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an explorative analysis

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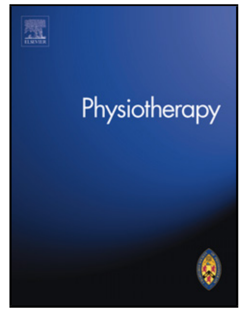

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Kinesiophobia is associated with pain intensity but not pain sensitivity before and after exercise: an explorative analysis

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Abstract

Objective To compare clinical pain intensity, exercise performance, pain sensitivity and the effect of aerobic and isometric exercise on local and remote pressure pain thresholds (PPTs) in patients with chronic musculoskeletal pain with high and low levels of kinesiophobia.

Design An experimental pre–post within-subject study.

Setting An exercise laboratory in a multidisciplinary pain clinic.

Participants Fifty-four patients with chronic musculoskeletal pain.

Interventions Acute aerobic and isometric leg exercises.

Main outcome measures Clinical pain intensity (numerical rating scale, range 0 to 10), Tampa Scale of Kinesiophobia, aerobic and isometric exercise performances (intensity and maximal voluntary contraction), and PPTs at local and remote body areas before and after exercise conditions.

Results Patients with a high degree of kinesiophobia demonstrated increased pain intensity compared with patients with a low degree of kinesiophobia [high degree of kinesiophobia: 7.3 (1.6) on NRS; low degree of kinesiophobia: 6.3 (1.6) on NRS; mean difference 1.0 (95% confidence interval 0.08 to 1.9) on NRS]. Aerobic and isometric exercises increased PPTs, but no significant group differences were found in PPTs before and after exercise.

Conclusions Clinical pain intensity was significantly higher in patients with a high degree of kinesiophobia compared with patients with a low degree of kinesiophobia. Despite a difference in isometric exercise performance, the hypoalgesic responses after cycling and isometric knee exercise were comparable between patients with high and low degrees of kinesiophobia. If replicated in larger studies, these findings indicate that although kinesiophobic beliefs influence pain intensity, they do not significantly influence PPTs and exercise-induced hypoalgesia in patients with chronic musculoskeletal pain.

Keywords: Kinesiophobia; Fear of movement; Pain; Exercise; Physical activity

<A>Introduction

Chronic pain is one of the most disabling conditions [1]. Several mechanisms may be involved, including facilitation of central pain mechanisms and reduced efficiency of pain descending pain inhibitory pathways [2,3], as well as psychological factors. Among people with chronic musculoskeletal pain, fear of performing physical exercise or body movements due to the assumption of increased pain or further injury (e.g. fear avoidance or kinesiophobia) [4,5] is common [6], and has been associated with increased pain intensity [7] and disability [8,9].

Despite these beliefs, physical exercise is an important component in the treatment of chronic musculoskeletal pain [10]. Physical exercise decreases pain sensitivity [exercise-induced hypoalgesia (EIH)] in healthy subjects [11] and in patients with chronic musculoskeletal pain, although less efficiently [12]. In healthy subjects, modulation of pain sensitivity has often been characterised by elevations in pain thresholds in exercising limbs (i.e. local EIH) and non-exercising limbs (i.e. remote EIH) following both high-intensity aerobic exercise (e.g. cycling or running) [13,14] and low- and high-intensity isometric exercise (i.e. muscle contraction without joint movement) [13,15,16]. In subjects with different musculoskeletal pain conditions, the effect of exercise on pain sensitivity is still controversial as both hypoalgesia [17,18] and hyperalgesia [19,20] have been reported. Reduced EIH has been related to older age and increased pain sensitivity [21], as well as reduced efficiency of pain modulatory pathways [22]. However, no studies have investigated the influence of fear of movement beliefs on EIH, which represents a major knowledge gap. Such knowledge may have clinical implications, as management of fear of movement beliefs could improve the effects of exercise. Previous studies have demonstrated that the presence of fear of movement may influence treatment outcome [23,24].

A previous experimental crossover study investigated the effect of different types of exercise on pain sensitivity in patients with chronic musculoskeletal pain, and found reduced EIH in patients with chronic pain with high vs low pain sensitivity [25]. Information was also collected on fear of movement, and these data now provide a unique opportunity to investigate the influence of fear of movement on EIH. Thus, the primary aim of this explorative analysis was to compare the effects of aerobic and isometric exercise on local and remote pressure pain thresholds (PPTs) between patients with chronic musculoskeletal pain with high and low fear of movement. A secondary aim was to compare the clinical pain intensity and exercise performance between groups. It was hypothesised that patients with high fear of movement would demonstrate: (1) reduced EIH and less intense exercise performance; and (2) increased clinical pain intensity.

<A>Materials and methods

<B>Subjects

This explorative analysis was performed using data on fear of movement and EIH at local and remote assessment sites in 54 out of 61 patients with chronic musculoskeletal pain {mean age 45.7 [standard deviation (SD) 11.2] years; 39 females} included in a previous experimental crossover study that investigated the effect of cold pressor test, aerobic exercise, isometric exercise and quiet resting on pressure pain sensitivity in patients with chronic musculoskeletal pain [25]. The remaining seven patients did not complete the relevant questionnaire. All patients were recruited by letter after referral to a multidisciplinary pain clinic from January to December 2013. Patients were asked to refrain from physical exercise, coffee and nicotine on the days of participation. All patients provided written informed consent, and the experimental study was conducted in accordance with the Declaration of Helsinki and approved by the local ethical committee (S-20110070).

<B>Procedure

At inclusion, patients completed the 17-item Tampa Scale of Kinesiophobia (TSK) questionnaire [4] prior to participating in the experimental crossover study. Data on clinical peak pain intensity on a numerical rating scale (NRS) (range 0 to 10; 0=no pain, 10=worst pain imaginable) during the previous 24 hours was also collected. The NRS has shown good test–retest reliability in patients with chronic pain (r=0.96, P<0.05) [26]. On two different days, all patients performed two exercise conditions (cycling and isometric contraction) in randomised and counterbalanced order, and PPTs were recorded at the legs, arm and shoulder before and immediately after both exercise conditions.

<B>Pressure pain thresholds

PPTs at four different sites were assessed with a handheld pressure algometer (Somedic, Hörby, Sweden) with a stimulation area of 1 cm^2 and an increment rate at 30 kPa/second. The patient was instructed to press a button the first time the pressure was perceived as slightly painful. Two assessments were completed for each site, and the average was used for further analysis. Site 1 was located in the middle of the dominant quadriceps femoris muscle, 20 cm proximal to the base of the patella. Site 2 was located in the middle of the non-dominant quadriceps femoris muscle, 20 cm proximal to the base of the patella. Site 3 was located in the middle of the dominant biceps brachii muscle, 10 cm proximal to the cubital fossa. Site 4 was located in the non-dominant upper trapezius muscle, 10 cm from the acromion in direct line with the neck. Within- and between–session test–retest reliability of handheld pressure algometry for assessment of pain sensitivity has been demonstrated previously in patients with chronic pain [25].

<B>Aerobic exercise

As described previously [25], the aerobic exercise condition consisted of a 15-minute cycling exercise (Ergomedic 928E, Monark Exercise AB, Vansbro, Sweden) at age-related target heart rates corresponding to 75% of patients' maximum oxygen consumption (VO_{2max}). Patients were instructed to maintain a pedal rate as close to 70 revolutions per min as possible throughout the 15-minute cycling exercise, and a heart rate monitor (Monark Exercise AB) was strapped around the patient's chest. Exercise resistance was manipulated, if necessary, to keep the heart rate at the desired level. The first 2 minutes were used as warm-up, and the intensity was kept below a heart rate corresponding to 50% of the patient's VO_{2max}. Pedal resistance was increased over the next 3 minutes until a target heart rate corresponding to 75% VO_{2max} was achieved by the beginning of the fifth minute; after this, the patient continued cycling for 10 minutes. Rating of Perceived Exertion (scale 6 to 20), exercise intensity (Watts) and heart rate (beats/minute) were obtained just before ending the 15 minutes of cycling.

<B>Isometric exercise

The isometric exercise condition consisted of a 90-second isometric knee extension with the dominant leg at submaximal intensity corresponding to 30% of the patient's maximal voluntary contraction, which was determined in a previous session. During the sustained submaximal isometric contraction, patients were required to match the target force as displayed on a monitor. All patients were verbally encouraged to sustain the force throughout the 90 seconds.

<B>Statistics

Based on the recommended threshold for a high degree of kinesiophobia (total TSK score ≥38) [5], participants were subgrouped into two groups: high and low kinesiophobia. The effect of aerobic and isometric exercise on PPTs at local and remote sites was initially analysed with two-way repeated measures analysis of variance (RM-ANOVAs), with the factors 'time' (before and after) and 'assessment site' (legs, arm, and shoulder) used as repeated measures and 'kinesiophobia group' (low, high) as the group factor. Furthermore, due to different sex ratios between the groups and previously demonstrated sex differences in PPTs [27] and EIH [28–30], all pain-related parameters were adjusted for sex by z-transformation: a parameter was subtracted by the mean value for women and men, respectively, and divided by the SD for women and men, respectively. After z-transformation, the majority of variables did not deviate significantly from normality (Shapiro-Wilks test: $P>0.05$). Potential differences in demographics, clinical pain intensity and exercise performance parameters at baseline between groups of participants with low and high degrees of kinesiophobia were analysed with unpaired *t*-tests. Potential differences in baseline PPTs and average percentage change in PPTs between the test stimuli before and after exercise (last divided by first 'test stimuli' * 100%) were analysed with mixed-model ANOVAs. *P*-values<0.05 were considered significant for RM-ANOVAs and *t*-tests. In case of significant factors or interactions in the RM-ANOVAs, Bonferroni-corrected post-hoc comparisons incorporating correction for the multiple comparisons were made. Effect sizes of the group differences were calculated based on Hedges' g, due to dissimilar group sizes. Effect sizes were evaluated as follows: for a small effect, $g=0.20$; for a medium effect, $g=0.50$; and for a large effect, $g=0.80$. Finally, Spearman's correlations were used to investigate the relationship between the kinesiophobia score and clinical pain intensity, PPTs and the percentage change in PPT after each of the exercise conditions. Due to multiple correlational analyses, the *P*-value was divided by the number of correlational analyses, and *P*-values≤0.01 were considered significant for the correlations.

<A>**Results**

<B>Participant characteristics

Based on the TSK score, two groups of patients were established with 23 and 31 participants in each group (Table 1). The high kinesiophobia group (TSK ≥38) had a significantly higher proportion of men (42%) compared with the low kinesiophobia group (9%). No significant differences in age or body mass index were found between the groups.

<insert Table 1 near here>

<B>Clinical pain and pain sensitivity

Clinical pain intensity was increased significantly in the high kinesiophobia group compared with the low kinesiophobia group [Table 1; high degree of kinesiophobia: 7.3 (SD 1.6) on 0 to 10 NRS; low degree of kinesiophobia: 6.3 (SD 1.6) on 0 to 10 NRS; mean difference 1.0 (95% confidence interval 0.08 to 1.9) on 0 to 10 NRS], but the pain duration was not different. The low kinesiophobia group had higher PPTs, although no significant differences were found between groups.

<B>Exercise performance and exercise-induced hypoalgesia after cycling

Intensity (Watts) during cycling had a tendency to be decreased in the high kinesiophobia group compared with the low kinesiophobia group. No significant differences between groups were found in heart rate or rating of perceived exertion reported during cycling. The RM-ANOVAs demonstrated a significant main effect for time (Fig. A, see online supplementary material), with the post-hoc test showing an increase in PPTs immediately after cycling compared with before cycling. The effect of cycling on PPTs was not significantly different between groups. Moreover, no significant differences were found in percentage increase in PPTs between high and low kinesiophobia groups.

<B>Exercise performance and exercise-induced hypoalgesia after isometric exercise

Isometric muscle strength was significantly lower in the high kinesiophobia group compared with the low kinesiophobia group. The RM-ANOVAs demonstrated a significant main effect for time (Fig. B, see online supplementary material), with the post-hoc test showing an increase in PPTs immediately after isometric exercise compared with before exercise. The effect of isometric exercise on PPTs was not significantly different between groups. Moreover, no significant differences were found in percentage increase in PPTs after isometric exercise between groups.

<B>Correlations between kinesiophobia, pain intensity, pain thresholds and EIH

Kinesiophobia scores were significantly correlated with pain intensity (Table B, see online supplementary material) and isometric muscle strength. No significant correlations were found between kinesiophobia scores and PPTs, or between kinesiophobia scores and change in PPTs after exercise.

<A>Discussion

This explorative analysis is the first to investigate the association between kinesiophobia, clinical pain intensity, PPTs and EIH after aerobic and isometric exercise in patients with chronic musculoskeletal pain. Clinical pain intensity was significantly higher in patients with a high degree of kinesiophobia compared with patients with a low degree of kinesiophobia. Despite the difference in exercise performance, the hypoalgesic responses after cycling and isometric knee exercise were comparable between patients with high and low degrees of kinesiophobia. If replicated in larger studies, these findings indicate that although kinesiophobic beliefs influence pain intensity, they do not significantly influence PPTs and EIH in patients with chronic musculoskeletal pain.

<B>Clinical pain intensity and exercise performance

Fifty-seven percent of the present study population was classified with a high degree of kinesiophobia. This finding is in agreement with previous studies [6,7,31–33] on different chronic pain populations, indicating that kinesiophobia is prevalent across diverse chronic pain conditions. Clinical pain intensity was higher and isometric muscle strength was reduced in patients with a high degree of kinesiophobia compared with patients with a low degree of kinesiophobia. These findings are in agreement with a previous study demonstrating a significant negative association between kinesiophobia and muscle strength in a static shoulder elevation test in workers with neck/shoulder pain [8]. Unexpectedly, aerobic exercise performance was not significantly different between groups, and the correlations did not reach significance. Although this could be related to the small sample size, the finding is in accordance with a previous study investigating the influence of kinesiophobia on walking endurance in patients with chronic low back pain [34]. However, positive associations between kinesiophobia and pain intensity [6,7], and kinesiophobia and self-reported disability [6,33] have been demonstrated previously in patients with chronic musculoskeletal pain, suggesting that pain-related cognitions might facilitate pain intensity and deconditioning [35], or that pain intensity might drive escape and avoidance behaviours [36]. These current and previous findings suggest that identification of kinesiophobic beliefs may be important for understanding pain intensity and pain-related disability in patients with chronic musculoskeletal pain.

<B>Baseline pressure pain sensitivity

No significant differences in PPTs were found between groups, and no significant association was demonstrated between kinesiophobia and PPTs. This finding was unexpected as previous studies investigating the influence of other pain-related cognitions within the fear avoidance model have demonstrated an association between pain catastrophisation and pain tolerance [37], as well as between pain catastrophisation and temporal summation of pain [38]. Moreover, a recent study demonstrated a moderately strong association between kinesiophobia and pain catastrophising in patients with neck pain [39]. A possible explanation for the equivocal results could be that the association is only manifest when the pain test stimuli is related to more intensely painful stimuli above the pain threshold. This is supported by a previous study indicating that pain catastrophisation enhances pain via supraspinal processes [40]. However, Martel *et al.* did find an association between pain catastrophisation and mechanical pain thresholds in the oesophagus in healthy subjects [41]. The influence of kinesiophobia on pain sensitivity has not been investigated previously, and further research into its influence on different aspects of pain sensitivity (e.g. thresholds, tolerance and temporal summation of pain) is warranted.

<B>Exercise-induced hypoalgesia

Aerobic and isometric exercise increased PPTs at local and remote assessment sites, which is in agreement with other studies showing a hypoalgesic response after exercise in healthy subjects [13–16,42] and patients with chronic pain [17,43–46]. In contrast to these findings, earlier studies have demonstrated a lack of EIH response in patients with chronic pain [18,19,47–49], and the results from a recent meta-analysis indicate that a subset of patients with chronic pain demonstrated impaired EIH responses compared with asymptomatic controls [11]. This study did not include healthy control groups with low and high degrees of kinesiophobia, and it may be that although exercise produced hypoalgesia in the included sample, the EIH responses in this population may be markedly impaired compared with healthy controls. No significant difference in EIH was found between patients with low and high degrees of kinesiophobia, and the TSK score was not significantly associated with any of the EIH responses in the present study. One reason for this unexpected finding could be related to the significant difference in isometric exercise performance between groups with low and high kinesiophobia, as a previous study in patients with fibromyalgia showed larger

EIH responses after exercise at a preferred lower intensity compared with prescribed higher intensity exercise [17]. However, no significant difference in aerobic exercise performance was found, suggesting robust EIH despite different levels of kinesiophobia. The influence of kinesiophobic beliefs on EIH has not been investigated previously, but the lack of association between kinesiophobia and EIH suggests that the mechanisms responsible for the EIH response are not significantly related to pain-related cognitions. However, the influence of kinesiophobia on EIH may have less influence in this sample when chronic pain is present compared with the potential influence in asymptomatic controls, which should be investigated further.

<B>Clinical implications

Although physical exercise is an important component in the treatment and management of patients with chronic musculoskeletal pain, previous research has demonstrated that not all patients with musculoskeletal pain experience a hypoalgesic response following exercise [19,25,48]. This study suggests that the hypoalgesic response to exercise is not influenced significantly by fear of movement beliefs, indicating that physical exercise can induce hypoalgesia in subjects with chronic musculoskeletal pain regardless of such beliefs.

<B>Study limitations

This exploratory secondary analysis is limited by the small sample size. Limitations include lack of statistical power; in particular, the comparison of PPTs and EIH between groups should be interpreted with care. Larger studies should confirm the findings of this study. The intensity of aerobic exercise was not based on an exhaustive physical performance test, and determination of VO_{2max} and the duration at the desired intensity was limited to 15 minutes, which may create some concern in terms of interpretation of the aerobic exercise performance between groups.

<A>Conclusions

These findings indicate that although kinesiophobic beliefs influence pain intensity, they do not influence PPTs and EIH significantly, suggesting that exercise can induce hypoalgesia in subjects with chronic musculoskeletal pain, regardless of such beliefs.

Ethical approval: This study was conducted in accordance with the Declaration of Helsinki, and was approved by the local ethical committee (S-20110070). All patients provided written informed consent.

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Conflict of interest: None declared.

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Table 1

Mean (standard deviation) scores of clinical pain intensity and duration, pressure pain thresholds, exercise performance and exercise-induced hypoalgesia (EIH) responses after aerobic and isometric exercise in patients with chronic musculoskeletal pain with low and high degrees of kinesiophobia [cut-off: Tampa Scale of Kinesiophobia (TSK) score ≥38]

		Raw data				Z-scores		Statistics	
Domain	Variables	Total sample (*n*=54)	Low kinesiophobia (*n*=23)	High kinesiophobia (*n*=31)	Mean difference (95% CI)	Low kinesiophobia (*n*=23)	High kinesiophobia (*n*=31)	*P*-value	Effect size (Hedge's g)
Clinical pain profile	Pain duration (years)	10.9 (10.8)	10.3 (9.2)	11.3 (11.1)	-1.0 (-7.1 to 4.9)	-0.03 (1.01)	0.01 (0.99)	0.89	0.04
	Clinical pain intensity (NRS: 0 to 10)	6.9 (1.6)	6.3 (1.6)	7.3 (1.6)	-1.0 (-1.9 to -0.08)	-0.39 (0.96)	0.27 (0.93)	0.015	0.67
Pressure pain thresholds	Dominant quadriceps muscle (kPa)	529 (390)	468 (387)	575 (392)	-107 (-323 to 108)	0.10 (0.77)	-0.07 (1.14)	0.55	0.17
	Non-dominant quadriceps muscle (kPa)	556 (390)	471 (390)	619 (385)	-148 (-361 to 67)	0.08 (0.85)	-0.06 (1.09)	0.59	0.14
	Dominant biceps muscle (kPa)	306 (237)	273 (235)	331 (240)	-58 (-189 to 73)	0.14 (0.78)	-0.10 (1.12)	0.38	0.24
	Non-dominant trapezius muscle (kPa)	353 (276)	340 (315)	363 (249)	-23 (-177 to 131)	0.27 (0.94)	-0.20 (0.99)	0.09	0.48
Exercise performance	Cycling intensity (Watts)	99 (35)	99.1 (29.6)	98.2 (39.2)	-0.9 (-18.7 to 20.5)	0.28 (0.93)	-0.21 (1.00)	0.08	0.50
	Heart rate (beats/minute)	151 (10)	151 (11)	150 (11)	1 (-5 to 6)	-0.004 (0.83)	0.003 (1.11)	0.98	0.01
	Perceived exertion (RPE: 6 to 20)	15 (2)	14.9 (1.4)	15.3 (1.6)	-0.4 (-1.2 to 0.4)	-0.12 (0.95)	0.09 (1.03)	0.46	0.21
	Isometric muscle strength (N)	228 (110)	231 (114)	224 (108)	7 (-54 to 68)	0.34 (1.20)	-0.25 (0.73)	0.03	0.61
EIH after bicycling	Dominant quadriceps muscle (%)	122.4 (31.1)	129.4 (35.8)	117.2 (26.5)	12.2 (-4.8 to 29.2)	0.14 (1.02)	-0.10 (0.80)	0.34	0.26
	Non-dominant quadriceps muscle (%)	124.5 (37.4)	135.4 (42.6)	116.4 (31.3)	19.0 (-1.1 to 39.2)	0.15 (1.03)	-0.11 (0.96)	0.34	0.26
	Dominant biceps muscle (%)	127.3 (42.2)	144.4 (53.2)	114.7 (26.1)	29.7 (7.6 to 51.7)	0.25 (1.11)	-0.18 (0.86)	0.12	0.44
			120.6 (28.7)	112.6 (20.0)				0.58	0.16

	Non-dominant trapezius muscle (%)	116.0 (24.2)			8.0 (-5.3 to 21.2)	0.09 (1.09)	-0.07 (0.92)		
EIH after isometric knee extension	Dominant quadrics muscle (%)	114.9 (28.7)	119.6 (38.1)	111.4 (19.1)	8.2 (-7.6 to 24.1)	0.05 (1.23)	-0.04 (0.79)	0.75	0.09
	Non-dominant quadriceps muscle (%)	113.6 (24.6)	119.1 (22.4)	109.5 (25.7)	9.6 (-3.8 to 23.1)	0.10 (0.86)	-0.07 (1.09)	0.54	0.17
	Dominant biceps muscle (%)	110.4 (24.1)	118.8 (24.2)	104.2 (22.4)	14.6 (1.8 to 27.4)	0.24 (0.97)	-0.18 (0.98)	0.12	0.42
	Non-dominant trapezius muscle (%)	110.7 (18.1)	112.0 (19.3)	109.7 (17.4)	2.3 (-8.0 to 12.5)	0.01 (1.04)	-0.01 (0.97)	0.93	0.02

NRS, numerical rating scale; RPE, rating of perceived exertion; CI, confidence interval.

Raw data and mean difference (95% CI) are presented for the total sample, and sex-adjusted z-scores are presented for low and high TSK groups. *P*-values and effect sizes are based on sex-adjusted z-scores and independent *t*-test between low and high kinesiophobia groups.