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Introduction

Fear-related anticipation of pain can cause altered muscular activation and guarded movements[1,2] and is associated with hyper-vigilance to cues that indicate pain, or the corollaries of pain. The ability to shift attention away from pain-related stimuli is also impaired.[3] Psychological and biomechanical mechanisms that underlie movement-related pain responses are often considered in isolation, but conscious aspects of movement may influence the manner in which they combine to contribute to musculoskeletal pain responses.[4]

The theory of reinvestment proposes that individual differences in the propensity that people have for conscious involvement in their movements plays a role in the way they respond to various factors known to influence movement control.[4,5] The Movement Specific Reinvestment Scale, a reliable scale with construct validity, was developed specifically to measure the propensity for conscious involvement in movement.[6] The scale consists of two five-item subscales. The Conscious Motor Processing subscale reflects a person's tendency to consciously control their movements whereas the Movement Self-Consciousness subscale reflects a person's concerns about their style of movement and about making a good impression when they move. Responses to the Movement Specific Reinvestment Scale are recorded using a Likert-type scale with each item ranging from one (strongly disagree) to six (strongly agree).

Normative values in younger general populations have not been reported previously, but higher scores on the Movement Specific Reinvestment Scale have been shown to be associated with greater movement disruption under psychological pressure in sports

performers,[6] higher fall incidence in elderly people,[7] and more severe functional impairment following stroke.[8] It has been concluded from these studies that people with a high propensity for movement specific reinvestment are more likely to consciously monitor and control their movements, which can disrupt more effective automatic-control processes.[5]

To date efforts to understand the causes of knee pain, especially patellofemoral pain, mostly focus on the biomechanical factors that contribute to the pain rather than psychological factors or the interaction between biomechanical and psychological factors. In this regard, it is surprising that the role of movement specific reinvestment in musculoskeletal knee pain has not been investigated previously given that conscious attention is mobilized by factors such as fear or anxiety[5] and that people may attempt to modify the mechanics of their movement in order to adapt to pain or anticipated pain.[4] Investigation of the role of movement specific reinvestment in knee pain is therefore potentially useful considering the importance of the knee in human locomotion.   This study explored the relationship between Movement Specific Reinvestment Scale scores and self-reported knee pain in a group of young and middle-aged adults. A higher general propensity for movement specific reinvestment was expected to be associated with a greater likelihood of self-reported knee pain, either because the tendency to be consciously involved in movement causes knee problems that lead to pain or because knee pain causes a person to become more consciously engaged in their movements.

Methods

This exploratory study used questionnaire data initially collected to describe movement specific reinvestment and the prevalence of knee pain in young and middle-aged adults. The participants were a convenience sample of adults aged 18 to 55 attending a three day university science fair in 2012; participants included staff, students and the general public. Those unable to complete the questionnaire were excluded. Participants, who consented to be involved, self-completed the Movement Specific Reinvestment Scale as well as questions about knee pain and clinical characteristics of self-reported knee pain (presence of swelling, duration of pain, laterality, sudden or gradual onset).[9] The question about knee pain 'have you had pain or problems in the last year in or around the knee?' was modified from the knee pain screening tool, validated for use in large scale population-based studies.[10] Body mass index, estimated from directly measured weight and height, was categorised as not overweight (body mass index <25) and overweight (body mass index, 25 and over). University ethical committee approval was obtained.

This data has been used to explore the association between the Movement Specific Reinvestment Scale subscale scores (Conscious Motor Processing and Movement Self-consciousness) and self-reported presence of musculoskeletal knee pain. Differences in mean scores between those with and without knee pain and between different demographic and body mass index groups were investigated using unpaired t-tests. Binary logistic regression was used to explore the association between self-reported knee pain and Movement Specific Reinvestment subscale scores, controlling for age, gender and body mass index. For each clinical characteristic (whether the knee ever swells up, whether the knee pain had lasted more than one month, whether the knee pain was bilateral and whether the onset of the knee

pain followed sudden injury), differences in mean scores were compared across those without knee pain, those with knee pain with the clinical characteristic, and those with knee pain without the clinical characteristic, using one-way analysis of variance and, if statistically significant, between each two-way comparison, for example, those with the clinical characteristic and those without knee pain, using unpaired t-tests.

Results

Of the 101 participants, 34 (33.7%) responded positively to the question 'have you had pain or problems in the last year in or around the knee?' and were classified as having self-reported knee pain (Table 1). Scores on the Movement Specific Reinvestment Scale were available for 99 participants. Mean Conscious Motor Processing subscale scores, but not mean Movement Self-consciousness subscale scores, were significantly higher in those with knee pain compared to those without knee pain (mean difference 3.03; t-test 2.66, df=97, P=0.009; 95% CI 0.77 to 5.30; Table 1). Conscious Motor Processing subscale score was an independent predictor of knee pain when controlling for Movement Self-consciousness subscale score, age, gender and body mass index, with the odds of knee pain increasing by 16% for each point increase in the subscale score (n=96, adjusted odds ratio 1.16; 95% CI 1.04 to 1.30).

For all of the clinical characteristics investigated, statistical differences were evident between groups for Conscious Motor Processing scores but not for Movement Self-conscious scores(Table 2). With the exception of one clinical characteristic, (sudden or gradual onset of knee pain), those who reported knee pain with the characteristic and those who reported knee

pain without the characteristic had statistically significantly higher mean scores than those without knee pain. However, for sudden or gradual onset of knee pain, only those who reported that their knee pain came on following a sudden injury demonstrated a significantly higher mean score compared to those without knee pain (difference in mean score 5.9; t=3.30, df = 75, P=0.01; 95% CI 2.36 to 9.53). There was no significant difference between those with knee pain which was not of sudden onset and those without knee pain (P=0.21).

Discussion

Overall, a propensity for movement specific reinvestment appeared to be associated with self-reported knee pain in the participants, with conscious motor processing, rather than movement self-consciousness. Previous studies have also found that propensity for conscious motor processing plays a more prominent role than movement self-consciousness in people with movement related problems, such as falling,[7] stroke, [8] and Parkinson's disease.[11] These findings suggest that concerns about moving effectively (or safely), which are likely to involve conscious motor processing, outweigh concerns about making a good impression when moving, which are likely to involve movement self-consciousness.

Compared to people without knee pain and people who reported gradual onset of knee pain, conscious motor processing scores were significantly higher in those who reported knee pain due to sudden injury. The Movement Specific Reinvestment Scale is a trait scale so it is plausible that those more likely to consciously process their movements are prone to knee injury perhaps because they may be more guarded when they move.[2] The lack of an association with gradual onset of knee pain militates against pain catastrophising by those with high conscious motor processing scores, but we acknowledge that this was a cross-

sectional design, which precludes establishing the direction of the relationship. It is equally plausible that, consistent with fear-avoidance models, knee pain leads to increased conscious motor processing.

Previous studies of movement specific reinvestment suggest that a five to eight unit difference in scores on the Scale is clinically relevant.[7,8,11] In this study, a mean difference in Conscious Motor Processing subscale scores of only 3.3 units was observed between those with or without knee pain; however, this would increase the likelihood of knee pain by approximately 50%. Moreover, the difference in mean scores between those without knee pain and those with knee pain due to sudden injury was nearly 6 units, notwithstanding that the sample size was small and the confidence intervals consistent with a much smaller increase.

Participants in the study were a convenience sample rather than a random population sample, but knee pain rates and their gender distribution were similar to population–based studies,[12,13] which suggests that the findings may be generalizable. This study is a post hoc analysis of a database containing information on the Movement Specific Reinvestment Scale and self-reported knee pain. Because of the opportunistic nature of the study a limited number of factors were available for inclusion in the analysis and no formal sample size estimation was possible, so the exploratory approach to the regression analysis may have caused the data to be over-fitted, giving rise to an optimistic interpretation of the findings.

Nevertheless the potential implications of the findings are wide-ranging. There are possible public health implications because of the potential for negative health consequences associated with activity avoidance.[3] There is increasing international interest in stratifying patients with musculoskeletal problems based on clinical and psychological characteristics in order to optimise individual patient management.[14] For example potential clinical sub-groups in patellofemoral pain are currently being investigated[15]; and in back pain there is interest in targeting interventions to sub-groups using psychosocial characteristics.[16] The propensity for movement specific reinvestment may play a role in individual responsivity to pain or to the mechanisms that underlie causes of pain, which could be an important consideration for targeted rehabilitation strategies in different individuals. Knee pain patients with a high propensity for movement specific reinvestment may need different rehabilitation strategies compared to those with a low propensity. Equally, elite sports performers with a high propensity for movement specific reinvestment may require targeted preventative interventions because they are more prone to knee injury. In such cases, implicit rehabilitation strategies that target unconscious aspects of movement may be preferred over explicit strategies that target conscious aspects.[17,18,] Further research to substantiate the preliminary findings of this study is warranted using large-scale prospective designs in general and sporting populations.

Clinical Message

- knee pain is more commonly reported by people with a propensity for conscious involvement in their movements

- The propensity for conscious involvement in movement may play a role in individual responsivity to knee pain or to the mechanisms that underlie knee pain and hence may be useful in directing rehabilitation strategies.

Conflict of Interest Statement

The authors declare that they have no competing interests.

Contributors

JS, RM and PD conceived and designed the study; AC and KP collected and collated the data; JS, RM, PD and JR developed the analytical plan and interpreted the data findings; PD and NC undertook analysis of the data; JS, RM, JR and PD wrote the paper; all authors commented on drafts and have seen the final draft. JS is guarantor of the study.

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Table 1: Distribution of study population characteristics and mean reinvestment scores in subgroups of the study population (N=101)

Characteristic	n (%)	Knee pain prevalence n (%)	Movement Specific Reinvestment Mean total score (SD)	Movement Self-consciousness Mean score (SD)	Conscious Motor Processing Mean score (SD)
Knee Pain					
Presence	34 (33.7%)		34.2 (10.17)	14.8 (6.83)	19.5 (5.34)*
Absence	67 (66.3%)		30.8 (10.15)	14.3 (5.92)	16.4 (5.34)
			2 missing	2 missing	2 missing
Age in years	Mean 30 (SD 10.00)		R = -0.131	R = -0.233#	R=0.019
<25	44 (43.6%)	11 (25.0%)	34.0 (10.07)	16.3 (5.65)**	17.7 (5.55)
25-34	31 (30.7%)	11 (35.5%)	29.9 (11.51)	13.7 (6.99)	16.2 (5.83)
35-55	26 (25.7%)	12 (46.2%)	30.8 (8.52)	12.4 (5.48)**	18.4 (5.02)
			2 missing	2 missing	2 missing
Gender					
Male	43 (43.0%)	12 (27.9%)	32.5 (9.89)	13.9 (6.23)	18.6 (4.78)
Female	57 (57.0%)	22 (38.6%)	31.7 (10.58)	15.0 (6.26)	16.7 (5.86)
	1 missing	1 missing	3 missing	3 missing	3 missing
Body mass index	Mean 25.2 (SD 4.20)		R= 0.111	R=0.083	R=0.113
<25	54 (55.1%)	17 (31.5%)	31.2 (8.75)	14.1 (5.29)	17.1 (4.94)
=>25	44 (44.9%)	17 (38.6%)	33.0 (12.05)	15.0 (7.36)	18.1 (6.21)
	3 missing	3 missing	4 missing	4 missing	4 missing

R = Spearman's correlation coefficient. #P=0.02
*Mean Conscious Motor Processing score for presence of knee pain compared with absence of knee pain P=0.009;** mean Movement Self-consciousness score for 35+ compared with <25 years of age, P=0.007; all other comparisons for presence of knee pain and total and factor reinvestment scores were not statistically significant.

Table 2: Distribution of reinvestment scores in knee pain subgroups and comparison across those without knee pain, those with knee pain with clinical characteristic and those with knee pain without clinical characteristic (N=99). F statistics refer to each one-way ANOVA between the three groups.

	n	Movement Self-consciousness (N=99) Mean (SD)	Conscious Motor Processing (N=99) Mean (SD)
Participants with no knee pain	66	14.3 (5.92)	16.4 (5.34)
Participants with knee pain with given clinical characteristics:			
Since starting with your knee problem, does your knee **ever swell up**?			
Yes	13	17.2 (6.97)	20.8 (4.00)
No	20	13.3 (6.45)	18.6 (6.08)
		F=1.63; P=0.201	F=4.19; P=0.018
Have you had pain and discomfort for **more than one month**?			
Yes	12	16.3 (7.20)	21.4 (5.87)
No	21	13.9 (6.63)	18.3 (4.90)
		F=0.64; P=0.532	F=4.87; P=0.01
In which knee have you had pain or problems?			
Unilateral	18	15.9 (6.69)	19.6 (6.14)
Bilateral	15	13.4 (6.97)	19.3 (4.56)
		F=0.74; P=0.481	F=3.51; P=0.034
Did your current knee problem come on?..**Because of a sudden injury**			
Yes	11	16.4 (7.23)	22.4 (6.65)
No (gradual)	22	14.0 (6.65)	18.0 (4.08)
		F=0.58; P=0.561	F=6.21; P=0.003