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Original Research Article

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Correlations between physical activity and prognostic markers in patients with idiopathic pulmonary fibrosis

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ABSTRACT

Background: In this study, we investigated the associations between physical activity parameters and prognostic factors in patients with idiopathic pulmonary fibrosis (IPF).
Methods: Physical activity was measured in IPF patients using a SenseWear armband. Demographic data, pulmonary function test results, the 6-minute walk distance (6MWD), the gender-age-physiology (GAP) index score, dyspnea severity (modified Medical Research Council, mMRC), and fatigue severity (Multidimensional Fatigue Inventory, MFI-20) were recorded.
Results: Thirty-five IPF patients (29 males, aged 65.7 ± 8.0 years) were included in the study (forced vital capacity (FVC)=77±16.2%, diffusing capacity for carbon monoxide (DLCO)=55.7±16.4%, 6MWD=398.4±88 m, GAP index=3.4±1.1 (18 stage 1, 17 stage 2). Patients with GAP stage 2 had lower step counts than those with GAP stage 1 (3325.1±2253 steps vs. 7892±3132 steps, p<0.001). The time spent in moderate to vigorous physical activity (MVPA, defined as the time spent in activities ≥3.0 METs) was significantly shorter in GAP stage 2 patients than in GAP stage 1 patients (7 minutes [IQR: 1.5–18.5] vs 56 minutes [IQR: 30.5–139.5], p<0.001). The step count and GAP index score (Rs=-0.716, p<0.001), age (Rs=-0.381, p=0.024), FVC (Rs=0.443, p=0.008), DLCO (Rs=0.715, p<0.001), 6MWD (Rs=0.833, p<0.001), MFI-20 score (Rs=-0.783, p<0.001), and mMRC score (Rs=-0.833, p<0.001) were correlated. Multiple regression analysis revealed that the step count was independently associated with the 6MWD (p=0.005) and MFI-20 score (p=0.014). The MVPA time was correlated with the GAP index score (Rs=-0.810, p<0.001), age (Rs=-0.427, p=0.010), FVC (Rs=0.490 p=0.003), DLCO (Rs=0.736, p<0.001), 6MWD (Rs=0.809, p<0.001), MFI-20 score (Rs=-0.830, p<0.001) and mMRC score (Rs=-0.826, p<0.001). Multiple regression analysis revealed that the MVPA time was independently associated with the GAP index score (p=0.007).
Conclusions: The physical activity parameters of IPF patients were associated with prognostic markers such as the GAP index score, pulmonary function parameters and the 6MWD.

Key words: idiopathic pulmonary fibrosis, physical activity, fatigue, dyspnea, disease progression

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Introduction

Idiopathic pulmonary fibrosis (IPF) is a chronic, fibrotic interstitial lung disease of unknown etiology, characterized by progressive dyspnea and a decline in lung function, with a poor prognosis and an average life expectancy of only 3–5 years after diagnosis [1, 2]. While prognostic tools such as forced vital capacity (FVC), the diffusing capacity for carbon monoxide (DLCO), and the multidimensional gender-age-physiology (GAP) index are available, the progression and prognosis of IPF remain highly heterogeneous, underscoring the need for improved strategies to predict outcomes and optimize patient management [3, 4]. Another commonly used indicator, the 6-minute walk test (6MWT), reflects functional exercise capacity [5-7]. Some studies suggest that a shorter 6-minute walk distance (6MWD) and desaturation during or at the end of the 6MWT may indicate an increased risk of mortality in IPF patients [6-10]. However, these established tools capture only a snapshot of functional status and may not fully reflect the real-world variability of physical activity in daily life [11-13].

Physical activity is widely recognized as a critical factor in mitigating worsening respiratory symptoms [14]. Patients with respiratory disease often enter a debilitating cycle of reduced lung function, aggravated dyspnea, decreased physical activity, muscle deconditioning, and ultimately increased disability or mortality [15]. Although ample evidence links low physical activity levels to higher exacerbation frequency and mortality in chronic obstructive pulmonary disease (COPD) [12-16], far fewer clinical trials have focused on physical activity endpoints in IPF [12]. Metrics such as daily step count and time spent in moderate-to-vigorous physical activity (MVPA) appear to hold prognostic value; however, their significance in IPF remains controversial due to inconsistent methodologies and limited data [11, 12]. Recent reviews highlight the urgent need for standardized approaches to measuring physical activity and further research into how activity correlates with IPF progression and patient-centered outcomes [11, 12].

In IPF specifically, daily physical activity levels are lower than those in healthy controls and even in individuals with other interstitial lung diseases (ILDs) [17-19]. A small number of studies in IPF cohorts have explored how daily step count is related to key clinical parameters such as the 6MWD [19-23], lung function measures (FVC, DLCO) [19-21], dyspnea [21], and fatigue [21], whereas fewer have examined MVPA [22, 24]. Nevertheless, initial evidence suggests that MVPA may also be correlated with important clinical outcomes, such as the 6MWD and quality of life [22, 24].

Despite these promising findings, methodological inconsistencies and limited sample sizes restrict the broader applicability of physical activity metrics in IPF. We hypothesized that objective measures of daily physical activity—namely step count and time spent in MVPA—would be associated with key prognostic markers (dyspnea, fatigue, FVC, DLCO, 6MWT results, and the GAP index), thereby providing insights beyond traditional, static assessments. Accordingly, our study aimed to investigate these relationships in IPF patients and explore differences in physical activity metrics across GAP stages, as well as their associations with clinical factors such as age, sex, and comorbidities.

Methods

Patients with IPF who were followed up at the Istanbul University Faculty of Medicine, Department of Pulmonary Diseases, Interstitial Lung Diseases Outpatient Clinic, were included in the study. Patients were eligible for inclusion if they had been diagnosed with IPF according to current guidelines and were able to speak and read Turkish. The exclusion criteria were respiratory tract infections or an exacerbation of IPF occurring within the four weeks prior to enrolment. Additionally, any extrapulmonary impairments that could interfere with physical activity, such as significant comorbid conditions or problems that prevent physical activity, diagnoses of psychiatric or cognitive disorders, and progressive neurological or neuromuscular disorders, were also exclusion criteria.

All participants provided voluntary, written informed consent for data collection on the basis of a clear understanding of the purpose of the data collection. The study was approved by the Clinical Research Ethics Committee of Istanbul University Faculty of Medicine (Ethics No: 2020/1565).

Patient demographics, including age, sex, body mass index (BMI), smoking status, radiological and pathological evaluation results, long-term oxygen therapy (LTOT) requirements, comorbidities, and the use of antifibrotic treatment, were recorded. Disease severity and mortality risk were assessed using the GAP index and the GAP staging system [4].

Spirometry and single-breath DLCO tests were performed in accordance with the current American Thoracic Society (ATS)/European Respiratory Society guidelines, utilizing established reference values for interpretation [25, 26]. Exercise capacity was assessed using the 6MWT according to the ATS criteria [27]. For patients on LTOT, the 6MWT was performed while participants used their typical oxygen flow. The 6MWT was performed twice to reduce learning effects, and the test with the participant's best performance was selected for analysis [28]. Desaturation was considered if oxygen saturation (SpO_2), as measured by pulse oximetry, decreased to 88% or less during or at the end of the 6MWT [6]. The modified Medical Research Council (mMRC) dyspnea scale questionnaire was used to evaluate dyspnea, and the Multidimensional Fatigue Inventory (MFI-20) was used to evaluate fatigue [29-31].

Physical activity was monitored using a SenseWear Pro armband (BodyMedia Inc., Pittsburgh, PA, USA) for seven days [19, 21, 32-34]. The armband was positioned on the patient's right upper arm at the midpoint of the triceps brachii. Patients were instructed to wear the armband throughout the day (except when showering). The minimum recording time for analysis was defined as at least three days, with a wear time threshold of 94% (equivalent to 22.5 hours) to identify valid days of physical activity, excluding the first and last days of recording [35-38]. These devices measure the time spent in MVPA (defined as the time spent in activities ≥3.0 metabolic equivalents (METs)) and the number of steps taken [11, 39].

We selected the SenseWear armband because it objectively measures physical activity by combining accelerometry data with MET calculations. This device was chosen for its validated accuracy in assessing daily physical activity in respiratory disease populations, as well as its practicality and acceptability for continuous, multi-day monitoring [21, 35, 38]. Compared to simpler devices such as pedometers or basic accelerometers, the SenseWear armband provides detailed metrics, including activity intensity and duration, crucial for capturing nuanced physical activity patterns in IPF patients [38].

Statistical analysis

Statistical analyses were performed using SPSS version 29.0.1 software (AIMS, Istanbul, Turkey). Normality of continuous variables was assessed using the Shapiro–Wilk test. Continuous variables are presented as mean ± standard deviation (SD); additionally, variables with non-normal distribution are also presented with median and interquartile range (IQR). Categorical variables are expressed as frequencies (percentages). Comparisons between groups were performed using Student's t-test for normally distributed variables and the Mann–Whitney U test for variables that were not normally distributed.

Associations between physical activity (step count, MVPA) and age, BMI, smoking history (pack-years), FVC (%), forced expiratory volume in one second (FEV1) (%), DLCO (%), the GAP index, MFI-20, and mMRC scores were examined using Spearman correlation analysis.

Multivariate linear regression analysis was performed to identify factors independently associated with step count and MVPA. To prevent multicollinearity, the GAP index was selected to represent combined clinical parameters including age, sex, FVC, and DLCO. Therefore, individual parameters such as age, sex, FVC, and DLCO were not separately included in the regression models. The final linear regression models included the GAP index score, 6MWD, 6MWT desaturation, and MFI-20 score as predictors. The normality of residuals from the regression models was assessed using the Shapiro–Wilk test and found to meet the normality assumption. All correlation analyses were exploratory in nature, and p-values were not adjusted for multiple comparisons. A p-value less than or equal to 0.05 was considered statistically significant. A post-hoc power analysis was conducted using G*Power software to confirm the adequacy of the sample size for the multivariate regression models.

Results

Thirty-eight patients were enrolled in this study. However, three patients were excluded from the final analyses because they did not wear the accelerometer correctly and had two or fewer evaluable days. All 35 participants included in the final analysis had at least three valid days with ≥94% wear time, ensuring data quality. Following these exclusions, 35 patients with IPF (29 males, 6 females, age: 65.7±8.0 years) were included in the study. The mean FVC was 77±16.2%, the mean DLCO was 55.7±16.4%, the mean 6MWD was 398.4±88 m, and the mean GAP index score was 3.4±1.1 (18 stage 1, 17 stage 2). There were no patients classified as GAP stage 3. 16 (46%) patients were desaturated during the 6MWT. Three (9%) patients received LTOT. Most patients (n = 28, 80%) had comorbidities, and nearly all (n = 33, 94%) received antifibrotic treatment (17 on nintedanib and 16 on pirfenidone). Moreover, the vast majority of our patients (n=27, 77%) were either active smokers or ex-smokers. The clinical characteristics of the study population and the mean armband parameter values, as well as the mMRC and MFI-20 scores, are shown in Table 1.

Table 1. Patient characteristics and clinical features

Parameters	**mean±SD/n, %**
Age (year)	65.7±8.0
BMI (kg/m2)	28.1±3.5
Male (n, %)	29, 83%
Smoking status (n, %)	
Past smoker	22, 63%
Nonsmoker	8, 23%
Current smoker	5, 14%
Past smoking history (pack-years)	25.0±9.8
Use of antifibrotics (n, %)	33, 94%
Nintedanib	17, 52%
Pirfenidone	16, 48%
LTOT (n, %)	3, 9%
FVC (% pred.)	77±16.2
DLCO (% pred.)	55.7±16.4
6MWD, metres	398.4±88
Desaturation during 6MWT (n, %)	16, 46%
GAP index score	3.4±1.1
GAP stage (n, %)	
Stage I	18, 51%
Stage II	17, 49%
Comorbidities (n, %)	28, 80%
Systemic hypertension	15, 43%
GERD	14, 40%
OSA	11, 31%
Pulmonary hypertension	9, 26%
Diabetes mellitus	8, 23%
MFI-20 score	58±20
mMRC- dyspnea scale score (0-4)	1.9±1.1
0	3, 9%
1	11, 31%
2	9, 26%
3	10, 28%
4	2, 6%
Armband (Activity monitor)	
Step count	5674±3558
MVPA (minutes), median (IQR)	24 (IQR: 7–56)

Abbreviations: 6MWD: six-minute walk distance, 6MWT: six-minute walk test, BMI: body mass index, DLCO: diffusion capacity of the lungs for carbon monoxide, FVC: forced vital capacity, GAP: Gender-Age-Physiology, GERD: gastroesophageal reflux disease, LTOT: long-term oxygen therapy, MFI-20: Multidimensional Fatigue Inventory, mMRC: modified Medical Research Council, MVPA: moderate-to-vigorous physical activity, OSA: obstructive sleep apnoea, % pred.: percent of predicted, SD: standard deviation, IQR:interquartile range.

In the physical activity assessment, the mean daily step count was 5674 ± 3558 (Table 1). In univariate analyses, step count correlated negatively with age (Rs = −0.381, p = 0.024) and positively with FVC (Rs = 0.443, p = 0.008), DLCO (Rs = 0.715, p < 0.001), and 6MWD (Rs = 0.833, p < 0.001). Similarly, it was also associated with lower GAP index (Rs = −0.716, p < 0.001), MFI-20 (Rs = −0.783, p < 0.001), and mMRC (Rs = −0.833, p < 0.001) scores. BMI, FEV1 (%) and smoking history (pack-years) were not significantly correlated with the step count (Table 2).

Table 2. Variables correlated with the step count and MVPA

Step count	**Rs**	**p Value**
6MWD (m)	**0.833**	< **0.001**
mMRC	**-0.833**	< **0.001**
MFI-20	**-0.783**	< **0.001**
GAP index score	**-0.716**	< **0.001**
DLCO (%pred.)	**0.715**	< **0.001**
FVC (%pred.)	**0.443**	= **0.008**
Age	**-0.381**	= **0.024**
FEV1 (%pred.)	0.296	= 0.084
BMI	0.128	= 0.465
Past smoking history (pack-years)	-0.139	= 0.490
MVPA	**Rs**	**p Value**
MFI-20	**-0.830**	< **0.001**
mMRC	**-0.826**	< **0.001**
GAP index score	**-0.810**	< **0.001**
6MWD (m)	**0.809**	< **0.001**
DLCO (%pred.)	**0.736**	< **0.001**
FVC (%pred.)	**0.490**	= **0.003**
Age	**-0.427**	= **0.010**
FEV1 (%pred.)	0.278	= 0.106
Past smoking history (pack-years)	-0.188	= 0.347
BMI	-0.065	= 0.710

Abbreviations: 6MWD: six-minute walk distance, BMI: body mass index, DLCO: diffusing capacity of the lungs for carbon monoxide, FEV1: forced expiratory volume in the first second, FVC: forced vital capacity, GAP: Gender-Age-Physiology, MFI-20: Multidimensional Fatigue Inventory, mMRC: modified Medical Research Council, MVPA: moderate-to-vigorous physical activity, % pred.: percent of predicted, Rs: Spearman rank correlation coefficient.

Patients with GAP stage 2 took significantly fewer steps than those with GAP stage 1 (3325±2253 vs. 7892±3132 steps, p<0.001). The number of steps recorded for patients who did not desaturate during the 6MWT was significantly greater than for those who desaturated (7659±3399 vs. 3317±1977 steps, p<0.001). Factors such as sex, smoking status and the presence of comorbidities did not significantly affect the step count (Table 3).

We used a multivariate linear regression model (adjusted R^2 = 0.705) to identify factors associated with step count, including GAP index score, 6MWD, 6MWT desaturation, and MFI-20 score as predictors. We found that 6MWD (β = 0.424; B = 17.14, 95% CI: 5.44–28.84; p = 0.005) and MFI-20 score (β = −0.333; B = −59.29, 95% CI: −105.47 to −13.11; p = 0.014) were independently associated with the step count. The post-hoc power of the study was calculated based on a multiple regression model, with the step count as the dependent variable and the GAP index score, 6MWD, 6MWT desaturation, and MFI-20 score as predictors. This analysis revealed an observed power of 99.8% (n=35, 4 predictors, R^2=0.705, type 2 error probability (β) = 0.002, two tailed).

As MVPA values were non-normally distributed, the primary summary metric used was the median. The median time spent in MVPA (≥3.0 METs) was 24 minutes (IQR: 7–56). For reference, the mean time was 45±51 minutes. In univariate analyses, MVPA showed positive correlations with FVC (Rs = 0.490, p = 0.003), DLCO (Rs = 0.736, p < 0.001), and 6MWD (Rs = 0.809, p < 0.001), as well as negative correlations with the GAP index (Rs = −0.810, p < 0.001), mMRC (Rs = −0.826, p < 0.001), MFI-20 (Rs = −0.830, p < 0.001), and age (Rs = −0.427, p = 0.010). BMI, FEV1 (%) and smoking history (pack-years) were not significantly correlated with MVPA (Table 2).

The median MVPA duration was significantly shorter in patients with GAP stage 2 compared to those with GAP stage 1 (7 minutes [IQR: 1.5–18.5] vs 56 minutes [IQR:30.5–139.5], p<0.001). Patients without desaturation during the 6MWT had longer MVPA durations than those who desaturated (52 minutes [IQR:19–137] vs 6.5 minutes [IQR: 0.75–23],

Table 3. Comparison of Step Count and MVPA by Clinical Subgroups

		Step count* *Mean ± SD*	***p Value***	***MVPA time***† *Median (IQR)*	***p Value***
GAP stage 1		7892 ± 3132	< **0.001**	56 (30.5-139.5) min.	< **0.001**
GAP stage 2		3325 ± 2253		7 (1.5-18.5) min.	
Desaturation during 6MWT	**No**	7659 ± 3399	< **0.001**	52 (19-137) min.	< **0.001**
	Yes	3317 ± 1977		6.5 (0.75-23) min.	
Male		6114 ± 3589	= 0.109	26 (18-66) min.	= **0.021**
Female		3550 ± 2719		1.5 (0-29.8) min.	
Smoking status	**Current or Past**	5232 ± 3650	= 0.181	19 (6-56) min.	= 0.479
	Non	7165 ± 2947		45.5 (17.5-60.5) min.	
Comorbidity	**No**	5792 ± 3048	= 0.924	26 (19-62) min.	= 0.342
	Yes	5645 ± 3724		19.5 (6.3-55.3) min.	

Abbreviations: 6MWT: Six-minute walk test, GAP: Gender-Age-Physiology, MVPA: Moderate-to-vigorous physical activity, SD: standard deviation, IQR:interquartile range, min.: minutes.

Footnotes:
* Student's t-test.
† Mann–Whitney U test.

p<0.001). MVPA duration was significantly longer in men compared with women (26 minutes [IQR:18–66] vs 1.5 minutes [IQR: 0–29.8], p=0.021). Smoking status and presence of comorbidities did not significantly affect MVPA duration (Table 3).

We examined factors associated with MVPA time via a multivariate linear regression analysis (adjusted $R^2 = 0.657$), including the GAP index score, 6MWD, 6MWT desaturation, and MFI-20 score as predictors. We found that the GAP index score ($\beta = -0.464$; B = −20.54, 95% CI: −34.98 to −6.11; p = 0.007) was the only variable independently associated with MVPA. The post-hoc power of the study was calculated via a multiple regression model, with MVPA time as the dependent variable and the GAP index score, 6MWD, 6MWT desaturation, and MFI-20 score as predictors. This analysis revealed an observed power of 99.4% (n=35, 4 predictors, R^2=0.657, type 2 error probability (β) = 0.006, two tailed).

Discussion

Our results emphasize the multifaceted nature of physical activity in patients with IPF and reveal the complex relationships between physical activity and factors such as disease severity, lung function, exercise tolerance and the severity of dyspnea and fatigue. According to our results, higher step counts and longer MVPA times were correlated with younger age; better lung function; a longer 6MWD; and lower GAP index, MFI-20 and mMRC scores. Patients with GAP stage 1 had higher step counts and longer MVPA times than those with GAP stage 2. Notably, patients without exercise-induced desaturation had higher step counts and longer MVPA times than did those with desaturation. Multivariate regression analysis revealed that the 6MWD and MFI-20 score were independently associated with the step count, whereas the GAP index score was independently associated with the MVPA time.

A systematic review and meta-analysis evaluating physical activity in ILD patients reported that patients with IPF had a pooled mean of 4323 steps per day (95% CI: 3592–5053), with significant heterogeneity ($I^2 = 87\%$, p < 0.01) reflecting variability in study methodologies and patient characteristics [11]. Consistent with our findings, all the included studies indicate that IPF patients generally achieve a daily step count below the recommended 7000 steps for older adults. In our study, patients averaged 5674 steps per day, likely due to the mild to moderate severity of the disease.

Although physical activity is increasingly recognized as a key prognostic indicator in respiratory diseases, relatively few clinical trials have examined physical activity outcomes in IPF patients compared with those in COPD or asthma patients [12, 19-23]. Among the available IPF-focused studies, one involving 48 patients reported moderate correlations between step count and mMRC, MFI-20, FVC (%), DLCO (%), and 6MWD [21]; another involving 31 patients noted moderate correlations between the daily step count and the FVC (%), DLCO (%), and 6MWD [19]. Conversely, a separate study of 40 IPF cases revealed no associations between step count and pulmonary function parameters; a relationship was observed only with the 6MWD [22]. Two additional small studies likewise identified correlations between the step count and the 6MWD [20, 23]. Our results align with and expand on this limited literature by revealing strong correlations between daily step count and the 6MWD, DLCO (%), GAP index score, fatigue severity, and dyspnea intensity, as well as a moderate correlation with both FVC (%) and age. By assessing multiple prognostic and functional measures, our study reinforces the value of physical activity—specifically step count—as a marker of IPF disease severity.

A systematic review evaluating physical activity in respiratory diseases and a separate systematic review and meta-analysis focused on physical activity in ILD highlight the limited number of studies assessing MVPA specifically in IPF patients, which has been evaluated less frequently than step count [11, 12]. Furthermore, these studies, which evaluated MVPA, demonstrated significant heterogeneity in terms of sample size, methodology, and reported outcomes, with a pooled mean MVPA of 53 minutes (95% CI: 23–84), and significant heterogeneity (I^2 = 97%, $p < 0.01$) reflecting variability in study methodologies and patient characteristics [11, 21, 22, 32, 34]. In accordance with the World Health Organization guidelines and the systematic review's recommendation, we defined MVPA as activities exceeding 3.0 METs [11, 39]. Consistent with the non-normal distribution of MVPA in our study, we used the median (24 minutes, IQR: 7–56) as the primary summary measure, and, for reference, the mean time was 45±51 minutes.

The clinical significance of MVPA measures in IPF remains controversial because of the scarcity of relevant primary studies [11, 12]. In patients with asthma, MVPA has been shown to be correlated with both dyspnea and the 6MWD [40]. Among IPF patients, the time spent in MVPA has been significantly associated with the 6MWD in a cohort of 17 individuals [22], and a 12-month follow-up study of 37 IPF patients revealed weak-to-moderate correlations between changes in MVPA and changes in FVC% as well as the 6MWD [32]. Similarly, in a study of 111 patients with fibrotic ILD, the time spent in MVPA was found to have a moderate to strong correlation with the European Quality of Life five-dimensional index score [24]. In our study, the time spent in MVPA was strongly correlated with DLCO (%), the GAP index score, fatigue severity, and dyspnea intensity, and moderately correlated with FVC (%) and age. These observations, although based on limited data, reinforce the potential relevance of MVPA as an informative clinical measure in IPF. Step count primarily reflects overall ambulatory activity, while MVPA specifically indicates the intensity of physical engagement, potentially providing different clinical insights and prognostic significance. As we found an association between MVPA and GAP score, it suggest that MVPA may be a prognostic factor in IPF. Therefore, future clinical assessments could benefit from separately evaluating both step count and MVPA as complementary indicators.

Both the 6MWD and fatigue have been implicated in reduced physical activity among patients with IPF [21, 22]. Similarly, we found that the daily step count was independently associated with both the 6MWD and fatigue, and that patients who exhibited exercise-induced desaturation had notably lower MVPA and fewer steps. These findings highlight the importance of simultaneously evaluating symptom severity—particularly fatigue and dyspnea — and objective activity metrics. A recently published systematic review further underscores the value of patient-centered physical activity assessments in IPF, stressing the impact of fatigue and other symptoms on clinical outcomes [12].

Lower levels of physical activity have been identified as a significant risk factor for hospitalization and all-cause mortality in patients with IPF, although conflicting results have also been reported [32, 41-43]. Notably, one study identified MVPA as the only physical activity variable associated with 3-year transplant-free survival, underscoring the need for further investigation [32]. Although we did not evaluate the relationship between physical activity and hospitalization or mortality, our findings align the existing literature by demonstrating an independent association between time spent in MVPA and the GAP index score, a known predictor of mortality. Our study was not designed to longitudinally track mortality outcomes; instead, we utilized surrogate markers that have been shown in previous research to correlate strongly and independently with prognosis and mortality. In our cohort, patients in GAP stage 1 had a greater step count and longer MVPA duration than those in GAP stage 2. A potential limitation of our study sample is that it included no patients with IPF who were in GAP stage 3.

The relatively small sample size is another limitation of this study. Despite sufficient power for the regression models, the limited sample size curtails the broad applicability of our results. However, our outcomes are consistent with published data [21-23], suggesting reasonable reliability. Further multicenter research is needed to validate these associations and clarify how physical activity metrics might be used to optimize prognostic evaluation in IPF patients. Additionally, disease duration data were not collected in this study, representing a potential limitation, as longer disease duration may adversely affect physical activity outcomes. Although MVPA was not normally distributed, residuals from the regression model met the normality assumption. Nevertheless, the use of linear regression for skewed data may still be considered a methodological limitation.

A major strength of our study is the use of an armband to objectively quantify physical activity, which reduces bias and improves accuracy compared with self-report methods [44]. Although some researchers have used questionnaires [42, 43] and others have employed activity monitors [18, 21, 22, 32], studies utilizing activity monitors in IPF remain limited. A recently published systematic review [11] emphasized the importance of standardizing measurement methods and enhancing reporting quality for more effective cross-study comparisons. Accordingly, we adhered to the recommendations of Montoye et al. [38], as highlighted in that review. Notably, factors such as seasonal changes and occupational demands [45] can influence physical activity levels, and we were unable to evaluate all participants within the same time frame. However, it is important to note that there is currently no validated gold standard specifically for measuring physical activity in IPF, limiting direct comparability of our findings with previous studies.

Conclusions

In conclusion, the results of our study reveal a complex relationship between physical activity in IPF patients and various patient-centered and functional measures, underscoring the importance of physical activity in this progressive fibrotic lung disease. Future research, especially through longitudinal and multicenter studies, is essential to further explore the evolution of this relationship under conditions of disease progression. Furthermore, validation and calibration studies are required to obtain more accurate measurements of physical activity in patients with IPF.

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