Correlations between pain and function in a longitudinal low back pain cohort

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Abstract

Purpose. Most studies of low back pain (LBP) and functional limitation have been cross-sectional, and show only modest correlations between pain and function. Though functional limitation may be superior for predicting disability outcomes, there is a need to understand better the gap between pain and function. This study analysed changes in intra-individual correlations between pain and function over time.

Method. Seventeen men and 16 women currently experiencing LBP provided self-reports of LBP (0-to-10 scale) and functional status (Back Pain Functional Scale) for a maximum of 8 weeks. Spearman correlation coefficients between pain and function scores were calculated for each individual. The effects of pain history, pain intensity, variability and trends over time on pain–function correlations were assessed.

Results. There were no significant differences in correlation due to gender, age or pain intensity (low versus high). Participants with steeper slopes in change in pain score over the study period had significantly stronger correlations to function than those with weaker trends, r = 0.91 and r = 0.45, respectively. Participants with at least one pain-free score during the reporting period had significantly stronger correlations than those with no pain-free reports, r = 0.80 and r = 0.51, respectively. Participants having the first episode LBP had stronger correlations (r = 0.85) than those with persistent symptoms of LBP (r = −0.62).

Conclusions. The results suggest that over the course of LBP, within-person pain–function correlations are stronger than those reported in cross-sectional, population-based studies. Changes in pain ratings over time may have more clinical relevance than differences in pain levels between individuals. Among those with more long-standing pain, factors other than pain intensity, such as pain catastrophising or fear avoidant beliefs, may have a greater effect on day-to-day perceptions of functional limitation.

Keywords: BPFS, back pain functional scale, functional limitation, LBP, low back pain

Introduction

Low back pain (LBP) is a common malady experienced by as many as one-quarter of the adult population during the course of a year, and the vast majority will experience LBP at some point in their lives [1]. The disability related to LBP has a large economic impact on society as a whole, as the financial burden of the disease has been estimated to be as great as $50 billion annually in the USA [2]. In 1995, LBP was one of the most common reasons for Workers’ Compensation claims in the USA, with filings being recorded at a rate of 1.8 per 100 workers [3].

Many researchers have explored the relationship between self-reported LBP and functional limitation during work and other activities of daily living. This relationship has been a prominent issue in LBP research and one that has significant implications for rehabilitation practice. Physiological, psychological, socioeconomic and psychosocial factors can act and interact to affect the functional disability associated with back pain. Several behaviors and/or belief systems have been hypothesized to mediate the relationship between LBP and functional limitation, most notably including pain catastrophising, fear avoidant beliefs and poor expectations for recovery [4]. Pain catastrophising may lead to an exaggerated
interpretation of symptoms, fear avoidant beliefs might lead to unnecessary activity restriction and poor expectations for recovery may become a self-fulfilling prophecy. Presumably, those with a more long-standing history of pain or a longer duration of pain might show more evidence of these irrational or exaggerated beliefs about pain.

The correlation between pain and functional limitation is commonly investigated in the LBP literature, with the usual conclusion that the relationship between pain and dysfunction is poor, not well understood and mediated by a host of psychosocial factors. Some authors have cautioned against over-interpretation of self-reported pain ratings, as these ratings may bear little relationship to any physiological or pathological change [5]. Functional limitation is usually a superior measure to pain for predicting important disability outcomes such as return-to-work [6,7], supporting the need to focus rehabilitation efforts on improved physical and social functioning over pain relief.

However, researchers have highlighted a continuing need to understand the correlation (or lack of correlation) between pain and function, especially in relation to pain duration and lifetime pain experience. The disparity between patient report of pain and perceived disability has been cited as a reason to pursue more comprehensive pain assessment [5] and to employ more patient-centred approaches to care [8]. However, the majority of studies describing associations between pain and function have been cross-sectional studies conducted with chronic pain populations, and thus it is unclear whether these associations vary with time and pain experience [9]. A similar case has been made for the inconsistent correspondence between self-reported pain intensity and pain relief [5].

The disparity between self-reported pain and function as indicated in the literature might suggest that some caution is necessary in evaluating whether patients are actually showing signs of improvement. However, this conclusion more likely conflicts with clinicians’ perception of fairly parallel improvements in the pain and function of their patients during the course of treatment and recovery. The important distinction, of course, is not between patient populations, but in the interpretation of cross-sectional versus longitudinal data.

This basic distinction has not been clarified in the literature, and there are few LBP studies that have involved more than two or three repeated assessments of pain and function within a single episode of LBP. Analysing intra-individual correlations across longitudinal assessments may be one strategy for understanding the possible disconnect between pain and function, and may have important implications for setting treatment goals or for evaluating the efficacy of interventions.

The goal of this study was to compute within-person correlations between pain and function in a small experimental LBP cohort collected over an 8-week study period, and to test whether this association varied systematically by demographic characteristics or by pain history. The correlation of pain scores collected using a numerical rating scale and functional limitation measured with the Back Pain Functional Scale (BPFS) [10] were analysed for the effect of factors including pain intensity, pain-free periods and change (improvement or worsening) of pain perception. The effect of age and gender on the relationship of LBP and function were also explored.

Methods

Participants

Thirty-three individuals experiencing a current episode of LBP were recruited by postings at the research institute and at the offices of local clinicians (physical therapists, chiropractors and physicians) and by newspaper advertisement to participate in a maximum 8-week clinical study. The criteria for inclusion in the study were that potential participants should be between 18 and 65 years of age and presently experiencing LBP. Participants were included if it was the first experience with LBP, or if they were experiencing a recurrence. The nature of the study was explained to all who responded to the recruitment literature, and those expressing continued interest completed a medical history form and were interviewed by a healthcare provider. Exclusion criteria were as follows: no major structural abnormalities, no significant neurological deficits or evidence of severe nerve root compression and no active systemic, inflammatory, musculoskeletal or neoplastic disease or history of previous back surgery. Individuals were also excluded if they had an active worker’s compensation claim or related litigation pending. All participants gave written informed consent for participation in the study approved by the institutional review board of the Liberty Mutual Research Institute for Safety. One participant dropped out and was lost to follow-up after one visit. The 33 participants, 17 men and 16 women, who completed the study ranged in age from 19 to 64 years, and had a mean (standard deviation) age of 40.5 years (12.8 years), height of 169 cm (10.4 cm) and weight of 75.0 kg (13.3 kg).

Measures

Pain Score. A numerical pain rating scale (NRS) was used to quantify the intensity of back pain.
Participants rated their pain using a 0-to-10 scale, where 0 was ‘no pain’ and 10 was ‘the worst pain imaginable’, a scale validated for clinical application [11,12]. At the beginning of each session participants rated the pain intensity they were feeling ‘right now’.

**Functional level.** Immediately after providing the pain score, participants reported on their current perceived level of function in daily activities by completing the BPFS. This questionnaire requires the rating of functional impairment for 12 activities on a scale with six levels ranging from ‘unable to perform activity’ (0) to ‘perform with no difficulty’ (5). Summing the scores for the 12 activities provides an overall rating of function between 0 and 60.

**Experimental protocol**

Participants were seen either at the research institute or at outpatient clinics (physical therapy or chiropractic). Eight visits were scheduled over an 8-week period according to the following scheme. Visits were scheduled twice a week for the first 2 weeks, once a week for the third and fourth weeks and once each in the sixth and eighth weeks. A stopping criterion was used for participants whose pain resolved during the course of the experimental protocol. When participants reported no symptoms (0 on the NRS) at two consecutive sessions, participation was discontinued. When the experimental session was scheduled to coincide with a treatment session at a clinic, the ratings were made prior to treatment, to minimise confounding by the effect of the treatment.

**Data analysis**

The primary goal of the study was to describe the relationship between self-reported back pain and function over the course of a back pain episode. For each participant, Spearman correlation analyses were performed between BPFS-pain score pairs for all visits, and the coefficient was referred to as $Corr_{PF}$.

Additional analyses required the measure of a participant’s change in status with respect to back pain. The trend in pain level over the course of the study period, or ‘pain slope’ (PSlope) was determined by linear regression of pain score to time (in days since initial visit). PSlope was negative if symptoms were improving over time, and a positive value if the trend in LBP was increasing. The absolute values of PSlope were used to group participants, in order to examine the effects of trends in pain scores, irrespective of whether they represent progression or regression in symptoms.

One-way ANOVA was performed to test the effects of gender and age group (younger or older than 40 years of age) on $Corr_{PF}$. Independent samples’ $t$-tests were used to compare the correlations between groups dichotomously separated by the following: overall pain intensity, whether any ‘0’ pain scores were reported, history of pain behaviour and trending in pain scores (PSlope). The cut-points for the groupings in the pain intensity and PSlope analyses were determined post hoc by median split. The groupings for the history of pain behaviour analysis was based on a criterion described by VonKorff [13], the details of which are included in the results. The threshold for significance in statistical tests was set at $p < 0.05$.

**Results**

Of the 33 participants who had substantially completed the experimental protocol, 24 were receiving treatment at regular visits with a chiropractor or physical therapist at the time of induction into, and during the study. Twenty-six participants completed the entire eight-visit, 8-week protocol, two of whom achieved pain resolution (two consecutive ‘0’ pain reports) on the final visit. Five participants achieved resolution prior to the eighth visit, two at the third visit and one each at the forth, fifth and seventh visits. One participant was not able to attend the eighth and final visit of the protocol.

Overall, both mean pain score and function ratings improved over the course of the study period. As a group, there was an approximately 47% reduction in mean pain score from 3.0 to 1.6, and an approximately 31% improvement in BPFS scores, from 43.9 to 57.4. Population characteristics for pain score, duration of LBP, classification and functional scores are presented in Table I.

<table>
<thead>
<tr>
<th>Episodes</th>
<th>N</th>
<th>Pain Score (Overall)</th>
<th>Initial visit</th>
<th>Final visit</th>
<th>Back Pain Functional Scale (Overall)</th>
<th>Initial visit</th>
<th>Final visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>First episode</td>
<td>11</td>
<td>2.3 (1.2)</td>
<td>3.0 (1.6)</td>
<td>1.6 (1.5)</td>
<td>48.3 (9.0)</td>
<td>43.9 (8.0)</td>
<td>57.4 (7.3)</td>
</tr>
<tr>
<td>Previous episodes reported</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration of LBP* (years)</td>
<td>7.3 (7.5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Duration of symptoms for participants with a previous history of LBP.
The correlation of NRS pain score to BPFS score, \( \text{CorrPF} \), varied greatly among the study participants. The group mean (standard) Spearman correlation coefficients were \(-0.67 (0.33)\), with an inter-quartile range of \(-0.49\) to \(-0.93\). Correlations ranged from perfect negative correlation, \( r = -1 \), for several participants who experienced rapid resolution of their LBP, to near non-correlation \( (r = 0.01) \). One participant had a positive CorrPF \( (r = 0.15) \), indicating increasing function with increasing pain score. The variability between individuals in the perception of pain and functional limitation and the relationship between the factors is further illustrated in the time-series for three participants presented in Figure 1. These data was selected to demonstrate not only differences in pain–function correlation, but also differences in magnitude of functional limitation relative to perceived pain. The BPFS scores (right axes) have been inverted so that the relationship between the series can be more clearly observed.

When participants were grouped by the demographic factors of gender and age, the following results were observed. When grouped by gender, men \( (n = 16) \) had a mean (SD) pain score of 2.29 (1.30) and a BPFS of 49.2 (5.8), and women \( (n = 17) \) had means of 2.33 (1.11) and 47.6 (7.8), respectively. Mean CorrPF was \(-0.68 (0.33)\) for males and \(-0.66 (0.34)\) for females. When grouped by age, the 17 older participants (40 years of age or greater), had a mean pain score of 2.21 (1.19) and a BPFS of 48.2 (6.4), while the 16 participants had mean scores of 2.41 (1.23) and 48.6 (7.5), respectively. The mean CorrPF was \(-0.70 (0.27)\) for the older group versus \(-0.65 (0.39)\) for the 16 younger participants. One-way ANOVA showed no significant differences between CorrPF for either factor.

To test the effect of overall pain intensity on the strength of relationship between pain and function limitation, participants grouped by median split into a ‘low pain’ group \( (n = 16, \text{mean pain score} \leq 1.75) \) and ‘high pain’ group \( (n = 17, \text{mean pain score} > 1.85) \). The low- and high pain groups had CorrPF of \(-0.73 (0.32)\) and \(-0.62 (0.34)\), respectively. A \( t \)-test of CorrPF for each group showed no significant differences, \( p = 0.355 \), for participants in the low- or high pain groups.

The criteria described by Von Korff were used to classify participants based on their ‘pain history’ according to the following schema. Participants reporting greater than 50% of days with pain over the prior 6-month period were classified as Chronic. Those with less than half the days in pain for the past 6 months, but reporting a prior history of LBP were classified as Recurrent. Participants reporting a first episode of LBP, and having less than half of pain days over that same period, were classified as Transient. The grand means (group mean of individual participant’s mean calculated across the study period) for pain scores, function rating and the pain–function correlation, CorrPF, for the three groups are presented in Table II.

The resolution of pain symptoms, and restoration of function among the three groups was evaluated by comparing self-reports at the beginning and end of the study period. Pain ratings on the final study visit were considered indicative of ‘resolution’ of symptoms if the score of 0 or 1 was provided, and scores of 2 or greater suggested the episode was ‘unresolved’. Based on this scheme, at the end of the reporting period, the Transient group had 6 resolved and
2 unresolved cases, the Chronic group had 3 resolved and 4 unresolved cases and the Recurrent group had 12 resolved and 6 unresolved cases. A similar approach to evaluate functional restoration, a BPFS rating of 55 or greater was considered to indicate ‘normal’ function, and ratings of 54 or less were considered indicative of some degree of residual functional impairment. Based on these criteria, at the end of the study, 6 of 8 in the Transient group, 2 of 7 in the Chronic group, and 9 of 18 in the Recurrent group were functioning normally.

To test the effect of pain history, or longevity of pain symptoms, the classification scheme described above was used to assign participants into two groups. One group, referred to as the ‘first episode’ group was composed of the eight participants classified as Transient, by the Von Korff criteria. The other group, referred to as having ‘persistent’ symptoms was composed of the 25 participants assigned to the Chronic and Recurrent groups. A t-test of the correlations of the group experiencing a first episode, and the group experiencing persistent symptoms showed a statistically significant difference, \( p = 0.029 \), between groups, with a \( \text{CorrPF} = 0.85 \) (0.20) and \( 0.62 \) (0.34), respectively.

To explore how a participant’s unique pain experience over time influenced perceived functionality, the data were grouped based on the reporting of pain-free periods over the course of the study, as the literature suggests an association with disability [14]. Participants with a minimum of one ‘0’ pain score during the reporting period were assigned to Pain-free days group (\( n = 19 \)), and remaining cohort (\( n = 14 \)) who reported no ‘0’ pain scores were assigned to the No pain-free days group. The Pain-free day group had significantly greater \( \text{CorrPF} \) values, \( -0.80 \) (0.22), than those with no ‘0’ pain reports, \( -0.51 \) (0.37), with \( p = 0.017 \).

The variable PSlope allows the exploration of how individual trends in LBP might influence function in daily living. Figure 2 illustrates the trends plotted as a function of time for three participants, demonstrating: (a) an improving trend (negative slope), (b) a trend towards persistent pain (a flat slope) and (c) a trend towards increasing pain (positive slope).

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Table II. Pain scores, function ratings and CorrPF coefficients for participants grouped by pain classification.

<table>
<thead>
<tr>
<th>Classification*</th>
<th>Number of participants</th>
<th>Mean (SD) pain score</th>
<th>Mean (SD) BPFS score</th>
<th>CorrPF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transient</td>
<td>8</td>
<td>2.4 (1.4)</td>
<td>49.6 (6.2)</td>
<td>-0.83 (0.18)</td>
</tr>
<tr>
<td>Chronic</td>
<td>7</td>
<td>2.2 (1.2)</td>
<td>46.4 (6.3)</td>
<td>-0.60 (0.37)</td>
</tr>
<tr>
<td>Recurrent</td>
<td>18</td>
<td>2.3 (1.2)</td>
<td>48.7 (7.4)</td>
<td>-0.63 (0.36)</td>
</tr>
</tbody>
</table>

*Classification based on criteria of VonKorff (1994).
A scatterplot of CorrPF versus PSlope showed that the relationship between the variables was non-linear. Exponential, quadratic and logarithmic regression models were evaluated for best fit to the data. The logarithmic model provided the best with an $r^2 = 0.64$. The scatterplot with regression line is included in Figure 3.

**Discussion**

The study provided an opportunity to examine the natural history and progression of non-specific LBP in a population of generally high functioning, non-compensated individuals. The results indicated an overall trend towards improvement in both pain intensity and function during the study. Of the 33 participants, eight reported complete resolution of pain (defined as two consecutive pain-free visits) by the end of the 8-week study period. The trend in function ratings showed similar improvements over the course of the study. The mean BPFS score of 43.9 at induction into the study corresponds to a perceived overall functional limitation between ‘moderate’ to ‘little’ difficulty with daily activities. In contrast, the mean score of 57.4 reported at the end of participation indicates near normal function. Overall, the participants showed a pattern of recovery consistent with the literature with respect to the natural progression of uncomplicated, non-specific LBP in a population of high-functioning individuals [15].

The analysis of the effect of the demographic factors provided unanticipated results. Gender showed no significant effect on pain–function correlation. Some studies have found gender differences with respect to functional limitations due to LBP, but generally these studies have been cross-sectional in nature [16,17], thus making comparison difficult. When grouping participants by age (breakpoint at 40 years of age), the older group had slightly greater CorrPF values but the differences were not significantly different. Likewise, dichotomising the study population by pain intensity into high- and low pain groups also had no significant effect suggesting that the magnitude of pain ratings alone does not assure greater correspondence between the pain perceived and the functional impairment reported.

While the analyses of group demographics and overall pain intensity showed little effect on the strength of correlation, a different outcome was observed when characteristics of the individual’s pain profile were considered. Individuals who had pain-free periods during the study duration, and those who reported a greater range in the LBP reported over time were more likely to have stronger correlations between pain and function scores. Likewise, participants who reported a recent first experience with back pain seemed better capable of judging how changes in pain state affected their daily function. In general, when considering individuals with transient pain, on the order of two-thirds of the variance between perceived functional limitations can be explained by the concurrent pain report. The fact that those with a history of long-standing recurrence or more persistent symptoms showed significantly poorer correlations suggest that their perceptions might be influenced by other behaviours. Among these behaviours might be tendencies to catastrophise the disease process, or reluctance to undertake normal activities due to fear of pain exacerbation.

An examination of the time-series data presented in Figure 1 provides further evidence of individual variation in the relation of functional impairment to pain perception. The participant data in Figure 1a demonstrates a clear concordance between the pain and function ratings over time, and this is reflected in the high correlation coefficient. In contrast, the series in Figure 1b,c lack such harmony, as changes in function are not accompanied by concurrent changes in pain report of comparable magnitudes. In addition to the poor correlation between the variables, these two latter graphs illustrate the individual nature of the effect of the pain experience on function. In Figure 1b, a participant with a relatively persistent and high level of pain reports relatively little interference with daily activity, whereas the series in Figure 1c suggests marked impairment in function despite concurrent low levels of pain and periods of complete resolution. The disparities between functional limitation and LBP in the latter two time-series suggest that other factors such as apprehension or...
avoidance behaviours might be modulating perceptions or responses.

The individual nature of the LBP experience was also demonstrated in the analysis of CorrPF pain trends with the PSlope variable. When trends in pain were most pronounced, whether increasing or decreasing, the relationship between pain and functional limitation was greater than for those individuals who experienced relatively less change in pain intensity over the course of the reporting period. While stronger trends produced stronger correlations to function, the response was not linear. As seen in Figure 3, a logarithmic model provided a best fit of the relationship. This was exemplified by a very strong correlation or congruence for those whose pain reports were initially high but resolved rapidly. In contrast, for those individuals whose pain persisted over the reporting period with little variability, we observed greater decoupling between reports of pain and functionality. These results could lead to speculation that persistent pain, even at low levels may lead to distortions in the perception of one’s functional capacity, perhaps related to apprehension or other psychological overlay. However, such speculation must be tempered by the fact that there were few PSlope data points in the $-0.1$ to the $-0.2$ range that may have strengthened the evidence of the non-linear trend.

One important strength of the study is the longitudinal nature of the data. Most previous works in this area have involved cross-sectional studies, and the results have invariably shown poor correlation between LBP and perception of functional limitation, suggesting a disconnect between the two measures. In this study, by virtue of repeated measures collected over time during an episode of LBP, we had the opportunity to explore not only how factors such as age and gender affect these perceptions, but more importantly, how the strength of the relationship is shaped by variability and change or trend in pain experience of the individual. These strengths must be considered in light of the shortcomings of the study. The most notable weakness was the relatively high function, and low pain intensity reported by the study population. However, though the participants of this study may not be representative of patients filling the waiting rooms of spine surgeons or pain clinics, they are likely representative of the ‘walking wounded’, the substantial proportion of the adult population with LBP who are coping with functional deficits at work and home.

The findings suggest that the relationship between self-report of pain and function is not static, but rather seems to be modulated by factors related to individual pain history and the variability over time. Several of the analyses clearly demonstrated the individual nature of the pain–function relationship, which was further illustrated in the examination of time-series presented in Figure 1. The results also give credence to the observation that when investigating pain and functional limitation, examining such data in longitudinal fashion will likely yield a clearer picture of the relationship than with cross-sectional data often reported in the literature. The results of this study do not represent a metric for estimating function ratings from pain levels, or visa versa; however, the study does provide the researcher or healthcare provider with a glimpse of the subtleties of the interaction of pain and function in this population.

Clinical implications

Clinicians who see patients with LBP in repeated sessions (e.g. physical therapists, chiropractors) often use self-report measures of pain and functional limitation to gauge clinical improvement, but there is no available research to judge whether these two measures should be expected to move in parallel, or whether discordant changes in pain and function might have special relevance. Results of this study suggest that correlations between repeated measures of pain and dysfunction over the course of recovery for a single patient are considerably higher (interquartile range $= -0.49$ to $-0.93$) when compared to the correlations drawn from single, cross-sectional measurement of pain and function across groups of patients. Thus, longitudinal assessments of pain and functional limitation should be expected to improve in a parallel fashion for most patients, and there are no apparent differences in this longitudinal association by age or gender. A second finding with potential clinical relevance is that patients with a more chronic history of pain reported more discordant fluctuations in pain and function over time; thus, factors other than pain may modulate perceived functional impairment. One possible conclusion is that pain beliefs and other psychosocial factors, or ‘yellow flags’ [14], may play a more significant role in perceptions of disability and impairment once a pain problem has lingered for some time, with less relation to actual fluctuations in pain intensity. For repeated assessments of a single patient then, poor concordance between changes in pain and function may be a negative prognostic indicator or at least a sign that a more expanded assessment may be needed to identify personal circumstances representing barriers to recovery. However, more longitudinal research is needed (with larger patient samples) to determine whether discordant changes in pain and function might provide a useful indication for clinical decision-making or for discriminating useful patient sub-groups.
Summary

In repeated assessments of a small sample of volunteer patients with LBP, correlations between longitudinal fluctuations in self-reported pain and functional limitation were studied. Results showed a wide variation in within-person correlations, but the group mean correlation, $0.67 (0.33)$ suggested parallel fluctuations in pain and functional limitation for most patients over time. Discordant alterations in pain and function were associated with pain chronicity, and this may indicate the presence of psychosocial factors influencing perceptions of functional impairment. Larger-scale studies including more detailed assessments are needed to interpret the clinical meaning of discordant changes in pain and function.

References