

The association between daily physical activity and pain among women with fibromyalgia: the moderating role of pain catastrophizing

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Abstract

Introduction. Fibromyalgia (FM) is a condition marked by widespread chronic pain and psychological symptoms. The primary objective of this study was to examine the day-to-day association between physical activity and pain intensity among a sample of women with FM and the potential moderation of this association by pain catastrophizing.

Methods. Women with FM (N =107) completed questionnaires assessing pain, FM symptoms (Brief Pain Inventory; Revised Fibromyalgia Impact Questionnaire) and psychological measures (PROMIS-anxiety, PROMIS-depression) and were then asked to report their levels of daily pain catastrophizing, physical activity, and pain intensity once per day for a period of seven days using an electronic diary. In addition, objective measures of physical activity were collected using a wrist-worn activity tracker (Fitbit Flex) which measured daily step counts. Moderation analyses were performed with the SPSS macro PROCESS. Daily self-report physical activity was used as the independent variable and pain intensity (BPI) was the primary outcome, while daily pain catastrophizing was tested in the model as the potential moderator in this relationship.

Results. Moderation analyses indicated that association between physical activity and pain intensity was moderated by catastrophizing ($B = .003$, $SE = .001$, $p < .05$), with patients scoring higher in daily catastrophizing showing a relatively stronger link between lower day-to-day physical activity and increased daily FM pain. High catastrophizers were more likely to report more daily pain on days that they were more physically active, while this was not the case for low catastrophizers. Significant associations were observed between pain catastrophizing, pain intensity and Fitbit Flex step count ($p < .05$). Self-report physical activity (subjective) positively correlated with Fitbit Flex step count (objective; $p < .005$).

Discussion. Our findings suggest that increases in daily physical activity are associated with more self-reported pain intensity in women with FM pain, particularly among those with higher levels of pain catastrophizing. These results may have clinical implications for the design and testing of future behavioral interventions targeted at increasing reducing physical activity and/or catastrophizing pain cognitions among women experiencing FM pain.

Background

Fibromyalgia (FM) is a complex chronic widespread pain disorder including various symptoms such as sleep disturbances, fatigue, difficulty thinking clearly (“fibro fog”), stress, anxiety, and depression [1]. The prevalence of FM in the United States is approximately 6.4 percent and the condition is more common in women [2]. Despite this high prevalence, the etiology of the disorder is still unknown, and the diverse nature of FM symptoms suggests a complex biopsychosocial basis. Many of the most effective treatments for FM involve mind-body treatments that emphasize physical activity along with a cognitive and emotional focus (e.g., yoga, movement therapies). Exercise studies have demonstrated that patients with FM are physically deconditioned, with low levels of cardiorespiratory endurance and decreased muscle strength [3]. While exercise has been identified as an important intervention for FM symptom management, patient adherence with recommended exercise regimens is often sub-optimal, presumably due to actual or feared activity-related increases in pain.

The fear-avoidance model of chronic pain, introduced [4] and further developed by Vlaeyen and colleagues [5–7], presents putative pathways by which pain patients might become enmeshed in a downward spiral of increasing avoidance, disability, and pain. It postulates that when bodily sensations are misinterpreted in a catastrophic way (e.g., pain means danger), pain-related fear increases, which is followed by the initiation of a number of safety behaviors including avoidance and guarded movements [7]. Several studies have shown that fear-avoidance beliefs are stronger predictors of physical functioning and disability in patients with chronic pain than biomedical variables [6, 8, 9]. In addition, avoidance behavior may hinder recovery as it diminishes the number of opportunities to correct patient’s beliefs and expectations about pain, thereby allowing for wrongful anticipation of pain to persist [10–12]. These inter-relationships between fear-avoidance-related factors such as catastrophizing and outcome variables such as physical disability have been examined predominantly in cross-sectional studies, and reviews have frequently called for further prospective research on these associations [13, 14]. The aim of the present daily diary study was to examine the associations among daily pain symptoms, catastrophizing, and physical activity in patients with FM. We hypothesized that catastrophizing would have important moderating effects on associations between physical activity and pain intensity in patients with FM.

Methods

In total, we invited 140 FM patients for screening. Patients were diagnosed as having FM (as confirmed by physician and medical records) and met the 2011 American College of Rheumatology criteria, which require the presence of widespread pain as well as a number of other somatic (e.g., sleep disturbance, fatigue), psychological (e.g., depression, anxiety) and cognitive symptoms [15].

After screening the 140 FM patients, 107 participants met the inclusion and exclusion criteria described below. This study was approved by the Partners Human Research Committee, and written informed consent was obtained from all participants. Participants were screened for the following criteria. The inclusion criteria were as follows: (1) 18–75 years old, (2) female, (3) Wolfe et al.’s [15] research criteria for FM diagnosis for at least 1 year, (4) baseline pain intensity of at least 3/10 on average and pain report for at least 50 percent of days, and (5) fluent in English and able to provide written informed consent. The exclusion criteria included (1) comorbid acute pain condition or comorbid chronic pain condition that is rated by the subject as more painful than FM, (2) current use of stimulant medications, (3) pregnant or nursing, (4) any psychiatric disorder involving a history of psychosis (e.g. schizophrenia, severe personality disorders), (5) psychiatric hospitalization in the past 6 months, (6) current or recent use of illicit drugs, (7) active suicidal ideation, and (8) lower limb vascular surgery or current lower limb vascular dysfunction (as part of the assessment protocol, patients underwent sensory testing on the legs).

Procedures

The baseline visit included the informed consent, completion of questionnaires, and confirmation of eligibility (described below). Sociodemographic information included date of birth, marital status, educational, current occupational status, duration of pain symptoms, and medical comorbidities (Table 1). In addition, participants were asked to complete daily diaries for 7 days using a Likert scale via the Research Electronic Data Capture (REDCap) assessing daily pain and negative cognitions on pain (e.g. catastrophizing). Four surveys were used to assess key study variables: (1) Revised Fibromyalgia Impact Questionnaire (FIQR), (2) Brief Pain Inventory

(BPI), (3) Pain Catastrophizing Scale (PCS), Patient-Reported Outcomes Measurement Information System (PROMIS)-anxiety, PROMIS- depression.

FM pain and symptoms. In order to measure FM symptomatology, we used the FIQR [16] and the BPI [17]. The FIQR is a 21-question measure with an 11-point numeric rating scale (NRS) of 0 to 10, with 10 being “worst.” The FIQR is divided into three subscales for scoring: (1) “function,” (2) “overall impact,” and (3) “symptoms,” as well as a total overall score to assess the total impact of FM symptoms on a patient’s life. The BPI is a 15-item measure, which includes two multi-item subscales that measure (1) pain intensity and (2) pain interference with daily activities[17]; the BPI is well-validated in chronic pain and is frequently recommended as an outcome measure of pain severity and pain interference.

Emotional Distress- Anxiety and Depression: Participants completed the PROMIS anxiety and depression short forms, which are widely used and extensively validated [18, 19]. The anxiety subscale consists of 7 items that ask respondents about the frequency with which they experience emotions such as fear, stress, and anxiety (“never” to “always”). The depression subscale consists of 8 items in which respondents indicate the frequency with which they have experienced emotions such as worthlessness, hopelessness, and sadness (“never” to “always”). Higher scores indicate more severe symptoms of emotional distress.

Daily Pain Catastrophizing. Patients were asked to report their levels of catastrophizing (0 “not at all” to 4 “all the time”; same response scale as used in the PCS) once a day for a period of 7 days using a Likert scale via the Research Electronic Data Capture (REDCap). The Situational Catastrophizing Questionnaire (SCQ) is a six-question adaptation of the PCS (described above). It has been used by our group in other studies and has been described more fully by Edwards and his lab [20, 21]

Daily Physical activity. Patients were asked to report their levels of physical activity (0 “not at all” to 100 “all the time”) once a day for a period of 7 days using a Likert scale [22] via the Research Electronic Data Capture (REDCap).

Daily Fitbit Flex Step Counts (physical activity). The Fitbit Flex is a popular, relatively inexpensive, and widely available small wristband that tracks physical activity, including measures of the estimated number of steps per day. The Fitbit Flex provides a valid measure of physical activity [23-25]. The FitbitFlex wirelessly synchronizes data to a computer, tablet, or phone and provides participants with feedback through a user-friendly website. Patients in the study wore the Fitbit Flex for the week during which they completed daily diaries; Fitbit Flex data was downloaded and stored at the end of the week. Participants optionally kept their Fitbit Flex after completion of the study. These data were used as part of an exploratory analysis to explore whether objective and subjective measures of physical activity are correlated.

BMI (Body Mass Index). The BMI was calculated according to the following formula $BMI = \text{body mass [kg]} / (\text{height [m]})^2$.

Data analysis

All analyses were conducted using IBM-SPSS v.24. Descriptive data for continuous variables are presented as means and standard deviations (SDs), and data for categorical variables are presented as percentages (see Table 1).

Statistical assumptions and Pearson's correlation coefficients were analyzed using SPSS (v. 23; IBM Corporation, Armonk NY) for MacVR. We conducted both bivariate correlations, controlling for age and education level, and the significance of associations did not differ. Thus, we will only report bivariate correlations.

To test our moderation model, we used the SPSS PROCESS macro, as it allows to test moderation effects [26]. We tested Model 1, in which daily physical activity was the predictor, pain intensity (BPI) the dependent variable, daily pain catastrophizing was the moderator of the relationship between physical activity and pain intensity controlling for FM symptoms (FIQR) and Body Mass Index (BMI).

Results

Descriptive statistics for study measures are presented in Table 1. The average age of patients was 39.5 (SD = 12.4) and all participants were female. Missing data percentages were low with baseline questionnaires missing only 1.7 percent and diary data missing only 17.6 percent. Table 2 shows Pearson correlations among study measures and Table 1 shows the means and standard deviations of the variables used in the moderation analysis as well as demographics.

Moderation Analysis

We examined whether pain catastrophizing moderates the relationship between physical activity and pain intensity. Results showed that the overall model was significant, $F(5, 87) = 17.81, p < .001, R^2 = .50$. Although the main effects of physical activity and pain catastrophizing were not significant ($p > .05$), the association between physical activity and pain intensity was moderated by pain catastrophizing. In order to further examine the significance of simple slopes of the interaction, a simple moderation model was first conducted, and results showed the interaction was significant ($B = .003, SE = .001, p < .05$). These results suggest that the association between physical activity and pain intensity is contingent on pain catastrophizing (Table 3). A visual representation of the moderation is presented in Figure 1 depicting the association between physical activity and pain at different levels of catastrophizing (i.e., 1 SD above and below the mean; Figure 1). In addition, significant associations were observed between pain catastrophizing, pain intensity and Fitbit Flex step count ($p < .05$). Self-report physical activity positively correlated with Fitbit Flex step count ($p < .005$).

Discussion

The aim of this study was to explore the moderating effects of catastrophizing on the relationship between daily physical activity and pain intensity in patients with FM. The main finding was that catastrophizing moderated the relationship between daily self-report physical activity and pain intensity. Pain catastrophizing and physical activity both appear to influence pain levels in FM, with catastrophizing magnifying the pain-increasing effects of physical activity among FM patients. Our results support previous findings about the importance of psychosocial factors including anxiety depression and catastrophizing that should be targeted in chronic pain patients to pain related disability and sedentary behaviors [22, 27].

A primary challenge to effective self-management of chronic pain is limited adherence to physical activity and lifestyles that are most likely to reduce the physical and emotional "triggers" that worsen symptoms in chronic

pain [28–30]. We now have abundant evidence that negative affective and cognitive states contribute to reduced activity levels in patients with chronic pain [31]. While we do not have data on the mechanisms by which these associations unfold, it is possible that high catastrophizing may magnify the perception of pain on days when physical activity levels are relatively higher, promoting a feeling of reduced motivation and increased physical symptoms. Past evidence has indicated that high pain catastrophizing predicts deficits in exercise-associated hypoalgesia [32], which may contribute to our observations of larger activity-provoked increases in pain among patients with high catastrophizing.

Furthermore, as fear of movement due to potential injury represents a response to pain influenced by catastrophizing[5], this could be a further mechanism through which catastrophizing can increase perceived pain intensity on days of increased physical activity. Catastrophizing has also been shown to be significantly associated with fatigue and to serve as a good predictor of fatigue severity[33], which may be one of the pathways by which catastrophizing reduces engagement in daily activity. Finally, pain catastrophizing seems to have a maladaptive influence on brain circuitry that is involved with pain facilitation and central sensitization [34, 35]. Therefore, it seems that it is important to assess catastrophizing and target it when focusing on improving physical function in patients with patients with FM [36–38].

In addition, it is important to note that measuring physical activity is inherently challenging, regardless of the method of measurement. Evaluating patient-reported activity estimates and accelerometer-monitored steps appears to yield overlapping yet substantially distinct domains of information. It is interesting to note that patient-reported daily activity is correlated with pain intensity and with other FM symptoms as well as Fitbit-assessed step count. While the subjective and objective measures of physical activity were modestly and significantly correlated in this study, they appear to have different patterns of association with other subjective reports of FM symptomatology. While some have argued that accelerometry may offer a better assessment of physical activity than subjective self-report as it avoids issues of recall bias, there are notable limitations for objective physical activity assessments, including the inability to assess dynamic physical activity, dependence on accelerometer wear location (e.g., wrist vs. hip), and sensitivity to the assessment variables analyzed (e.g., step count, activity counts) [39].

The limitations of this study should be recognized when interpreting these results. First Physical activity over a 7-day period may not be representative of habitual physical activity levels. Second, participants used in our study, included only women with moderate to severe FM pain; this sample may not fully represent all FM populations, such as those with milder FM symptoms or men. Finally, this study is based on baseline data assessing patients' daily symptoms. As a result, it would be useful to examine the extent to which significant interactions that emerge with baseline data replicate in the same sample of patients after cognitive based interventions targeting catastrophizing reductions.

Conclusions

Collectively, given the physical limitations imposed by pain, catastrophizing seems to be an important outcome to target with chronic pain interventions, as there are strong associations with cardiovascular and respiratory conditions [40]. Aerobic exercise, stretching, strengthening and aqua therapy has been shown to reduce pain and improve functional capacity and quality of life [41, 42]. Future interventions combining skills targeting physical activity and reducing negative maladaptive pain cognitions (e.g Cognitive Behavioral Therapy) might be able to

reduce kinesiophobia and promote a healthier lifestyle in women with chronically painful musculoskeletal conditions.

Declarations

Ethics approval and consent to participate

The involvement of human subjects in this study was reviewed, approved, and monitored by the Institutional Review Board (IRB) of Brigham & Women's Hospital (Boston, MA, USA).

Consent for publication

N/A

Availability of data and materials

Upon request, and subject to certain criteria, conditions, and exceptions we will provide access to individual de-identified participant data.

Competing interests

The authors declare no conflict of interest

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Authors' contributions

All authors contributed equally to this work.

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Tables

Table 1. Clinical Profile and Demographics characteristics (N=107)

| | |
|--|-------------|
| | 39.5±12.4 |
| Demographics | |
| Hispanic | 79.4% |
| Employed | 53.3% |
| Married | 31.8% |
| Living Alone | 15.9% |
| Education Level (college degree) | 59.8% |
| Body Mass Index | 29.5±7.4 |
| Fibromyalgia Symptoms (FIQR;0-100) | 56.6±16.6 |
| Pain Intensity (BPI; 0-10) | 5.2 ± 1.8 |
| Fitbit Flex (Step Counts) | 5,755±2,626 |
| Pain Catastrophizing (average 7 days;) | 21.5 ± 14.0 |
| Physical Activity (average 7 days; 0-100) | 46.3±15.0 |
| HAS Anxiety | 10.0±3.3 |
| HAS Depression | 10.0±4.2 |

FIQR: Fibromyalgia Impact Questionnaire-Revised; PCS: Pain Catastrophizing Scale; SD: standard deviation.

Table 2. Pearson Correlations between physical activity, BMI, Fibromyalgia Symptoms pain catastrophizing, pain intensity and Fitbit Flex

| Variables | 1 | 2 | 3 | 4 | 5 | 6 |
|--|-------|------|-------|------|------|---|
| 1. Fibromyalgia Symptoms (FIQR) | - | | | | | |
| 2. Body Mass Index (BMI) | .10 | - | | | | |
| 3. Pain Catastrophizing (average 7 days) | .62** | .01 | - | | | |
| 4. Physical Activity (average 7 days) | .27** | -.12 | .12 | - | | |
| 5. Pain Severity (Brief Pain Inventory) | .64** | .03 | .58** | .20* | - | |
| 6. Fitbit Flex Steps (Count) | -.13 | -.14 | .16 | .32* | -.02 | - |

Table 3. Moderation model examining the influence of physical activity and pain catastrophizing on pain intensity (BPI) controlling for BMI and Fibromyalgia Impact (FIQR) among women with fibromyalgia.

| Fixed effects | β | SE | t | p |
|--|---------|------|-------|----------------|
| Constant | 2.89 | 1.33 | 2.16 | $p \leq 0.05$ |
| BMI (Body Mass Index) | -.002 | .01 | -.12 | ns |
| Fibromyalgia Symptoms (FIQR) | .04 | .01 | 4.25 | $p \leq 0.001$ |
| Pain Catastrophizing | -.04 | .08 | -.49 | ns |
| Physical Activity | -.04 | .02 | -1.64 | ns |
| Physical Activity x Pain Catastrophizing | .003 | .001 | 1.95 | $p \leq 0.05$ |

Note. The average across the 7 diary timepoints was calculated for physical activity and pain catastrophizing; β : unstandardized regression coefficient; SE = Standard error

Figures

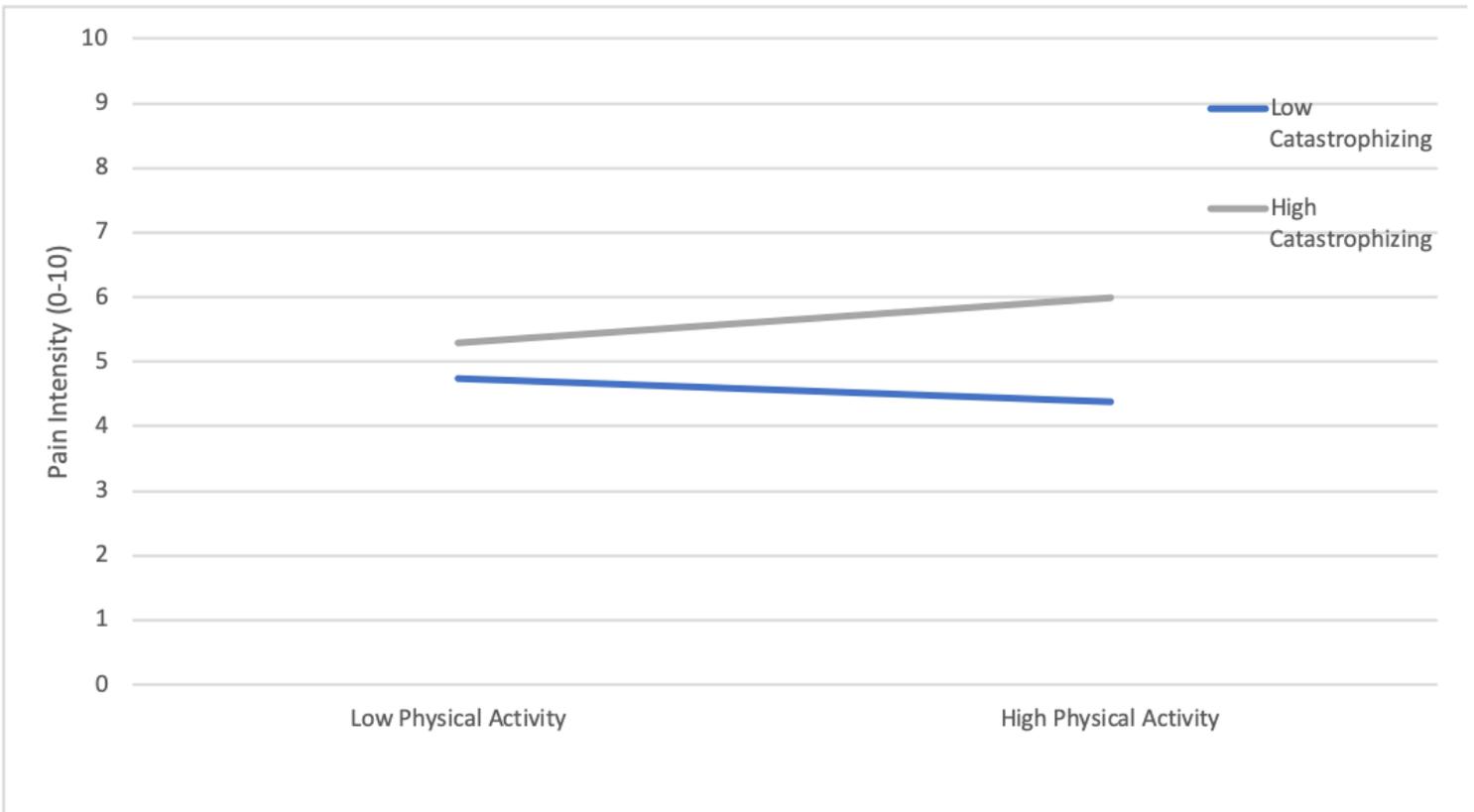


Figure 1

The significant effects of the interaction between daily pain physical activity and daily catastrophizing on pain intensity.