Six of the 17 patients included in the present study (35%) were hospitalized for an AE both 1 year before and 1 year after the hospitalization of interest.

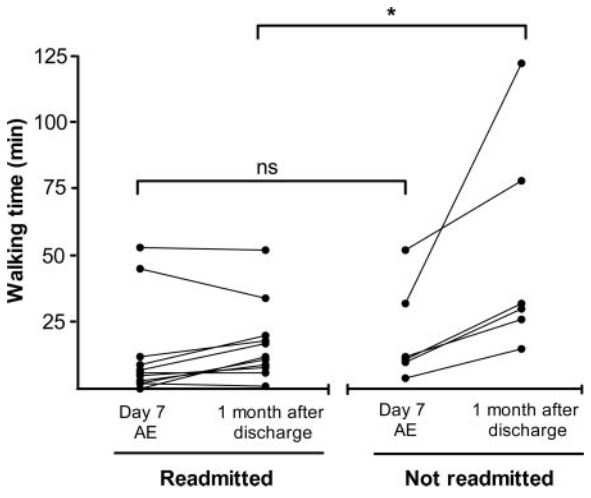

FIGURE 4. Walking time at day 7 of hospitalization for an AE and at 1 month after discharge in COPD patients readmitted within 1 year and in patients not readmitted. *p = 0.03; ns = not significant.

DISCUSSION

The present study showed that patients with COPD had very low level of physical activity during and after hospitalization for an AE independently of whether the exacerbation was infectious or not. Time spent in weight-bearing activities was low, especially in patients with quadriceps muscle weakness at the end of the hospitalization period. Furthermore, patients with hospitalization for an AE in the previous year had an even lower activity level when compared to patients without a recent AE. In addition, patients with lower walking time at 1 month after hospital discharge were more likely to be readmitted the following year.

The significant reduction in quadriceps muscle force observed during the course of an 8-day hospitalization period for an AE reproduced the results found by our group.[6] It is important to underline that this was a different group of patients, assessed in a different period of time. It is also worthwhile to underline that the median reduction of 5% predicted in quadriceps force corresponds to 7% of the baseline value lost during only 5 days. No data are available on minimal clinically important difference for this outcome, but we believe that a 7% reduction in such a short period of time seems clinically relevant, especially in patients with existing muscle weakness. One reason to believe that this reduction is clinically relevant is that in stable COPD patients, a 6-month intense exercise program containing both strength and endurance training resulted in improvements of approximately 20% in quadriceps force.[27] Therefore, a loss of 7% in a period of only 5 days seems relevant. It is known that different reasons may be linked to this decrease in muscle force,[7–11] and during an AE a combination of these factors may be present.[28] In the current study, time spent on weight-bearing activities was significantly correlated to the quadriceps force at the end of the hospitalization period. This suggests that the pronounced inactivity observed during and after the hospitalization period should be included as one of the factors linked to muscle force impairment during an AE. The clinical relevance of these findings can be appreciated from the correlation between the reduction in quadriceps force and the slow recovery of walking time. Although we cannot exclude that the low physical activity level could be interrelated to other factors associated to the development of skeletal muscle weakness in hospitalized COPD patients, inactivity is a factor relatively easy to be detected by clinicians. From the literature, it is clear that there is a causal relationship between the absence of weight-bearing activities and leg muscle weakness.[13] We believe, however, that our results do not provide

definitive evidence to draw conclusions involving causal relationship between muscle weakness and physical inactivity during hospitalization. In the present study, inactivity may be one of the causes of strength decline, or there may be other underlying factors leading both to inactivity and muscle weakness.

No significant changes were observed in body mass index and fat-free mass during the exacerbation period. This was not surprising for two main reasons: (1) although no special nutritional intervention was performed, patients had their nutritional status accompanied by the hospital nutrition service during the whole hospitalization period (as any other hospitalized patient); and (2) the hospitalization period was probably not long enough to the point of resulting in nutrition changes that would affect significantly these two outcomes. These results are in line with a study by Vermeeren et al,[9] who also did not find changes in these two outcomes during hospitalization for an AE in COPD patients.

Probably the most important result from the present study is the striking inactivity in patients hospitalized for an AE. At the beginning of the hospitalization period (day 2), patients spent little time on weight-bearing activities (median, 7% of the time during the day). More surprisingly, this remained almost unchanged close to discharge (median, 9%), whereas a nonstatistically significant improvement was seen at 1 month after discharge (median, 19%). In a recent study,[14] we showed that stable COPD patients spent 33 ± 16% of the time during the day on weight-bearing activities, while healthy elderly patients spent 52 ± 16%. Therefore, even 1 month after discharge from the hospital, the time spent on weight-bearing activities was still considerably lower when compared to stable patients[14] (only 20% of stable COPD patients had such a short time spent in weight-bearing activities). In addition, the short time spent by patients walking is characterized by low movement intensity (slow walking speed). These results raise concerns on the management of AEs. Obviously, optimal pharmacotherapy by itself seems not enough to avoid inactivity in patients with COPD during and after an AE. Hence, the potentially harmful effects of inactivity elicited by the marked reduction in physical activities are not prevented. It can be argued that inactivity in hospitalized subjects is not a specific feature of COPD. In the general elderly population, it has been shown that hospitalization frequently leads to decline in functional status.[29] However, it was impressive to observe specifically in COPD patients that the inactivity during hospitalization was so pronounced and was related to potential clinical consequences (*ie*, decrease in muscle force, risk of readmission). The causes for this inactivity are probably multiple: firstly, the patients are obviously severely ill and are likely to present worsening of their symptoms, such as dyspnea. The fear of feeling even more breathless may lead these patients to keep themselves as much inactive as possible. Secondly, one could speculate that the hospital environment can contribute to physical inactivity. However, the fact that even one month after discharge patients are still inactive at home when compared to stable patients supports the suggestion that the hospital environment is not the only factor contributing to inactivity. Another fact that also contributes to this reasoning is that, in the study by Donaldson et al,[15] COPD patients treated as outpatients during an AE also decreased their physical activity. Strategies such as early exercise training[30,31] and neuromuscular electrical stimulation[32] seem promising to counteract the inactivity in these patients, although further investigation on this issue is required. Third, it can be speculated that other factors may also play a role contributing to physical inactivity during a COPD exacerbation, such as depression and the muscle weakness itself.

In the present study, patients who had a hospitalization for an AE in the previous year (53% of the patients) showed less recovery in physical activities than those without a hospitalization for an AE in the previous year. Therefore, patients with frequent exacerbations may be prone to a more rapid decline in physical activity in daily life, and this may have repercussions on health-related quality of life.[1] Although data on activity monitoring before the hospital admission were not obtained, it seems that functional capacity in these patients gradually decreases over time.[15] In addition, although walking time during hospitalization and all baseline clinical characteristics were not significantly different between patients readmitted and patients not readmitted in the following year, walking time at 1 month after discharge was significantly higher in the patients not readmitted (Fig 4). These results have clinical importance since they confirm the relation between inactivity and a higher risk of hospital readmission for an AE of COPD, as previously shown by Garcia-Aymerich et al.[33] According to the threshold proposed in their study (walking at least 60 min/d), 15 of the 17 patients assessed at 1 month after discharge could be considered to be at risk for readmission. Indeed, 11 of these 15 patients were actually readmitted before 1 year (sensitivity, 73%). However, since four patients at risk for readmission were not readmitted, it is clear that usual physical activity level should not be considered the only factor predicting hospital readmission.

A recent study by Donaldson et al[15] showed that time spent outdoors decreases significantly during an

AE. In addition, results of that study also suggested that patients with frequent exacerbations recover their physical activity level to a lesser extent than patients without frequent exacerbations. Both findings were confirmed in the present study, despite the fact that the studies had different designs. The present study may provide new insight in some issues of the study by Donaldson et al.[15] For instance, although the study by Donaldson et al[15] provides solid data about the decrease in activity in COPD patients, the authors state that time spent outdoors cannot be equated with physical or muscular activity. Time spent outside the patient's home does not necessarily mean time spent actively. In addition, the tool used to quantify activity in that study was subjective, and could therefore suffer from the inaccuracy observed in self-reports of physical activities in different populations,[34] including elderly[35] and COPD patients.[16] The present study, using an objective, valid, and accurate tool, provided a detailed profile of the marked decrease in physical activities during and after hospitalization for an AE of COPD. Furthermore, the study by Donaldson et al[15] suggested that physical activity is quickly recovered after an AE. The present study suggests that time spent actively, although increased after 1 month of spontaneous recovery, was still far from what stable COPD patients usually present in daily life[14] (Fig 1, 2). This apparent discrepancy between the findings of the studies may rely on two facts. First, the study by Donaldson et al[15] included exacerbations of any severity, including mild exacerbations. In fact, only 6.2% of the exacerbations in that study resulted in hospitalization.[15] The present study, however, focuses on inactivity during severe exacerbations requiring hospitalization. Future research is required to investigate whether the decrease in physical activity seen in patients treated at home is comparable to the marked inactivity observed in hospitalized patients. Secondly, Donaldson et al[15] used a diary, *ie*, a subjective tool to assess physical activity, whereas we used an objective tool (activity monitor). It is possible that subjective and objective tools reflect different aspects of the assessment of physical activity in daily life.[36,37] Nevertheless, our findings concerning slow recovery of physical activity after exacerbations are in line with other studies that also suggested that the impact of AEs may be long lasting in terms of lung function,[38] muscle force,[6] and quality of life.[39]

The mortality rate in the present study was 28% within 1 year (5 of 18 patients), similar to the findings of Groenewegen et al[4] (23%) and Garcia-Aymerich et al[33] (29%). Although the profile of physical activities was not different in these five patients compared to the others, they tended to have a shorter 6MWD at day 8 of hospitalization (median, 166 m [IQR, 106 to 210 m]; vs median, 298 m [IQR, 185 to 409 m]; $p = 0.08$). This possibly contributed to their higher BODE index and reinforces the value of the 6MWD or a multicomponent scoring system as a predictor of mortality risk.[22] The present study was, however, underpowered to draw any final conclusions on the end point of mortality. Furthermore, the BODE index may have been influenced by the transient consequences of the AE itself (*eg*, reduced FEV_1 and 6MWD), and its calculation in the same group of patients in stable condition previously to this hospitalization might have shown different results.

Unfortunately, the present study did not include activity monitoring before the exacerbation of interest. However, this problem is difficult to circumvent, since it would be necessary to assess a large number of stable patients and wait for them to be hospitalized, what would happen in a different time interval for each patient. Therefore, repeated baseline measures would be required since patients may deteriorate activity level over time even without AEs. In addition, another limitation of the study was the absence of long-term serial reassessments of physical activities in daily life after AE (3 months or 6 months after discharge). This could help to determine the long-term time course of recovery of activity level after an AE. However, all patients were proposed to take part in a pulmonary rehabilitation program after completion of the study, and 7 of them were actually included in the program after the 1-month reassessment (4 of the 11 patients readmitted within 1 year and 3 of the 6 patients not readmitted). Although the precise impact of pulmonary rehabilitation on daily physical activity is still unclear, it is reasonable to assume that taking part in a rehabilitation program would interfere with the long-term outcome of the present study. The small sample size could also be considered a limitation since statistical power may have been insufficient to allow careful subanalysis and to show significant changes in aspects such as the increase in standing time after 1 month (Fig 2). However, the study was powered to show changes in walking time, which is the primary activity of subjects in free-living conditions.[36] With the current sample size and an α value of 0.05, the study had 80% of power to detect the changes observed in walking time between day 7 of hospitalization and 1 month after discharge. Another problem arising from the small sample size is the limited generalization of the results. For instance, care must be taken when generalizing these results to patients using noninvasive ventilation, patients in Global Initiative for Chronic Obstructive Lung Disease stage I, or

patients treated at home (outpatients), since the patients investigated did not have these characteristics.

In summary, patients with COPD are severely inactive during and after hospitalization for an AE. Low time spent in weight-bearing activities was seen especially in patients with more pronounced muscle weakness at the end of the hospitalization period. In addition, in patients with frequent exacerbations, the physical inactivity is even more marked. Therefore, efforts and strategies to enhance physical activity are important and should be among the aims of the disease management during and following the AE periods.

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