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Research Paper

Sleep disturbance in individuals with physical disabilities and chronic pain: The role of physical, emotional and cognitive factors

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ABSTRACT

Background: Sleep problems are common for individuals living with physical disabilities and chronic pain. However, the factors that influence the relationship between pain and sleep problems in these populations remain unknown.
Objective: The aim of this study was to increase our understanding of the physical, emotional and cognitive factors associated with sleep disturbance in individuals with chronic health conditions often associated with physical disabilities.
Methods: Participants were recruited from a database of individuals with a variety of chronic health conditions, including multiple sclerosis, spinal cord injury, back pain, osteoarthritis, and amputations. To participate in the study, they needed to report having a chronic pain problem. Participants completed an online survey using REDCap assessing average pain intensity (Numerical Rating Scale-11), pain extent (number of painful body areas), sleep disturbance (PROMIS Sleep Disturbance), depression (PROMIS Emotional Distress-Depression) and catastrophizing (Coping Strategies Questionnaire). A total of 455 participants ($M_{age} = 58.9$; $SD = 11.4$), of which 292 (64%) were women, provided complete data. We performed a series of four regression analyses.
Results: After controlling for age and sex, the predictors explained an additional 7–16% of the variance in sleep disturbance. The final model with all of the predictors explained 22%.
Conclusions: Consistent with the study hypothesis, all the variables examined made significant and independent contributions to the variance in sleep disturbance. The findings provide additional evidence that physical, emotional and cognitive factors all play a role in the sleep quality of individuals with chronic health conditions often associated with physical disabilities.

Getting a good night's sleep is a common challenge for individuals with chronic health conditions,[1] and poor sleep is related with a decreased health-related quality of life in people living with physical disabilities.[2] In addition, chronic pain is more common in individuals with chronic health conditions than in otherwise healthy populations.[3] Given the well-established link between sleep disturbance and pain,[4] it is reasonable to hypothesize that pain can, in turn, aggravate sleep problems. Therefore, sleep should be considered a critical health domain to be evaluated and treated in people living with chronic health conditions who also have chronic pain. However, knowledge regarding the specific factors that contribute to sleep problems in these populations remains limited.

Pain extent (i.e., the number of bodily areas where someone experiences pain) and pain location have been shown to play a role on sleep quality over and above pain intensity in healthy samples,[5] and pain extent has also been shown to be related to poorer function in adults[6] and youths[7] living with physical disabilities. Individuals with chronic widespread pain also report high rates of sleep problems and insomnia.[8] Depression has also shown to be higher in people living with physical disabilities.[9] Although depression has been shown to be linked to both pain and sleep problems in samples of patients with chronic pain,[10,11] its association with sleep disturbance in samples of individuals with health

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conditions associated with physical disability has not yet been evaluated. Cognitive factors such as catastrophizing may also play a role in sleep disturbance in this population. Catastrophic thinking is usually higher in people with chronic pain[12,13] and in people with depression. Moreover, rumination, which is a key component of catastrophizing, is known to be associated with sleep problems.[14]

In summary, a number of variables – including pain extent, depression, and catastrophizing – have been shown to be related with sleep quality in a variety of populations. They may therefore also influence sleep in individuals living with chronic health conditions often associated with physical disabilities and chronic pain.[10] However, the relative importance of these factors as predictors of sleep problems is not known, as no investigators have examined all of these factors in the same study. Moreover, the extent to which each of these factors plays a role in sleep disturbance when controlling for the other factors is not known.

Given these considerations, the aim of this study was to increase our understanding of the physical, emotional and cognitive factors that are associated with sleep disturbance in individuals with physical disabilities and chronic pain. We hypothesized that pain intensity, pain extent, depressive symptoms and pain catastrophizing would all make significant and independent contributions to explain the variance of sleep disturbance after controlling for demographic variables (i.e., sex and age). Specifically, we anticipated that more pain intensity, a greater number of painful areas, more depressive symptoms and higher levels of catastrophizing would all be associated with more sleep disturbance.

Methods

Participants

Participants were recruited from a database of individuals from the United States with medical conditions commonly associated with physical disabilities, including spinal cord injury (n = 91), multiple sclerosis (n = 171), back pain (n = 197), osteoarthritis (n = 99), amputation or limb loss (n = 65), diabetes (n = 57), post-polio syndrome (n = 51) and muscular dystrophy (n = 30). These individuals had participated in previous survey studies and had agreed to be contacted again for possible participation in additional research studies. This database is maintained by the University of Washington. Inclusion criteria for participation in the current study were (1) having chronic pain (defined as a constant or recurrent bothersome pain during the last three months, on at least half the days) and (2) having access to a computer or smartphone with internet connection.

Procedures

Study data were collected and managed using REDCap electronic data capture tools[15] hosted at the University of Washington. REDCap (Research Electronic Data Capture) is a secure, web-based application designed to support data capture for research studies, providing: (1) an intuitive interface for validated data entry; (2) audit trails for tracking data manipulation and export procedures; (3) automated export procedures for seamless data downloads to common statistical packages; and (4) procedures for importing data from external sources.

Potential participants were sent emails with a brief explanation of the purpose of the study and a general description of the contents of the survey questions, as well as a link to access the online survey if they were interested in participating. Once they opened the link, two screening questions to confirm they met criteria for having chronic pain were asked ("Have you experienced a constant or recurrent bothersome pain during the last three months?" and "Have you experienced pain at least half the days in the past three months?"). If they qualified for the study (i.e., if the answer to both questions was "yes"), they were then shown an informed consent statement that they could digitally sign if they wanted to participate. If they signed, they were then taken to the first question of the survey.

A total of 2871 potential participants were contacted via email (using the REDCap email feature). From these, 420 email addresses (15%) were incorrect or no longer working. Forty potential participants (2% of those with a working email) declined to participate (5 reported that they were too busy, 1 too fatigued, 5 did not want to complete the survey online, 5 wanted economic compensation for participation, and 24 did not provide a reason for declining). Fifty-four of them (2%) answered the email saying that they did not qualify because they did not have chronic pain. A total of 860 participants (35%) agreed to participate (i.e., opened the survey link, read the information and answered the screening questions). Of these, 158 (18% of those agreeing to participate) did not meet the inclusion criteria for having chronic pain. In total, 702 participants provided at least some information: 235 (33% of those meeting the inclusion criteria) provided a partial response (they did not finish the survey) and 467 (67%) finished the survey, with 455 responding in full to all the questionnaires used in the present study (that is, 12 of the survey completers, 2%, did not respond to all the items or questions included in the present study). All the data presented is cross-sectional.

Data were collected anonymously. The only information linked to each participant email address was whether or not they had responded to the survey. Participants were sent a maximum of two email reminders if the survey was not responded within one week and one month after the initial email was sent. Email invitations were sent in weekly batches of 150. Data collection took place between October 2016 and June 2017. Participation was voluntary and participants were not required to answer any question they did not want to answer (i.e., they could advance through the survey and finish it leaving questions blank). Questionnaires with missing data were excluded from the analyses. The survey took an average of 45 min to complete, and participants were not compensated for their time. Other measures, including a pool of items for the validation of a new questionnaire, were included in the survey to be examined in analyses addressing other research questions. A telephone number and email address for the study PI (RdlV) were provided if participants had any questions. A total of 15 emails and 16 phone calls were received and responded via the same media. The main topics of the questions asked were about: (1) study eligibility, (2) economic compensation for participation, and (3) additional details regarding the purpose of the study. The Institutional Review Board of the University of Washington reviewed the protocols and considered the study of "minimal" risk and exempt from a full board review.

Measures

Demographic information

An *ad hoc* questionnaire with six questions was used to collect information about: age, sex, race or ethnicity, diagnosis, education level and work status.

Average pain intensity

The 0–10 numerical rating scale (NRS-11) where 0 is "No pain" and 10 is "The worst pain possible" was used to assess average pain intensity over the last week. This scale has been widely used and validated to measure pain across different populations including

participants with chronic pain.[16]

Pain extent

A list with 12 possible pain locations (Head, Neck, Chest, Shoulders, Back, Arms, Hands, Bottom/hips, Belly/pelvis, Legs, Feet and Other) was presented to the participants. They were asked to check all the areas of the body where they currently experienced pain. To compute the pain extent score, one point was assigned to each selected area, and the numbers were summed, resulting in a score with a possible range of 1–12 (a score of 0 was not possible because all the included participants had pain in at least one location). The use of a list of body areas to compute a pain extent score has been successfully done in the past.[5,6,8]

Sleep disturbance

To asses sleep disturbance, we administered the PROMIS Sleep Disturbance 6a Short Form scale. The Patient-Reported Outcomes Measurement Information System (PROMIS®) was developed to improve and unify the measurement of patient-reported outcomes. The short forms of a number of PROMIS subscales[17] were used to collect information about several of the variables included in the study, including sleep disturbance. The short forms PROMIS scales scores have shown good psychometric properties in ethnically diverse samples[18] and in a variety of clinical conditions (i.e. chronic obstructive pulmonary disease, back pain, major depressive disorder, chronic heart failure, rheumatoid arthritis and cancer).[19] For the sleep Disturbance PROMIS scale, Cronbach's Alpha was 0.90 in this sample, indicating excellent internal consistency. We scored the responses to the sleep disturbance items into T-scores, per PROMIS scoring guidelines.[20] A higher score indicates more sleep disturbance.

Depressive symptoms

Depressive symptoms were assessed using the PROMIS Emotional Distress-Depression Scale short form (8 items), and T-scores were computed.[20] Cronbach's alpha for the Depression scale was 0.94 in the current sample, indicating excellent internal consistency. A higher score indicates more depressive symptoms.

Catastrophizing

We used the 2-item Coping Strategies Questionnaire (CSQ) to assess catastrophizing.[21] This scale has been shown to be valid and reliable when used with chronic pain patients. The Cronbach's alpha of these two items in the current sample was 0.84, indicating good internal consistency. A higher score indicates higher catastrophizing.

Data analysis

We first computed means and standard deviations of the demographic and other study variables to describe the sample. We then evaluated the distributions (skewness and kurtosis) of the study variables and also evaluated the predictors for the presence of multicollinearity, calculating the Durbin-Watson statistic, the variance inflation factor (VIF) and the tolerance, to ensure that they met the assumptions for the planned regression analyses. Pearson correlations between each of the study variables were computed to better understand their associations. To evaluate the association between each predictor and sleep disturbance controlling only for demographic variables, we performed a series of four regression analyses, regressing the measure of sleep disturbance on age and sex (step 1), and then each of the four study predictor variables in turn. In order to test the study hypothesis that each predictor would account for significant and independent variance in the prediction of sleep disturbance, we conducted a single multiple regression analysis, the measure of sleep disturbance as the criterion variable. In step 1 we entered age and sex as control variables. In step 2 we entered the four predictor variables (pain intensity, pain extent, depressive symptoms and catastrophizing separately). IBM SPSS 21 for Windows was used to conduct the data analyses.

Results

Participants

A total of 455 participants provided complete data for the questionnaires used in the analyses. See Table 1 for a description of the sample. As can be seen, the mean age of the participants was 58.9 years (SD = 11.4 years), 292 (64%) were women and most of them (411, 91%) were Caucasian. The most frequent diagnoses were: back pain (43%), multiple sclerosis (38%), osteoarthritis (22%), and spinal cord injury (20%). The education level was high, 84% of participants had attended University or Graduate School. Most of the participants in the sample (71%) were retired, on disability or unemployed due to pain, 25% were working either full or part time. Mean pain intensity was 5.3 out of 10 (SD = 1.9). The average number of painful areas (pain extent) was 4.5 (SD 2.2, range 1–11). Mean T-score on the PROMIS Sleep Disturbance scale in this sample was 49.8 (SD 10.1). Depression mean T-score in this sample was 50.2 (SD 10.1). Finally, Catastrophizing mean score in this sample was 4.3 (SD = 3.3).

Assumptions testing

The distribution of the data was adequate to perform the planned analyses: skewness and kurtosis were adequate (range, −0.30 to 0.87 for skewness, −0.81 to 0.34 for kurtosis), and the correlation coefficients between the predictor variables were all

Table 1
Description of the study sample (N = 455).

Variable	Mean (SD) or Percent (N)	Range
Age, years	58.9(11.4)	22–94
Sex		
Men	36% (163)	
Women	64% (292)	
Ethnicity/Race[a]		
Caucasian	91% (411)	
African American	3% (14)	
More than one race	3% (15)	
Other	3% (14)	
Diagnosis		
Back pain	43% (197)	
Multiple sclerosis	38% (171)	
Osteoarthritis	22% (99)	
Spinal Cord Injury	20% (91)	
Amputation/limb loss	14% (65)	
Diabetes	13% (57)	
Post-polio syndrome	11% (51)	
Muscular Dystrophy	7% (30)	
Highest level of education		
Secondary school	10% (44)	
Vocational or technical	7% (33)	
College or University	53% (240)	
Graduate school	31% (139)	
Current work status		
Full-Time	14% (63)	
Part-Time	11% (49)	
Homemaker	4% (16)	
Unemployed due to pain	11% (50)	
Unemployed due to disability	19% (84)	
Retired	41% (187)	
Student	1% (5)	

[a] Participant information missing for Ethnicity/Race (n = 1).

below 0.50. The Durbin-Watson statistic was adequate (2.1)[22], the variance inflation factor (VIF) was lower than 10 for all the variables in each step of the regression analyses[22] (the maximum VIF was 1.6). Moreover, the tolerance was higher than 0.6[22] for each variables in each step. These findings indicate that multicollinearity among the predictors would not bias the results. The correlations between variables ranged between 0.12 and 0.52 (see Table 2).

Predicting sleep disturbance from pain intensity, pain extent, depressive symptoms and pain catastrophizing

The results of the five regression analyses predicting sleep disturbance from each predictor individually (after controlling for age and sex) and the four predictors entered as a block are presented in Table 3. As can be seen, pain intensity accounted for an additional 14% (β to enter = 0.37, $p < 0.001$), pain extent accounted for an additional 5% (β to enter = 0.23, $p < 0.001$), depressive symptoms accounted for an additional 10% (β to enter = 0.32, $p < 0.001$), and pain catastrophizing accounted for an additional 10% (β to enter = 0.32, $p < 0.001$) of the variance in sleep disturbance after controlling for age and sex. As a group, the four predictors accounted for an additional 21% (F for final model = 18.73, $p < 0.001$) of the variance in sleep disturbance after controlling for the demographic variables. In all analyses, more pain intensity, greater pain extent, more depressive symptoms and more pain catastrophizing were associated with more sleep disturbance. The final model with all of the predictors explained 22% of the variance in sleep disturbance, which is considered a large effect.[23]

Discussion

Consistent with the study hypothesis, all three of the primary study predictors (i.e., pain extent, depressive symptoms and pain catastrophizing) made significant and independent contributions to explain the variance of sleep disturbance over and above sex, age, and pain intensity. Specifically, we found that a greater number of painful areas, more depressive symptoms and higher levels of catastrophizing were associated with greater sleep disturbance in the study participants. This is consistent with the idea that sleep disturbance is multi-determined factors in adults with physical disabilities and pain. The findings have important theoretical and clinical implications.

First, although pain extent was identified as an important variable for people living with physical disabilities as long as two decades ago,[24] it remains a pain domain that is commonly overlooked by both researchers and clinicians. However, it appears to play an important role explaining some of the variance of sleep disturbance. This finding makes sense, as it seems reasonable to expect that individuals with pain in multiple locations might have more difficulty time finding a comfortable sleeping position than individuals with pain in only one location. Thus, assessing and treating, as appropriate, all of the areas of pain in someone with multiple painful areas could potentially improve treatment outcomes, including outcomes related to sleep quality. In order for clinicians to understand which treatments influence pain extent, researchers should consider including measures of pain extent as an outcome variable in clinical trials, even if it is included as only a secondary outcome variable. While inclusion of pain extent as an outcome is rare, there are studies that have included this design feature.[25] The current findings indicate that more attention to pain extent both as predictor and outcome in pain research is warranted.

We also found that the severity of depressive symptoms contributed to the variance of sleep disturbance in our sample. This finding is consistent with research showing that sleep problems are common in individuals with depression (i.e., up to 70% of depressed individuals report sleep problems[26]), as well as the fact that sleep problems are themselves a symptom of clinical depression.[27] Given that depression is a common problem in individuals living with physical disabilities,[9] these findings indicate that it may be important to assess and treat depression as a part of treating sleep problems in this population. Empirically validated psychological and pharmacological treatments for depression are available for individuals with multiple sclerosis, as shown by a recent systematic review.[28] For patients with traumatic brain injury, a twelve session telephone and in person cognitive behavioral therapy intervention was found to be acceptable and feasible for depression improvement, although more research is needed to prove efficacy for this particular intervention.[29] Additional promising and highly accessible options for treating depression are also being developed, such as clinician-supported online cognitive behavioral treatments, which appear to be as effective as face-to-face therapy.[30]

Similar conclusions regarding the need to assess and treat catastrophizing in individuals with chronic pain and physical disabilities with sleep problems can be drawn. Catastrophizing has been shown to play a key role in function in individuals with chronic pain associated with a disabling condition.[12] Studies in patients with chronic pain as a primary condition have found that the tendency to ruminate and catastrophize are associated with poorer sleep quality and higher pain intensity,[31] and that patients with insomnia secondary to chronic pain report having intrusive pain-related thoughts prior to their bedtime.[32] A recent intervention study has shown that a psychological intervention targeting sleep was able to reduce pain catastrophizing in patients with knee osteoarthritis.[33] Moreover, a recently proposed model suggests a reciprocal relationship between pain, sleep, and catastrophizing in pain rehabilitation patients.[34] An important future direction for research would be to evaluate the extent to which addressing catastrophizing helps improve both pain and sleep symptoms in individuals with chronic pain, including individuals with chronic pain associated with physical disabilities. Catastrophizing assessment and treatment, perhaps as a component of depression treatment, should be considered in sleep interventions designed for people living with physical disabilities and pain.

The present study has a number of limitations that should be considered when interpreting the results. First, only three primary predictors (over and above pain intensity) were examined; as a group they only explained 8% of the variance in sleep disturbance. There are a number of other factors that would likely play a role in

Table 2
Pearson correlations between the study variables.

	Pain intensity	Pain extent	Catastrophizing	Sleep disturbance	Depression
Pain intensity	1	.21*	.40*	.36*	.28*
Pain extent	.21*	1	.12*	.24*	.24*
Catastrophizing	.40*	.12*	1	.32*	.52*
Sleep disturbance	.36*	.24*	.32*	1	.33*
Depression	.28*	.24*	.52*	.33*	1

*P < 0.01

Table 3
Multiple regression analysis predicting sleep disturbance.

Step and Variables	R^2	ΔR^2	F_{change}	*P*-Value	β to enter	β to enter *P*-Value	Final β	Final β *P*-value
Step 1: Control variables	.02	.02	3.55	.030				
Age					-.10	.038	-.08	.095
Sex					.08	.127	.04	.387
Predictors entered individually								
Step 2: Pain intensity	.16	.14	64.53	<.001	.37	<.001	.37	<.001
Step 2: Pain extent	.07	.05	21.43	<.001	.23	<.001	.23	<.001
Step 2: Depressive symptoms	.12	.10	44.82	<.001	.32	<.001	.32	<.001
Step 2: Catastrophizing	.12	.10	46.00	<.001	.32	<.001	.32	<.001
All predictors entered as a block								
Step 2: All predictors	.22	.21	25.87	<.001				
Pain intensity					.24	<.001	.24	<.001
Pain extent					.13	.007	.13	.007
Depression					.15	.004	.15	.004
Catastrophizing					.12	.027	.15	.027

*p < 0.05.
Multiple regression analysis conducted in a sample of 455 individuals with physical disabilities and chronic pain that completed an online survey.
Higher scores indicate: more sleep disturbance, more pain intensity, a higher number of pain locations, more depression symptoms and a higher level of catastrophizing.
R^2 = percentage of the variance explained by the model; F = how much variability the model can explain relative to how much it can't explain; Fchange = how much the model improves relative to the previous step; β to enter = change on the outcome per one unit of change on the predictor.

sleep disturbance, such as the absence of bedtime routines and sleep hygiene practice,[35] a lack of regular exercise,[36] use of certain medications,[37] and the presence of anxiety disorders.[10,38] However, measures of these variables were not included in the current study. Future research should consider the unique role that these and other factors play in sleep disturbance in rehabilitation populations. Additionally, pain catastrophizing is a multi-component domain.[39] However, the measure of catastrophizing we used cannot be scored to assess the subdomains of catastrophizing. Thus, we were not able to evaluate the extent to which each of the subdomains of catastrophizing – including rumination, pain magnification, and perceived helplessness – play unique and independent roles explaining sleep disturbance in our sample. Future research should examine this more closely, as knowledge in this area could have important implications for determining which catastrophizing component or components should be the focus of treatment. Moreover, we used a cross-sectional design. As a result, we are not able to draw causal conclusions between the variables studied. At best, the findings only identify the factors that have the potential to impact sleep disturbance. Future longitudinal and experimental studies (for example, studies that target for change pain extent, depression, and catastrophizing) are needed to determine if systematic changes in the predictors identified here have an impact on subsequent sleep disturbance. Finally, the sample was self-selected as individuals interested in research participation, so we don't know the characteristics of those who decided not to participate, and their diagnoses were confirmed when they joined the database, not when conducting the study (they were self-reported). Thus, the generalizability of the findings to rehabilitation populations in general is not clear. Additional research in other samples is needed to help evaluate the reliability of the current results.

Conclusions

Despite the study's limitations, the finding that multiple factors significantly contribute to sleep disturbance and that no single factor emerges as primary suggests that to treat sleep problems, a multi-factorial intervention might be more effective than an intervention that targets just one potential mechanism. For example, while a cognitive behavioral intervention for sleep, consisting of eight weekly 90-min group sessions teaching relaxation, sleep restriction techniques and cognitive restructuring that targeted catastrophizing, was shown to be effective in women with multiple sclerosis,[40] the beneficial effect of the intervention was only moderate. Approaches integrating the treatment of other domains, such as pain extent and depression, might increase the efficacy of this and other treatments. Research to evaluate this possibility is warranted.

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Conflicts of interest

All the authors declare no conflict of interest.

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