Measures of Spontaneous and Movement-Evoked Pain Are Associated With Disability in Patients With Whiplash Injuries

Tsipora Mankovsky-Arnold,* Timothy H. Wideman,† Christian Larivière,‡ and Michael J. L. Sullivan*‡

*Department of Psychology and †School of Occupational and Physical Therapy, McGill University, Montreal, Quebec, Canada.
‡Robert-Sauvé Occupational Health and Safety Research Institute (IRSST), Montreal, Quebec, Canada.

Abstract: This study examined the degree to which measures of spontaneous and movement-evoked pain accounted for shared or unique variance in functional disability associated with whiplash injury. The study also addressed the role of fear of movement as a mediator or moderator of the relation between different indices of pain and functional disability. Measures of spontaneous pain, single-point movement-evoked pain, repetition-induced summation of activity-related pain (RISP), and fear of movement and disability were obtained on a sample of 142 individuals who had sustained whiplash injuries. Participants’ pain ratings, provided after lifting a weighted canister, were used as the index of single-point movement-evoked pain. RISP was computed as the increase in pain reported by participants over successive lifts of 18 weighted canisters. Measures of functional disability included physical lift tolerance and self-reported disability. Hierarchical regression analyses revealed that measures of single-point movement-evoked pain and RISP accounted for significant unique variance in self-reported disability, beyond the variance accounted for by the measure of spontaneous pain. Only RISP accounted for significant unique variance in lift tolerance. The results suggest that measures of movement-evoked pain represent a disability-relevant dimension of pain that is not captured by measures of spontaneous pain. The clinical and conceptual implications of the findings are discussed.

Perspective: This study examined the degree to which measures of spontaneous and movement-evoked pain accounted for shared or unique variance in functional disability associated with whiplash injury. The findings suggest that approaches to the clinical evaluation of pain would benefit from the inclusion of measures of movement-evoked pain.

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Key words: Whiplash, pain, evoked pain, movement, fear, disability.

Whiplash injuries result from head and neck exposure to abrupt changes in velocity, most commonly caused by motor vehicle accidents.3,4 Whiplash accounts for approximately 80% of the soft tissue injuries incurred in motor vehicle accidents.11 The recovery trajectory following whiplash injury can be quite prolonged, with as many as 50% of individuals reporting symptoms of neck pain 1 year after injury.11,19 Approximately 15 to 25% of individuals who sustain whiplash injuries will remain permanently disabled.7,17,34,39

Pain severity has been identified as a significant determinant of whiplash-related disability.19 Although findings have been mixed, several studies have reported that more severe pain following injury is associated with more severe disability.5,10,19,20,33 However, the relation between pain severity and disability has been weaker than expected. Even in studies where pain severity has emerged as a significant predictor of disability, the variance in disability accounted for by pain severity has been modest, rarely exceeding 10%.26

Studies that have examined the relation between pain severity and disability in individuals with whiplash injuries have relied almost exclusively on measures of spontaneous pain.26 On measures of spontaneous pain, respondents are asked to rate the severity of the pain...
associated with their pain condition. Such measures are typically completed while the respondent is in a sedentary position. Because disability entails limitations of activity participation, measuring pain in the absence of activity demands may not provide the best index of disability-relevant pain. Measures of pain elicited by activity might have greater value as predictors of disability than measures of spontaneous pain.

In the present study, we examined whether measures of movement-evoked pain might account for unique variance in measures of disability beyond the variance accounted for by measures of spontaneous pain. Two measures of movement-evoked pain were used. We used a single-point measure of movement-evoked pain in which patients were asked to rate their pain as they lifted a 2.9-kg weighted canister. We also used a measure of repetition-induced summation of activity-related pain (RISP), in which we computed the change in pain ratings as patients lifted a series of 18 weighted canisters.

In spite of a wide range of treatment approaches that have been used to date, whiplash injuries continue to contribute to alarmingly high rates of persistent pain and disability. Studying the dimensions of pain experience that contribute to disability has both clinical and theoretical implications. From a clinical perspective, findings showing that measures of movement-evoked pain contribute unique variance to whiplash-related disability might lead to the development of more comprehensive clinical assessments of pain associated with whiplash injury. In turn, increased knowledge of the determinants of disability in individuals with whiplash injuries might point to new avenues of intervention. From a theoretical perspective, findings concerning the differential association between different measures of pain and measures of disability might bring greater precision to conceptual models addressing the role of pain in motor function in individuals who have sustained whiplash injuries.

In the present study, individuals with whiplash injuries participated in a testing session during which measures of spontaneous pain, single point movement-evoked pain, and RISP were collected. Participants also completed subjective and objective measures of disability. Regression analyses were used to assess the shared and unique variance in measures of disability accounted for by the 3 measures of pain. Secondary analyses addressed whether fear of movement mediated or moderated the relation between measures of pain and disability.

Methods

Participants

The study sample consisted of 142 participants (68 women, 74 men) who had sustained whiplash injuries in rear-collision motor vehicle accidents. Potential participants were recruited through advertisements posted in rehabilitation clinics and newspapers in Montreal, Quebec. Individuals were considered for participation if 1) they had sustained a whiplash injury in a rear-collision accident within the previous 24 months, 2) they had received salary indemnity from a motor vehicle insurer for whiplash-related limitations, and 3) there were no medical contraindications to participation in the lifting tasks used in the study. The mean age of the sample was 40.4 years with a range of 20 to 60 years. The mean time since injury was 8.4 months with a range of 1 to 24 months. The majority of the sample were married or living common-law (93%), had completed high school (95%), and were work-disabled (74%). Participants provided informed consent.

Measures

Spontaneous Pain

The McGill Pain Questionnaire (MPQ) was used as the measure of spontaneous pain associated with participants’ whiplash injury. On this measure, participants are asked to endorse the adjectives that best describe their pain experience. The MPQ Pain-Rating Index (PRI) was computed as the weighted sum of all adjectives endorsed. The MPQ-PRI has been demonstrated to be a reliable and valid measure of chronic pain experience.

Single-Point Movement-Evoked Pain

Participants were asked to rate their pain on an 11-point (0–10) numerical rating scale as they lifted a 2.9-kg canister. This measure represents the pain evoked by a physical task performed at one point in time.

RISP

The RISP score was derived by subtracting the mean pain ratings provided for the first 3 lifts from the mean pain ratings provided for the last 3 lifts in the series of 18 canisters. Higher values reflect greater increase in pain across successive lifts.

Lift Tolerance

Following completion of the canister-lifting task used to derive the index of RISP, participants were asked to lift a 3.9-kg canister with arm fully extended and hold for as long as possible. Lift tolerance was used as an index of functional disability. Previous research has shown that lift tolerance is significantly associated with measures of self-reported disability. Lift tolerance is often included as part of functional evaluation assessments.

Self-Reported Disability

The Pain Disability Index (PDI) was used as a self-report measure of pain-related disability. On this measure, participants rate their level of disability in 7 different domains of daily living (home, social, recreational, occupational, sexual, self-care, and life support). For each life domain, participants are asked to provide disability ratings on 11-point scales with the endpoints 0 (no disability) and 10 (total disability). Responses were summed to yield an overall index of self-reported functional disability. The PDI has demonstrated good internal consistency and correlates significantly with objective measures of disability.
Fear of Movement/Reinjury

The Tampa Scale for Kinesiophobia was used to assess participants’ fear of movement and reinjury associated with their experience of pain. On this measure, respondents rate their level of agreement with each of 17 statements reflecting worries or concerns about the consequences of participating in physical activity. The Tampa Scale for Kinesiophobia has shown good internal consistency (coefficient alpha = .77) and has been shown to be significantly correlated with measures of disability.

Procedure and Apparatus

Ethical approval for this study was received from the institutional review board of the Centre for Interdisciplinary Research in Rehabilitation of Greater Montreal. Only individuals who had received salary indemnity from the state motor vehicle insurer at some point following their injury were considered for participation. This selection criterion was used to ascertain diagnosis (only individuals whose diagnosis and disability have been verified by medical evaluation are eligible to receive salary indemnity) and to maximize sample homogeneity with respect to mechanism of injury. Participants were told that the study objective was to develop a new assessment procedure for persistent pain.

Participants were asked to complete the MPQ, Tampa Scale for Kinesiophobia, and PDI immediately before completing the canister-lifting task. The canister-lifting task was the same as that described in previous studies examining determinants of RISP. Participants were asked to stand in front of a height-adjustable table and were asked to lift and replace 18 canisters (4-L-size paint canisters) that were partially filled with sand. The canisters were arranged on the table in 3 rows of 6 columns (Fig 1). The canister weights were 2.9, 3.4, or 3.9 kg and were positioned such that each weight was represented twice in each location of a double Latin square. All of the canisters were identical so that participants would not be able to visually discern the variation in weights. The counterbalancing of the 3 different weights in 3 different locations diminished participants’ ability to anticipate the weight of each of the subsequent canisters. Counterbalancing was necessary to minimize possible expectancy effects on pain ratings. Participants proceeded through the task at their own pace.

The height of the table was adjusted so that the handle of the canisters in the front row (ie, closest to the participant) was at standing elbow height. The top of each canister was labeled with the letters A to R, and participants were instructed to lift each canister in alphabetical order (column 1 [A–C], column 2 [D–F], etc) until all of the lifts of the 18 canisters were completed. For every lift, participants were instructed to vertically lift the canister off the table to a height of approximately 5 cm and hold for approximately 3 seconds. Participants provided a pain rating after lifting each of the 18 canisters.

As shown in Fig 2, participants assumed 3 functional anthropometric postural positions while lifting the canisters: 1) For the normal reach position (ie, the row closest to the participant), the participant stood erect with his or her elbow bent at 90° (Position 1); 2) for the maximum reach position (ie, the second closest row), the participant stood erect with his or her arm fully extended (Position 2); and 3) for the extreme reach condition (ie, the furthest row), the participant was forward flexed with his or her arm fully extended (Position 3). In a prior study, it was estimated that the mean net moment (ie, force × distance corresponding to the weight and body segments) was approximately equivalent across columns, varying from 17.3 to 17.9 Nm at the shoulder and from 34.0 to 35.0 Nm at the back (L4–L5 joint). The corresponding mean percentage of strength varies from 40.3 to 41.5% at the shoulder and from 20.2 to 20.7% at the back.

Participants could provide their weight estimates in imperial or metric units. Weight estimates were all converted to metric units. The duration of each canister lift was recorded as well as the duration of rest periods.
between lifts. Mean pain ratings within “Column” were computed. An index of RISP was derived by subtracting mean pain ratings provided while lifting canisters in Column 1 from mean pain ratings provided while lifting canisters in Column 6. Higher values on this index reflect greater increase in pain across successive lifts.

The canister-lifting task was intended as a procedure to elicit movement-evoked pain. In this task, postural position and canister weight are manipulated to vary the physical demands of the task. To verify that the canister-lifting task was successful in eliciting movement-evoked pain, pain ratings for all canister lifts were subjected to a 3 (postural position) × 3 (canister weight) repeated measures analysis of variance. The analysis of variance revealed significant main effects for Position, $F(2, 282) = 211.9$, and Weight, $F(2, 282) = 161.8$, $P < .001$. Pain ratings increased monotonically as a function of postural position and canister weight. A significant interaction was also obtained such that, for the heaviest weight (3.9 kg), pain ratings for Positions 2 and 3 did not differ significantly, $t(148) = 4.395$, $P = .002$; and single-point movement-evoked pain, $t(140) = -2.427$, $P = .015$; and higher pain (score/10)

### Data-Analytic Approach

Means and standard deviations were computed for demographic and dependent measures. Separate t-tests for independent samples were used to examine sex differences on demographic and dependent measures. Hierarchical regression analyses were conducted to examine the contribution of the different pain measures (i.e., spontaneous pain, single-point movement-evoked pain, RISP) to the prediction of disability (i.e., self-reported disability, lift tolerance). Diagnostic tests indicated that data did not violate assumptions for planned statistical analyses. Variance inflation factors for variables included in the regression analyses ranged from 1.0 to 1.5, suggesting that the regression results were not adversely affected by multicollinearity.

Power analysis was conducted for a regression analysis predicting self-reported disability. On the basis of previous research, it was estimated that the effect sizes for covariates (3) and pain indices (3) would be modest and moderate, respectively. The effect sizes were selected as the smallest effect that would be important to detect, such that any smaller effect would not be of clinical or substantive significance. With a sample size of 142 and alpha set at .01, the analysis had a power greater than .80. Power analyses were computed with Power and Precision software.

### Results

#### Sample Characteristics

Table 1 presents the means and standard deviations on demographic and dependent variables for men and women. Mean scores on measures of spontaneous pain, fear of movement/reinjury, and self-reported disability were comparable to those reported in prior studies investigating the pain and disability associated with whiplash injuries. In addition, t-tests for independent samples revealed no significant sex differences for age, duration of pain, or education. Women obtained lower scores on the measure of lift tolerance, $t(140) = -2.427$, $P = .015$; and higher scores on the measures of pain-related disability, $t(140) = 3.221$, $P = .002$; spontaneous pain, $t(148) = 4.395$, $P = .000$; and single-point movement-evoked pain, $t(140) = 3.068$, $P = .003$. There were no significant differences between men and women on measures of fear of movement/reinjury or RISP.

### Correlations Between Measures of Pain, Disability, and Demographic Variables

Correlations between measures of pain, disability, and demographic variables are presented in Table 2. All 3 pain measures (spontaneous pain, single-point movement-evoked pain, and RISP) were found to be significantly correlated with lift tolerance and self-reported disability. Only the measures of spontaneous pain and the single-point movement-evoked pain were found to be significantly correlated with fear of movement. Finally, analyses revealed a significant positive correlation between the measure of RISP and pain duration.

### Prediction of Self-Reported Disability and Lift Tolerance

Hierarchical regression analyses were conducted to examine the degree to which measures of spontaneous pain, single-point movement-evoked pain, and RISP accounted for unique or shared variance in the prediction of self-reported disability (PDI) and lift tolerance. Two regressions were conducted using self-reported disability as the dependent variable, and 2 regressions were conducted using lift tolerance as the dependent variable. In the first regression, the question being addressed was whether the measures of single-point movement-evoked pain and RISP accounted for unique variance in the prediction of disability (PDI and lift tolerance), beyond the variance accounted for by a measure of spontaneous pain (ie, MPQ). In the second regression,
the role of fear of movement as a mediator or moderator of the associations between pain indices and disability was addressed.

The results of the hierarchical regression (Regression 1) examining the shared and unique variance contributed by the 3 pain indices to the prediction of self-reported disability are presented in Table 3. Age and sex were entered in the first step of the analysis and contributed significant variance (7%) to the prediction of self-reported disability. Pain duration was entered in the second step but was not a significant predictor of self-reported disability. Spontaneous pain severity (MPQ) was entered in the third step and contributed significant variance (12%) to the prediction of self-reported disability beyond the variance contributed by spontaneous and single-point movement-evoked pain.

In Regression 2 (Table 3), the mediating and moderating role of fear of movement was examined in the associations between the 3 pain indices and self-reported disability. To test mediation, fear of movement was entered in the third step of the analysis, before entering the 3 pain indices. To test the moderating role of fear, 3 interaction terms were computed by multiplying centered values for the 3 pain indices by fear of movement. The 3 interaction terms were included in the final step of the analysis. The results of Regression 2 indicate that the inclusion of fear of movement in Step 3 of the analysis reduced the size of the standardized beta weights for spontaneous pain and single-point pain. The contribution of spontaneous pain remained significant, suggesting that fear of movement partially mediates the relation between spontaneous pain and self-reported disability. The inclusion of fear movement in Step 3 of the analysis had a negligible influence on the size of the standardized beta weight for RISP. The interaction terms included in the last step of the analysis did not add significantly to the prediction of self-reported disability.

The results of the hierarchical regression (Regression 1) examining the shared and unique variance contributed by the 3 pain indices to the prediction of lift tolerance are presented in Table 4. In Regression 1, Step 1 (age, sex), Step 2 (spontaneous pain), and Step 5 (RISP) contributed significant variance to the prediction of lift tolerance. The pattern of findings is similar to that of the regression predicting self-reported disability, but the total variance accounted for is more modest.

**Table 2. Correlations Between Measures of Pain, Disability, and Demographic Variables**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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<td>1 Age</td>
<td>--</td>
<td></td>
<td></td>
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<tr>
<td>2 Pain duration</td>
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<td>4 Lift tolerance</td>
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<td>-0.240**</td>
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<td>5 TSK</td>
<td>-0.028</td>
<td>-0.030</td>
<td>0.401**</td>
<td>-0.161*</td>
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<td></td>
<td></td>
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<tr>
<td>6 Spontaneous pain (MPQ)</td>
<td>0.125</td>
<td>0.91</td>
<td>0.399**</td>
<td>-0.251**</td>
<td>0.292**</td>
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<tr>
<td>7 Single-point pain</td>
<td>-0.020</td>
<td>-0.060</td>
<td>0.282**</td>
<td>-0.109</td>
<td>0.369**</td>
<td>0.352**</td>
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<tr>
<td>8 RISP</td>
<td>-1.122</td>
<td>0.192*</td>
<td>0.280**</td>
<td>-0.174**</td>
<td>0.088</td>
<td>0.054</td>
<td>-1.127</td>
</tr>
</tbody>
</table>

Abbreviation: TSK, Tampa scale of Kinesiophobia.

NOTE. N = 142. Significance tests are 2-tailed.

*P < .05.

**P < .01.

**Table 3. Hierarchical Regression Predicting Self-Reported Disability**

<table>
<thead>
<tr>
<th>Regression 1: Pain</th>
<th>Step 1</th>
<th>Step 2</th>
<th>Step 3</th>
<th>Step 4</th>
<th>Step 5</th>
<th>Step 6</th>
<th>Step 7</th>
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<tbody>
<tr>
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<td>-.150*</td>
<td>-.045</td>
<td>.282**</td>
<td>.178*</td>
<td>.095</td>
<td>.304**</td>
</tr>
<tr>
<td>R² Change</td>
<td>.075</td>
<td>.003</td>
<td>.136</td>
<td>0.204</td>
<td>.029</td>
<td>.002</td>
<td>.082</td>
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<tr>
<td>F Change</td>
<td>5.597</td>
<td>.136</td>
<td>0.204</td>
<td>2.650</td>
<td>.002</td>
<td>.000</td>
<td>15.914</td>
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<tr>
<td>P Value</td>
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<td>.712</td>
<td>.000</td>
<td>.106</td>
<td>.534</td>
<td>.000</td>
<td>.000</td>
</tr>
</tbody>
</table>

Regression 2: Pain and fear

<table>
<thead>
<tr>
<th>Regression 2: Pain and fear</th>
<th>Step 1</th>
<th>Step 2</th>
<th>Step 3</th>
<th>Step 4</th>
<th>Step 5</th>
<th>Step 6</th>
<th>Step 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta</td>
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<td>-.167*</td>
<td>-.044</td>
<td>.287**</td>
<td>.191*</td>
<td>.095</td>
<td>.257**</td>
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<tr>
<td>R² Change</td>
<td>.075</td>
<td>.001</td>
<td>.136</td>
<td>.063</td>
<td>.063</td>
<td>.002</td>
<td>.067</td>
</tr>
<tr>
<td>F Change</td>
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<td>11.726</td>
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<td>13.679</td>
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<tr>
<td>P Value</td>
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<td>.012</td>
<td>.000</td>
<td>.001</td>
<td>.534</td>
<td>.000</td>
<td>.265</td>
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</tbody>
</table>

NOTE. N = 142. All predictor variables are centered. Standardized beta weights are from the final regression equation.

*P < .05.

**P < .01.
In Regression 2 (Table 4), the mediating and moderating role of fear of movement was examined in the associations between the 3 pain indices and lift tolerance. In Regression 2, only Step 1 (age, sex) and Step 6 (RISP) contributed significantly to the prediction of lift tolerance. The contributions of fear of movement, spontaneous pain, and single-point movement-evoked pain were in the expected direction but failed to attain statistical significance. The inclusion of fear of movement in Step 3 of the analysis had a negligible influence on the size of the standardized beta weight for RISP. The interaction terms included in the last step of the analysis did not add significantly to the prediction of lift tolerance.

### Discussion

The primary objective of this research was to assess the degree to which measures of movement-evoked pain accounted for variance in measures of disability in patients with whiplash injuries. The results of this study are consistent with previous research showing that measures of spontaneous pain account for significant variance in disability. The results of the study extend previous research in showing that a measure of movement-related summation of pain (ie, RISP) contributes unique variance to the prediction of disability beyond the variance accounted for by measures of spontaneous pain and single-point movement-evoked pain.

As noted earlier, a number of previous studies have reported findings showing that measures of spontaneous pain are significant yet modest predictors of disability in patients with whiplash injuries. For example, Sullivan et al reported a correlation of .38 (10% of variance) between pain severity and self-rated disability in a sample of individuals with chronic whiplash symptoms. Similar findings were reported by Nieto et al in a sample of patients with whiplash injuries in the subacute stage of recovery. Buitenhuis et al reported that pain severity was a significant predictor of disability in patients with whiplash injuries, accounting for approximately 10% of the variance in occupational disability. The present study also revealed a modest relation between a measure of spontaneous pain and disability.

Zero-order correlations revealed that a measure of single-point movement-evoked pain accounted for 8% of the variance in self-reported disability but was not significantly correlated with lift tolerance. In zero-order correlations, RISP also accounted for 8% of the variance in self-reported disability and 3% of the variance in lift tolerance. In multiple regression analyses, single-point movement-evoked pain did not emerge as a significant predictor of disability. However, in multiple regression analyses, RISP contributed an additional 8% of the variance for a combined (all 3 measures of pain) total of 23% of variance in self-reported disability. In other words, the proportion of variance in self-reported disability accounted for by pain increased almost 2-fold when RISP was included in the regression equation. The same pattern of findings emerged in the prediction of lift tolerance, although the total percentage of variance accounted for was more modest.

The present study also examined whether fear of movement mediated or moderated the contribution of different pain indices to the prediction of disability. Vlaeyen and colleagues have suggested that fear elicited by pain-relevant stimuli can lead to activity avoidance and, in turn, contribute to heightened disability. Numerous investigations have supported the view that fear is associated with heightened disability in individuals who have sustained musculoskeletal injuries. The pattern of findings in the present study is consistent with previous research showing that fear of movement partially mediates the relation between measures of spontaneous pain and disability. However, fear of movement did not emerge as a significant mediator or moderator of the relation between RISP and disability.

It might be premature, however, to conclude that fear of movement does not play a role in the relation between RISP and disability. In the present study, the measure of fear of movement was administered before the canister-lifting task. It is possible that fear of movement...
might have changed as a function of the participant’s pain experience through the performance of the task and, in turn, might have influenced changes in pain intensity. To address this possibility, a measure of situation-specific fear of movement would have been required, which was not used in the present study.

In a previous study of patients with chronic low back pain, fear of movement was shown to be significantly correlated with RISP. In the present study, fear of movement was not significantly correlated with pain. Two differences between the 2 studies include differences in the type of pain condition (low back pain vs whiplash) and the level of chronicity (7.3 years vs 8.4 months). It is possible that as a result of a history of experiencing increasing pain following repeated physical activity, fear of movement may become more closely associated with dynamic changes in pain experience and may be more likely to influence the relation between RISP and disability.

The mechanisms underlying RISP remain largely unknown. In previous research, the term temporal summation (TS) of pain (ie, windup) has been used to describe progressive increases in pain severity as a function of repeated noxious stimulation. There are indications that TS occurs centrally in second-order neurons in the spinal cord as a consequence of sustained C-fiber afferent input. TS has been demonstrated primarily in response to thermal stimulation, electrical stimulation, or pressure, with standardized duration of stimulation and interstimulus intervals. Enhanced TS has been observed in chronic pain conditions in which the pathophysiology of the disorder is thought to involve a maladaptive degree of central sensitization to pain (eg, fibromyalgia, temporomandibular joint disorder).

At present, it is unclear whether the mechanisms of TS are the same as the mechanisms of RISP. Research on TS suggests that the temporal dimension of noxious stimulation is critical to pain summation effects. For example, TS of thermal pain has been demonstrated with standard stimulus intervals of approximately 3 seconds, and stimulus presentation of approximately 1 second. This frequency appears to mimic the natural frequency of C nociceptors, which discharge at about once every 2 to 3 seconds at high stimulus intensities. Significant divergences from this protocol appear to attenuate or abolish the TS effect.

Another important difference between the procedure used to induce RISP and paradigms used to induce TS is that the pain stimulus in RISP is the result of participant-initiated activity, whereas in TS paradigms the participant is the passive recipient of painful stimulation. It is unclear what implications this difference might have for underlying mechanisms of action. However, because self-initiated activity is a component of most activities of daily living, susceptibility to RISP might have implications for the manner in which individuals with whiplash injuries are able to participate in important activities of their lives.

The findings of the present study join a growing body of research suggesting that whiplash injury might give rise to multiple and partially independent dimensions of pain experience. For example, the present study showed that measures of spontaneous pain and RISP made independent contributions to the prediction of disability. Cold hyperalgesia has also been associated with increased disability in individuals who have sustained whiplash injuries. One study showed that lower pressure pain and thermal pain thresholds predicted prolonged disability in individuals with whiplash injuries. In future research, it will be of interest to determine the degree to which these different dimensions of pain experience make independent or shared contributions to the prediction of disability. Greater understanding of the interrelations among multiple dimensions of pain might also shed light on the pathophysiology of pain experience following whiplash injury.

At present, it is unclear whether different dimensions of pain experience respond differentially to pain-reducing interventions. However, given the diverse modes of action of different pain-reduction interventions, it is possible that any 1 pain-reduction treatment might have an impact on some but not necessarily all dimensions of pain experience associated with whiplash injury. For example, a recent study conducted in our laboratory showed that transcutaneous electrical nerve stimulation was effective in reducing RISP but not single-point movement-evoked pain. Further research on the degree to which different dimensions of whiplash-related pain experience respond to different pain-reducing interventions might make it possible to tailor pain treatment to individuals’ pain profile.

Caution must be exercised in the interpretation of the present findings. The data used for the analyses presented in this paper were from a sample of individuals who were participating in a rehabilitation program and volunteered for participation in a pain study. To the degree to which these selection biases might have played a role in the composition of the sample, the limits of generalizability must be considered. Another limitation is that the design of the study was cross-sectional, thereby limiting the confidence that can be afforded to speculation about the direction of causality among study variables. It is important to note that a number of pain-related psychological variables not assessed in the present study, such as pain catastrophizing, self-efficacy, or outcomes expectancies, might have played a mediating or moderating role in the relation between pain and disability. In addition, reassurance about the safety of the task, provided in the consent form, might have diminished possible relations with the measure of fear of movement. Finally, the absence of process measures compromises the ability to make confident statements about the specific pathways linking different pain indices to disability.

In spite of these limitations, the results of the present study suggest that spontaneous measures of pain and RISP make independent contributions to the prediction of self-reported disability. The inclusion of measures of movement-evoked pain led to a 2-fold increase in the variance contributions of pain to subjective and objective measures of functional disability. The findings suggest that approaches to the clinical evaluation of pain...
would benefit from the inclusion of measures of movement-evoked pain. Additional research is required to identify the underlying processes linking different dimensions of pain to whiplash-related disability. Future research will be needed to explore the potential for matching pain treatments to individual pain profiles.

References


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