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INTERSTITIAL LUNG DISEASE

Impact of Psychological Deficits and Pain on Physical Activity of Patients with Interstitial Lung Disease

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Abstract

Purpose The impact of psychological deficits and pain on physical activity has not been adequately studied in patients with fibrotic interstitial lung disease (ILD). We aimed to determine the association of depression, anxiety, sleep quality, and pain with physical activity in fibrotic ILD.

Methods Waist ActiGraph activity monitors were worn for seven consecutive days to track step counts and moderate-to-vigorous physical activity (MVPA) minutes at baseline and 6-month follow-up. Psychological deficits and pain were assessed using the Hospital Anxiety and Depression Scale, the Pittsburgh Sleep Quality Index, and the Brief Pain Inventory. Multivariable linear regression was used to determine if each deficit independently predicted physical activity when adjusted for potential confounders.

Results A total of 111 patients were recruited, with 91 of these patients completing the 6-month follow-up. Median step count and MVPA minutes were 3853 steps/day (interquartile range 2236–6805) and 87 (17–225) min/week at baseline, respectively, with no significant changes at follow-up. Borderline or abnormal depression and anxiety scores were present in 19% and 22% of patients, respectively. Poor sleep quality and moderate-to-severe pain were present in 61% and 9% of patients. Higher depression scores were associated with fewer baseline and follow-up step counts and lower MVPA minutes at follow-up on unadjusted analysis; higher pain severity scores were associated with fewer baseline step count. Pain severity remained an independent predictor of reduced step count after adjusting for patient's age, smoking status, ILD severity, and weather variables.

Conclusions Pain severity may be a potentially modifiable determinant of physical activity in patients with fibrotic ILD.

Keywords Interstitial lung disease · Exercise · Accelerometry · Depression · Pain · Surveys · Questionnaires

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Introduction

Maintenance of physical activity is important for patients with interstitial lung disease (ILD) in the context of a progressive disease that lacks well-tolerated and highly effective pharmacotherapies. Despite this, patients with all major ILD subtypes frequently have reduced physical activity, which is primarily influenced by lung function and dyspnea [1, 2]. Patients with ILD can also have extrapulmonary comorbidities that further contribute to inactivity. For example, both circulatory impairments and lower limb muscle dysfunction limit exercise capacity of patients with ILD and those with other chronic lung diseases [3, 4]. However, these pulmonary and extrapulmonary deficits only partially account for low levels of physical activity, suggesting that other factors are also contributing to inactivity in this population.

Patients with ILD frequently report symptoms of depression and anxiety [5, 6], poor sleep quality [7], and pain [6]. Previous studies have shown the negative impact of depression, anxiety, and poor sleep on physical activity in specific ILD subtypes [7, 8], and pain severity also impacts activity levels in patients with chronic obstructive pulmonary disease (COPD) [9]. However, no studies have examined the association of these deficits with physical activity in a heterogenous sample of patients with fibrotic ILD. Accordingly, the primary focus of this study was to examine the cross-sectional association of physical activity with psychological deficits (i.e., depression, anxiety, poor sleep quality) and pain with daily physical activity at baseline in a large cohort of patients with fibrotic ILD. The secondary aim was to examine whether baseline psychological deficits and pain could predict physical activity at 6-month follow-up. We hypothesized that psychological deficits and pain would have a significant detrimental impact on physical activity at baseline and 6-month follow-up in patients with fibrotic ILD, and that this association would be independent of ILD severity.

Methods

Study Overview

This was a prospective cohort study that assessed physical activity in outpatients with fibrotic ILD at baseline and 6-month follow-up using accelerometers and pre-accelerometry self-report questionnaires. This convenience sample was recruited from two specialized ILD clinics between December 2016 and September 2017 after providing written informed consent (University of British Columbia Research Ethics Board H16-02980). Patients completed self-report questionnaires regarding their psychological deficits and pain prior to wearing waist activity monitors for seven consecutive days. Questionnaires and physical activity measurements were completed at baseline and follow-up.

Study Population

Consecutive patients meeting eligibility criteria were approached during their outpatient visits. Patients with fibrotic ILD that was not related to a systemic disease were eligible (i.e., idiopathic pulmonary fibrosis, IPF [10], chronic hypersensitivity pneumonitis, idiopathic non-specific interstitial pneumonia [11], drug-induced ILD, or unclassifiable ILD with these ILDs comprising the differential diagnosis [12]). Patients were excluded if they had ILD secondary to a multisystem disease (e.g., connective tissue disease, sarcoidosis), a significant extrapulmonary condition that impaired physical activity (e.g., musculoskeletal or cardiovascular disease), impaired mobility (e.g., requiring the use of a wheelchair), or had completed pulmonary rehabilitation within 6 months of recruitment.

Physical Activity Monitor

Patients wore waist tri-axial accelerometers on the opposite side of their handedness for seven consecutive days at baseline and 6-month follow-up (ActiGraph wGT3X-BT; ActiGraph, Inc., Pensacola, FL). The devices were initialized with a recording frequency of 50 Hz prior to distribution and analyzed using the ActiLife 6.13.3 software. Patients were instructed to engage in their normal routines and only remove the monitors when bathing or swimming. Accelerometry data were considered usable for each day if the patient had worn the device for a minimum of eight waking hours [13].

Data Reduction

All movements that occurred during sleep and activity monitor non-wear periods were removed prior to physical activity calculation. Sleeping periods were identified with the Cole–Kripke algorithm [14], with adjustments based on patients' self-reported logs. Accelerometer non-wear periods were first identified with the self-reported logs and further refined with the Choi algorithm [15].

Step Count and Moderate-to-Vigorous Physical Activity (MVPA) Calculations

Raw data were downloaded, summed, and filtered by the software to determine the average daily step count using a standard sensitivity filter. Freedson Adult VM3 thresholds were applied to the filtered data to categorize activity intensity as moderate, vigorous, or very vigorous [16]. MVPA was defined as any activity ranging from 'moderate' to 'very vigorous.' Patients were considered to have sufficient MVPA if they had engaged in at least 150 min of MVPA over the 1-week period [17]. Changes in MVPA greater than 26 min/week after 6 months were considered to be clinically meaningful [13].

Psychological Deficits and Pain Measurements

Depression and Anxiety

Depression and anxiety were measured by the Hospital Anxiety and Depression Scale (HADS) [18]. The HADS is a 14-item questionnaire, with seven items each relating to depression and anxiety. Each item is scored on a scale from 0 to 3, providing total summed scores ranging from 0 to 21. Patients are considered "normal" if their score ranges from 0 to 7, "borderline abnormal" with scores ranging from 8 to

10, and "abnormal" with scores of 11 or higher. The HADS has been validated for assessing depression and anxiety in the elderly population and in a variety of psychiatric and somatic conditions, including COPD [19, 20].

Sleep Quality

Sleep quality was measured using the Pittsburgh Sleep Quality Index (PSQI) [21]. This 19-item questionnaire assesses seven components of sleep: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, number of sleep disturbances, use of sleep medication, and daytime dysfunction. Each component is scored on a scale from 0 to 3 based on the response of the 19 items. The individual component scores are then summed to produce a global score ranging from 0 to 21. Poor sleep quality is indicated by a global score of 5 or greater. The PSQI has been validated for evaluating self-reported sleeping problems in older men and women [22, 23], and has been used to assess sleep quality in patients with fibrotic ILD [5].

Pain

The Brief Pain Inventory short form (BPI-SF) was used to measure pain [24]. The BPI-SF is a self-reported questionnaire that assesses the location, sensory intensity, and degree to which pain interferes with various aspects of life such as mood and enjoyment of life. The pain severity score ranges from 0 to 10, with mild pain indicated by a score of 1–3 and moderate-to-severe pain being ≥ 4 [25]. The BPI-SF has been validated for assessing non-cancer pain and has been previously used in patients with fibrotic ILD [5, 26].

Other Measurements of Interest

Patient age, sex, smoking pack-years, forced vital capacity (FVC), and diffusing capacity of the lungs for carbon monoxide (DLCO) were obtained from clinical records [27, 28]. Pulmonary function tests were included if conducted within 3 months of the initial baseline visit. Mean daily temperature and hours of daylight during the 1-week physical activity monitoring period were collected through the National Research Council Canada and The Weather Network [29, 30].

Statistical Analysis

Data were summarized using mean ± standard deviation or median (interquartile range). Spearman correlation or Wilcoxon rank-sum test was used to examine the unadjusted relationship of daily step count and weekly MVPA minutes with age, sex, smoking status, body mass index, ILD subtype, lung function, psychological deficits, and pain. Wilcoxon signed-rank test was used to compare physical activity measurements at baseline and at 6-month follow-up. Kruskal–Wallis test was used to assess the association of physical activity with location of pain. Multivariable linear regression models were used to determine whether depression, anxiety, sleep quality, and pain each independently predicted step count or MVPA minutes when adjusting for potential confounders. Confounders were selected on the basis of having a significant correlation with physical activity measurements at baseline ($r > 0.30$, $p < 0.05$). In addition, average temperature and hours of daylight during the 1-week period of physical activity monitoring were forced into the multivariable models as confounders based on their likelihood of affecting patients' activity levels [31]. Data normality was checked with the Shapiro–Wilk test and the regression analyses were performed with transformation if appropriate. All statistical analyses were performed using R version 3.4.2 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Study Population

One hundred and eleven patients with fibrotic ILD completed the baseline assessment, including 39 with IPF, and 91 completed the 6-month follow-up (Supplemental Fig. 1). On average, patients had mild and moderate reductions in their FVC and DLCO %-predicted, respectively, at baseline and follow-up. Patients with IPF had significantly lower DLCO %-predicted compared to those with non-IPF ILDs ($p = 0.02$ at baseline, $p = 0.01$ at follow-up). Patient characteristics are summarized in Table 1, with similar lung function, physical activity, psychological deficits, and pain at both time points.

Physical Activity

All patients met the pre-defined minimum activity monitor wear time threshold of 8 waking hours/day. The average wear times of the activity monitor during waking hours were 6207 ± 583 and 5963 ± 747 min/week (approximately 14–15 h/day) at baseline and follow-up, respectively. Our cohort had a median of 3853 (2236 to 6805) steps/day and 87 (17 to 225) MVPA min/week at baseline (Table 1). Patients with IPF walked fewer steps compared to the non-IPF ILD cohort, but this difference was not significant at baseline (median 3451 vs. 4207 steps/day, $p = 0.17$). MVPA minutes were similarly reduced in patients with IPF compared to non-IPF ILDs at baseline (69 vs. 107 MVPA min/week, $p = 0.72$). Sixty-two percent of the baseline cohort did not achieve the minimum of 150 min/week

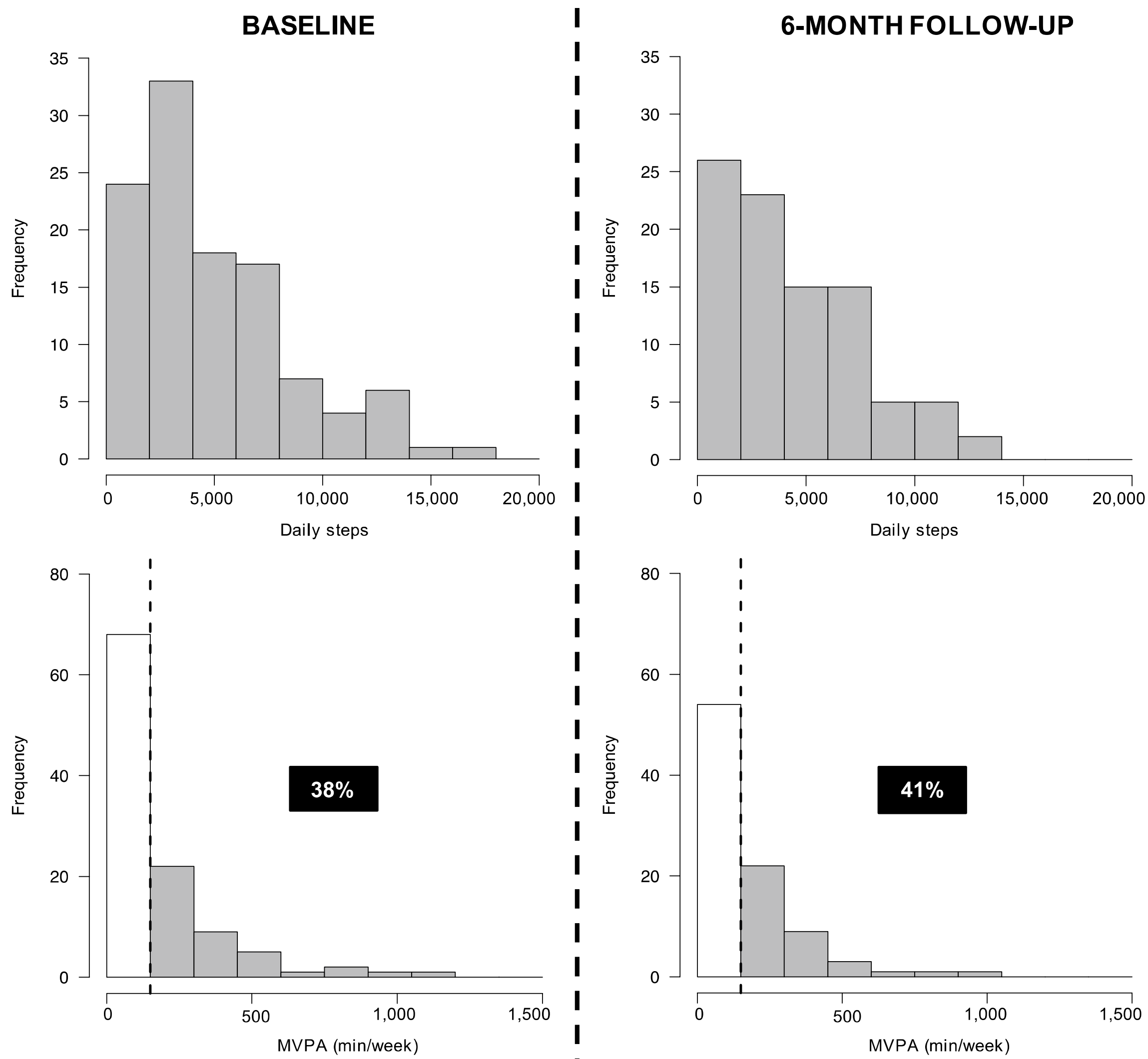

Fig. 1 Frequency distributions of daily step count and weekly MVPA minutes in patients with fibrotic ILD measured by waist activity monitors at baseline and 6-month follow-up. Dashed line indicates a minimum of 150 MVPA min/week recommended by physical activity guidelines; the percentage indicates the portion of patients who met this recommendation. *MVPA* moderate-to-vigorous physical activity

of MVPA that is recommended by the physical activity guidelines (Fig. 1) [17].

Physical activity measurements at 6-month follow-up remained comparable to baseline values, with no significant changes in step count (median change − 569 [− 1539 to 59] steps/day, $p=0.32$) or MVPA min (median change 0 [− 180 to 135] min/week, $p=0.94$). A clinically meaningful increase in MVPA minutes was observed in 26% of patients, while 27% had a decrease greater than this threshold [13]. Patients with IPF walked significantly less than those without IPF after 6 months (median 2640 vs. 4377 steps/day, $p=0.03$) (Table 1; Fig. 1, Fig. 3).

Psychological Deficits and Pain

All items of the questionnaires were answered by all patients. Sixty-seven percent of the cohort had pain or symptoms of at least one psychological deficit at baseline. Borderline or abnormal depression and anxiety scores were present in 19% and 22% of patients, respectively. Sixty-one percent of the cohort had poor sleep quality. Moderate-to-severe pain was present in 9% of patients, with mild pain reported in 68% of the cohort. The most frequently reported painful areas were the back (34%) and lower limbs (25%). Findings were similar comparing IPF and non-IPF patients (Fig. 2;

Table 1 Patient characteristics at baseline at 6-month follow-up

Variables	Mean ± SD, median (IQR), or *n* (%)		
	Baseline		
	Combined cohort (*n* = 111)	IPF (*n* = 39)	Non-IPF (*n* = 72)
Age (years)	70 ± 9	71 ± 7	69 ± 11
Male sex	69 (62%)	31 (79%)	38 (53%)
Ever-smoker	76 (68%)	32 (82%)	44 (61%)
Smoking pack-years (IQR)	19 (9–37)	22 (2–37)	14 (0–23)
Body mass index (kg/m^2)	29 ± 5	29 ± 5	29 ± 5
FVC (%-predicted)	77 ± 19	75 ± 18	78 ± 20
DLCO (%-predicted)	51 ± 16	46 ± 16	54 ± 16
Depression (HADS)[a]	4.5 ± 3.7	4.9 ± 3.7	4.4 ± 3.6
Anxiety (HADS)[a]	4.9 ± 3.4	4.8 ± 3.1	5.0 ± 3.6
Sleep quality (PSQI)[a]	6.0 ± 3.5	5.2 ± 3.4	6.5 ± 3.6
Pain severity (BPI-SF)[a]	1.9 ± 1.8	1.7 ± 1.6	2.1 ± 2.0
Physical activity			
Daily steps	3853 (2236–6805)	3451 (1622–6505)	4207 (2693–6805)
MVPA (min/week)	87 (17–225)	69 (23–205)	107 (16–228)
Variables	6-Month follow-up		
	Combined cohort (*n* = 91)	IPF (*n* = 32)	Non-IPF (*n* = 59)
Age (years)	70 ± 9	71 ± 7	70 ± 10
Male sex	56 (62%)	25 (78%)	31 (53%)
Ever-smoker	62 (68%)	25 (78%)	37 (63%)
Smoking pack-years (IQR)	20 (10–37)	17 (9–39)	20 (10–34)
Body mass index (kg/m^2)	29 ± 5	29 ± 5	29 ± 5
FVC (%-predicted)	76 ± 20	76 ± 19	76 ± 21
DLCO (%-predicted)	46 ± 14	40 ± 12	49 ± 14
Depression (HADS)[a]	4.6 ± 3.6	5.0 ± 4.0	4.3 ± 3.4
Anxiety (HADS)[a]	4.6 ± 3.4	4.6 ± 3.0	4.6 ± 3.6
Sleep quality (PSQI)[a]	5.9 ± 3.1	5.8 ± 3.5	5.9 ± 2.9
Pain severity (BPI-SF)[a]	1.9 ± 1.8	1.2 ± 1.5	2.2 ± 1.8
Physical activity			
Daily steps	3699 (1768–6216)	2640 (1431–5667)	4377 (2492–6809)
MVPA (min/week)	94 (17–239)	31 (13–189)	109 (34–250)

BPI-SF Brief Pain Inventory short form, *DLCO* diffusing capacity of the lungs for carbon monoxide, *FVC* forced vital capacity, *HADS* Hospital Anxiety and Depression Scale, *IPF* idiopathic pulmonary fibrosis, *IQR* interquartile range, *MVPA* moderate-to-vigorous physical activity, *PSQI* Pittsburgh Sleep Quality Index, *SD* standard deviation

[a]Depression, anxiety, and sleep quality were scored on a 21-point scale. Pain symptoms were scored on a 10-point scale; greater scores indicate more severe symptoms

Table 1). Psychological deficits and pain were persistent at 6-month follow-up, with similar frequency distribution and prevalence as baseline measurements (Fig. 3; Supplemental Fig. 2).

Association of Physical Activity with Psychological Deficits and Pain

At baseline, depression and pain severity scores had weak-to-moderate correlations with daily step count on unadjusted analysis (Table 2). Depression was the only deficit that was correlated with daily step count and weekly MVPA minutes at 6-month follow-up. Patients with borderline or abnormal depression scores took fewer steps (median difference 2123 [761 to 3329] steps/day, $p = 0.001$) compared to patients with scores in the normal range (Fig. 4). Similarly, patients with moderate-to-severe pain walked significantly less than patients with mild pain or without pain (median difference 1530 [− 137 to 3344]

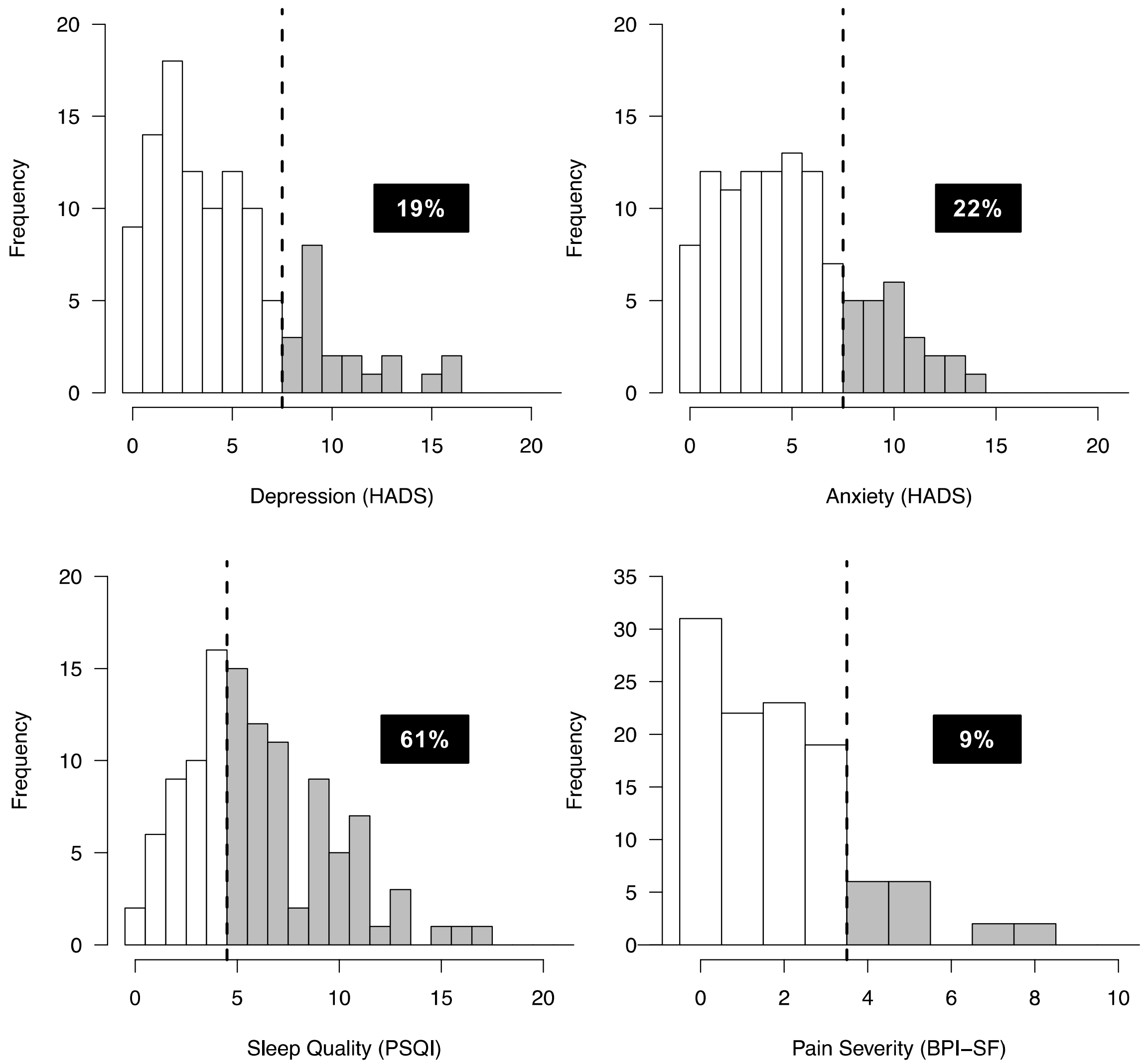

Fig. 2 Distribution and prevalence of psychological deficits and pain in patients with fibrotic ILD at baseline. Dashed lines indicate pre-specified clinically meaningful thresholds for each questionnaire. Gray and white bars indicate patients with and without clinically meaningful scores for extrapulmonary deficits, respectively. *BPI-SF* Brief Pain Inventory short form, *HADS* Hospital Anxiety and Depression Scale, *PSQI* Pittsburgh Sleep Quality Index

steps/day, $p = 0.03$). No specific pain location was associated with step count. Patients with more deficits had fewer average daily step counts (Supplemental Fig. 3). Pain severity independently predicted step count at baseline when adjusting for age, smoking status, FVC %-predicted, DLCO %-predicted, and average temperature and hours of daylight (Table 3). Depression showed a trend towards significance at predicting reduced baseline step count when adjusting for the same confounders. Psychological deficits and pain did not independently predict reduced MVPA at baseline. Similar findings were observed at 6 months. The multivariable models did not substantially improve when using transformed variables (Supplemental Table 1).

Discussion

We used a cohort of 111 patients with fibrotic ILD to examine the association of physical activity with psychological deficits and pain. We show that pain severity was an independent predictor of reduced step count when adjusting for age, smoking status, lung function, and weather variables, while depression showed a trend towards significance. These findings suggest potential areas that can be better targeted to potentially improve physical activity in patients with fibrotic ILD.

Using measurements from tri-axial accelerometers, we unsurprisingly found that physical activity was reduced in

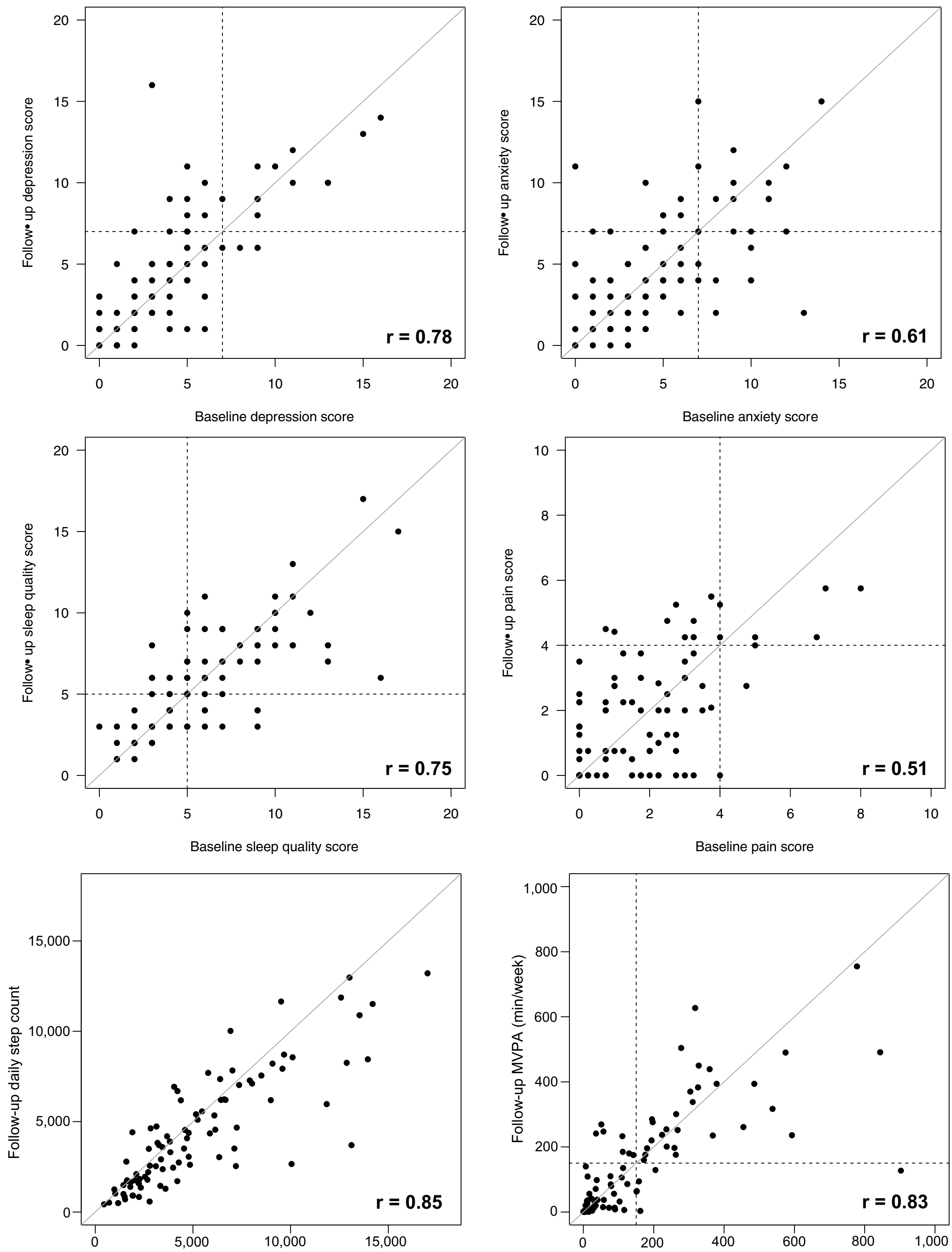

Fig. 3 Association of baseline and follow-up measures of psychological deficits, pain, and physical activity. The *r* values were obtained from Spearman's rank correlation. In the first four panels, points to the right of the vertical dashed line indicate patients with clinically meaningful symptoms of psychological deficits and pain at baseline; points above the horizontal dashed line indicate those with clinically meaningful symptoms at 6-month follow-up. Fifty-two and 38% of patients with depressive and anxiety symptoms at baseline had these symptoms present at 6-month follow-up, respectively. Seventy-one percent of patients with poor sleep quality at baseline reported poor sleep at follow-up, and 54% of patients reporting moderate-to-severe pain at baseline continued to have these symptoms after 6 months. The dashed lines in the last panel represent a minimum of 150 weekly MVPA minutes recommended by physical activity guidelines. *MVPA* moderate-to-vigorous physical activity

Table 2 Unadjusted association of baseline clinical variables with physical activity at baseline and at 6-month follow-up

Variables	Baseline ($n = 111$)		6-month follow-up ($n = 91$)	
	Daily steps	MVPA (min/week)	Daily steps	MVPA (min/week)
Age (years)	−0.39 (< 0.001)	−0.36 (< 0.001)	−0.37 (< 0.001)	−0.41 (< 0.001)
Male sex	– (0.52)	– (0.26)	– (0.82)	– (0.71)
Ever-smoker	– (0.042)	– (0.01)	– (0.13)	– (0.07)
Pack-years	−0.13 (0.20)	−0.18 (0.08)	−0.23 (0.04)	−0.29 (0.009)
Body mass index (kg/m2)	−0.13 (0.17)	−0.15 (0.12)	−0.05 (0.62)	−0.02 (0.88)
IPF versus non-IPF	– (0.17)	– (0.72)	– (0.03)	– (0.18)
FVC (%-predicted)	0.41 (< 0.001)	0.40 (< 0.001)	0.37 (< 0.001)	0.30 (0.004)
DLCO (%-predicted)	0.55 (< 0.001)	0.54 (< 0.001)	0.66 (< 0.001)	0.56 (< 0.001)
Depression (HADS)	−0.30 (0.001)	−0.17 (0.07)	−0.31 (0.003)	−0.28 (0.008)
Anxiety (HADS)	−0.05 (0.57)	−0.01 (0.86)	−0.04 (0.71)	−0.02 (0.86)
Sleep quality (PSQI)	−0.15 (0.12)	−0.09 (0.36)	−0.08 (0.47)	−0.07 (0.48)
Pain severity (BPI-SF)	−0.22 (0.02)	−0.16 (0.10)	−0.12 (0.27)	−0.06 (0.56)

Data shown are Spearman's rank correlations with p values in brackets. The Wilcoxon rank-sum test was used for categorical variables

BPI-SF Brief Pain Inventory short form, *DLCO* diffusing capacity of the lungs for carbon monoxide, *FVC* forced vital capacity, *HADS* Hospital Anxiety and Depression Scale, *IPF* idiopathic pulmonary fibrosis, *IQR* interquartile range, *MVPA* moderate-to-vigorous physical activity, *PSQI* Pittsburgh Sleep Quality Index

patients with fibrotic ILD. Our cohort's median of 3853 steps/day is similar to a recent Japanese IPF cohort [32], and substantially lower than the 7100 steps/day previously reported in healthy older populations [33]. Symptoms of depression, anxiety, poor sleep quality, and pain were common in both IPF and non-IPF ILDs, and the prevalence of these deficits was similar or higher compared to the rates found in community dwelling adults [34–37]. This high prevalence indicates the need for healthcare providers, caregivers, and patients to pay greater attention to these deficits and consider strategies to minimize their impact on patients' quality of life, healthcare utilization, and prognosis. Previous research has also shown that depression, anxiety, and sleep disturbance can lead to poor medication adherence in patients with multiple chronic diseases [38, 39], suggesting that earlier detection and treatment of these deficits may subsequently improve adherence to other therapies. It may therefore be beneficial to aggressively manage these symptoms to allow for maximal benefit to be achieved from interventions like pulmonary rehabilitation or ILD-targeted medications.

Pain severity was an independent predictor of baseline step count on adjusted analysis, with similar relationships observed at follow-up. This indicates that pain may be an important and potentially modifiable determinant of physical activity in fibrotic ILD, similar to emerging literature showing that pain is associated with lower physical activity in patients with COPD [9]. In addition, depressive symptoms among patients with fibrotic ILD may still be a clinically significant factor associated with reduced physical activity based on the borderline, but consistent association that was observed at both baseline and follow-up. Therefore, our findings suggest that interventions targeting physical activity should place more emphasis on how patients with fibrotic ILD are impacted by pain and depression in an effort to better facilitate their engagement in regular physical activity.

While we designed this study with the hypothesis that psychological deficits and pain may lead to lower physical activity, it is possible that reduced levels of activity lead to these symptoms. Although it was not measured in this study, dyspnea is another important variable that could impact psychological deficits, pain, and physical activity. For instance, patients could interpret the feelings of chest tightness or discomfort of dyspnea as "pain." Thus, it is likely that there is a relationship among these symptoms and analyzing these deficits separately may be an oversimplification of how physical activity is influenced by complex pathways. As preliminary evidence of this possibility, patients with multiple psychological deficits and/or pain had lower step count compared to patients with fewer deficits. Additional larger cohorts are needed to confirm these findings and conduct a more comprehensive investigation into how various symptoms interact with one another and act as mediator variables for other comorbidities. While this study was designed to broadly investigate the relationship of multiple psychological deficits and pain with physical activity in patients with ILD, future studies could expand on our findings and hypotheses to provide focused analysis of an individual deficit and its impact on patients' activity levels. Future studies should also consider additional factors (e.g., lifestyle, patient motivation) that may explain the high variability in physical activity that was incompletely estimated

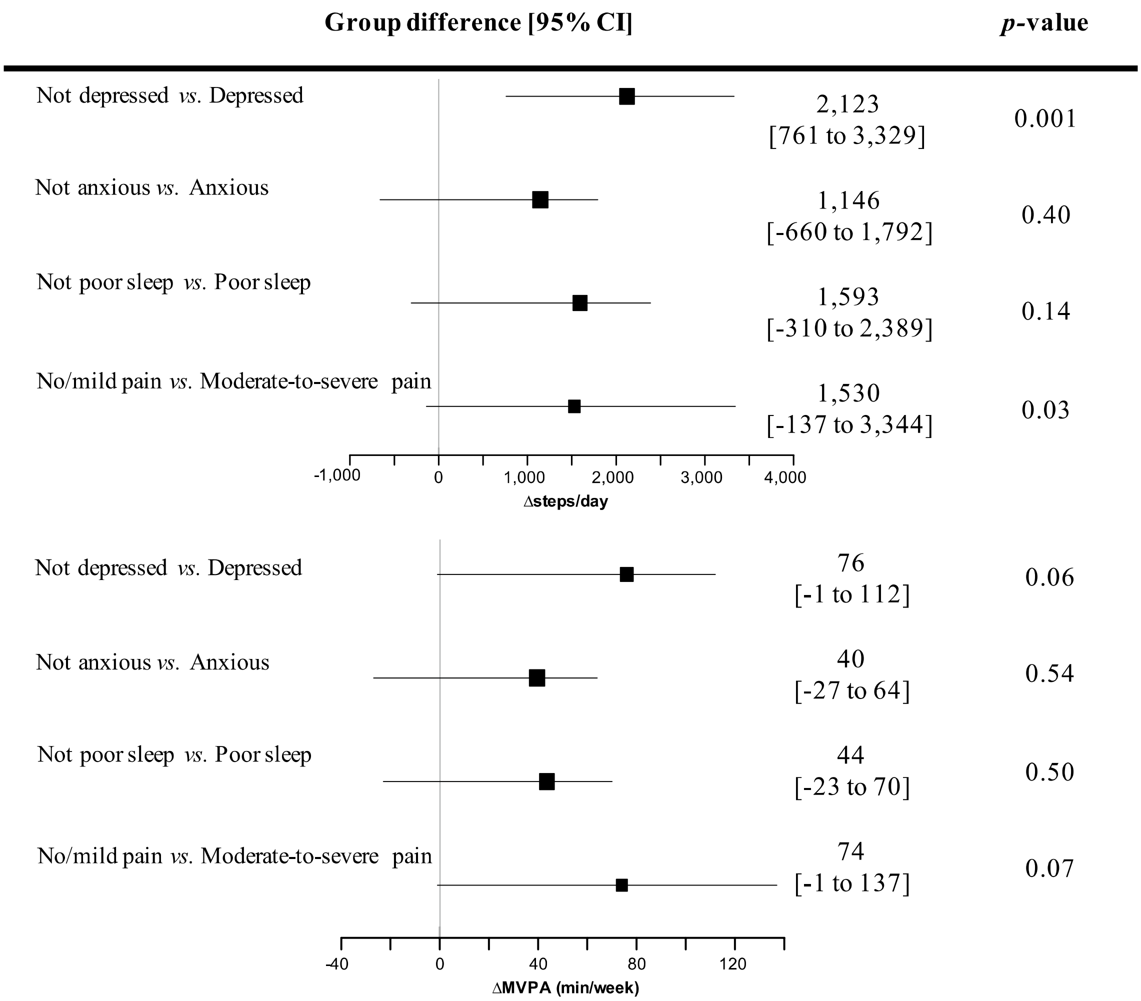

Fig. 4 Comparison of baseline physical activity (daily steps and MVPA) in patients with and without clinically meaningful symptoms of psychological deficits and pain at baseline. Wilcoxon rank-sum tests and median values were used to create the forest plot and derive the confidence intervals and *p* values

by the predictors in our study. Finally, psychological deficits and pain could be determinants of other important outcomes in fibrotic ILD such as dyspnea, quality of life, and mortality. These questions were beyond the scope of this study, but are important future topics that warrant further investigation.

Conclusions

We show in a large cohort of patients with fibrotic ILD that physical activity is low and that psychological deficits and pain are common and persistent. Higher pain severity is an independent predictor of fewer step counts at baseline when adjusting for age, smoking status, ILD severity, and weather variables, with depressive scores also showing a trend towards significance. Additional studies are required to determine whether these are modifiable determinants of quality of life, medication adherence, and prognosis in patients with fibrotic ILD.

Table 3 Adjusted association of baseline psychological deficits and pain with physical activity measured at baseline and 6-month follow-up in patients with fibrotic ILD

Predictor variables	Daily step count				Weekly MVPA (min)			
	Coefficient	Standard error	*p* value	Adjusted R^2	Coefficient	Standard error	*p* value	Adjusted R^2
Baseline								
Depression (per 1-unit)	−168	87	0.056	0.34	−4	6	0.53	0.18
Anxiety (per 1-unit)	23	99	0.82	0.31	7	6	0.27	0.19
Sleep quality (per 1-unit)	−102	95	0.29	0.32	−4	6	0.58	0.18
Pain severity (per 1-unit)	−355	175	0.046	0.35	−19	12	0.11	0.20
6-month follow-up								
Depression (per 1-unit)	−139	77	0.07	0.45	−7	5	0.15	0.29
Anxiety (per 1-unit)	31	83	0.71	0.42	2	5	0.66	0.27
Sleep quality (per 1-unit)	−50	79	0.53	0.42	−4	5	0.42	0.27
Pain severity (per 1-unit)	−301	155	0.055	0.45	−16	10	0.10	0.29

Each row represents a separate forced multivariable model. The associations of predictor variables with baseline physical activity were adjusted for age, smoking status, FVC %-predicted, DLCO %-predicted, and average temperature and hours of daylight. The associations of predictor variables with physical activity at 6-month follow-up were adjusted for age, smoking status, FVC %-predicted, and DLCO %-predicted. The coefficients represent the association of each predictor variable with step count or MVPA. For example, every one-point increase in pain severity score at baseline was associated with 355 fewer steps per day at baseline after adjustment for aforementioned confounders

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Author Contributions Literature search: SAH, CJR. Data collection: SAH, CJR, NK. Study design: SAH, CJR. Analysis of data: SAH, CJR, SAG, PGC, JAG. Manuscript preparation: SAH, CJR, SAG, PGC, JAG, NK. Review of manuscript: SAH, CJR, SAG, PGC, JAG, NK.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

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