Increased sensitivity to physical activity among individuals with knee osteoarthritis: Relation to pain outcomes, psychological factors, and responses to quantitative sensory testing

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ABSTRACT

Recent findings suggest that certain individuals with musculoskeletal pain conditions have increased sensitivity to physical activity (SPA) and respond to activities of stable intensity with increasingly severe pain. This study aimed to determine the degree to which individuals with knee osteoarthritis (OA) show heightened SPA in response to a standardized walking task and whether SPA cross-sectionally predicts psychological factors, responses to quantitative sensory testing (QST), and different OA-related outcomes. One hundred seven adults with chronic knee OA completed self-report measures of pain, function, and psychological factors, underwent QST, and performed a 6-min walk test. Participants rated their discomfort levels throughout the walking task; an index of SPA was created by subtracting first ratings from peak ratings. Repeated-measure analysis of variance revealed that levels of discomfort significantly increased throughout the walking task. A series of hierarchical regression analyses determined that after controlling for significant covariates, psychological factors, and measures of mechanical pain sensitivity, individual variance in SPA predicted self-report pain and function and performance on the walking task. Analyses also revealed that both pain catastrophizing and the temporal summation of mechanical pain were significant predictors of SPA and that SPA mediated the relationship between catastrophizing and self-reported pain and physical function. The discussion addresses the potential processes contributing to SPA and the role it may play in predicting responses to different interventions for musculoskeletal pain conditions.

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1. Introduction

Knee osteoarthritis (OA) is a degenerative joint condition that affects more than 17 million Americans and is a major cause of personal suffering and health care expenditure [20,82]. Many individuals with this condition experience severe pain, depressed mood, and activity restriction [1,7,21,27,42], limitations that can persist even after receiving the best available treatments [44,57,59]. Interestingly, the problematic aspects of this condition are not fully explained by OA-related joint degeneration [8,36,62]. This discrepancy has prompted increased research exploring the determinants of OA-related outcomes.

Emerging research has highlighted the clinical importance of activity-related pain among individuals with musculoskeletal conditions. Knee OA is commonly associated with pain during weight-bearing activities, resulting in difficulty with walking and climbing stairs [28,34,35]. Harden and colleagues recently reported that after climbing a flight of stairs, individuals with knee OA experienced significantly greater increases in pain than healthy controls and that their mean levels of activity-related pain doubled [37]. A similar sensitized response to activity has also been observed among individuals with back pain, whiplash, and fibromyalgia [50,51,58,80,81]. For example, Sullivan and colleagues have shown that certain individuals with these conditions experience increasing levels of pain as they perform activities of stable intensity

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[50,80,81]. These findings also show that increased levels of sensitivity to physical activity (SPA), measured by changes in pain during activity, are correlated with elevated pain catastrophizing, reduced activity tolerance, and increased disability [50,80,81]. These findings suggest that elevated SPA may represent an important risk factor for problematic sequelae after musculoskeletal injury [50,80].

Despite findings from other musculoskeletal populations, the potential value of SPA in predicting pain and function among individuals with knee OA remains unexplored. Practice guidelines commonly recommend activity-based interventions (eg, walking programs) for patients with knee OA [4,12,54]. However, discomfort during physical activity is an important barrier to treatment adherence [41]. Clinical measures of SPA may help capture this variance and facilitate treatment adherence by informing tailored activity-based interventions. Also, relationships between SPA and other measures of pain sensitivity have yet to be explored. Pain sensitivity is commonly measured via quantitative sensory testing (QST), which involves studying individual responses to standardized stimuli (eg, pressure, heat). QST research shows that OA is associated with widespread reductions in pressure pain thresholds and hyperalgesic responses to noxious mechanical stimuli [52,83,97]. Researchers have posited that this increased sensitivity is linked to the amplification of sensory processing within the spinal cord and throughout the central nervous system, a process known as central sensitization [53,95]. Exploring whether SPA is related to QST responses may help shed light on its underlying processes and the mechanisms that drive pain-related disability.

This study aims to address these gaps by determining whether individuals with knee OA experience increasing levels of discomfort during a standardized walking task; by establishing whether levels of SPA predict OA-related pain, physical performance and self-report function; and by exploring whether psychological factors and QST responses predict SPA. A secondary aim was to explore whether SPA functioned as a mediator between psychological factors and clinical outcomes.

2. Methods

2.1. Participants

Participants who were 50 years of age or older were recruited through advertisements in public media and physicians' offices to participate in a larger study exploring OA and insomnia [29]. This larger study consisted of people with and without OA and people with and without insomnia; participation included polysomnography to identify individuals with insomnia. In the present study, only individuals with OA were included. To enhance the generalizability of the present findings, we did not exclude individuals with other sleep disorders such as sleep apnea and periodic limb movement disorder, although we factored these parameters into the analytic approach. Potential participants reporting knee OA were eligible for the study if they: (1) met the American College of Rheumatology criteria for knee OA [2], (2) scored at least 1 on the Kellgren/Lawrence scale [46] for one or both knees, and (3) experienced near-daily knee pain (ie, pain that was present for more than 4 days per week and was rated as 2 or higher on a 0 to 10 scale) for at least 6 months. A board-certified rheumatologist confirmed the diagnosis of knee OA through a subjective history, clinical examination, and radiographic findings. Individuals were excluded from the study if they experienced serious medical comorbidities (eg, congestive heart failure, cerebrovascular accidents, cancer), other chronic pain or rheumatic conditions, severe or unstable

psychopathology, and cognitive impairments or dementia, or if they showed evidence of substance abuse through toxicology screening and a clinical interview. Participants regularly receiving opioid analgesic and/or sedative hypnotics were also excluded.

2.2. Procedures

All participants attended a preliminary session to provide informed consent and to complete screening questionnaires, a clinical interview, and bilateral knee radiography (standing and semiflexion views). Participants attended a subsequent testing session during which they were examined by a rheumatologist, completed a battery of questionnaires and anthropomorphic measures (hip and waist circumference), and underwent physical performance testing and QST. Participants agreed to discontinue analgesics and centrally acting substances, including nicotine and/or caffeine, within 24 h before this session.

2.3. Measures and indices

2.3.1. Self-report questionnaires
2.3.1.1. OA-related physical function and pain. The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) was used to measure physical function and pain. The WOMAC consists of a 5-item subscale addressing activity-related OA pain and a 17-item subscale addressing physical function. All items were scored on a 0 to 10 scale in which higher scores indicate greater pain or limitations. A third subscale addressing knee stiffness was not used in the present analysis. Previous research has validated the WOMAC among individuals with knee OA [9].

2.3.1.2. Pain catastrophizing. The Pain Catastrophizing Scale (PCS) was used to measure levels of pain catastrophizing. The PCS consists of 13 items scored on a 0 to 4 scale. Higher scores indicate greater levels of catastrophic thinking. The PCS is a valid, reliable, and widely used measure of pain catastrophizing [64,65,78].

2.3.1.3. Depressed mood. The Depression subscale of the Profile of Mood States (POMS) questionnaire was used to measure depressed mood. This subscale consists of 15 items scored on a 0 to 4 scale. Higher scores indicate greater levels of depressive mood. The POMS scale has been identified as a valid and reliable measure of depression among individuals with chronic pain conditions [22].

2.3.1.4. Sleep disturbance. The Pittsburgh Sleep Quality Index (PSQI) was used to measure sleep disturbances. The PSQI evaluates sleep disturbances in 7 different categories: sleep quality, latency, duration, efficiency, disturbance, use of sleep medication, and daytime dysfunction. Each of the 7 categories is scored on a 0 to 3 scale; higher scores indicate decreased sleep quality. The PSQI is a widely used and validated measure of sleep disturbances among individuals with chronic pain [13,73].

2.3.2. Anthropomorphic measures
Consistent with previous literature, waist and hip circumference were measured to create an index of abdominal fat accumulation (ie, waist-to-hip ratio, WHR) [17,39,63,96]. Waist circumference was measured with a tape measure around the abdomen at the level of the navel between the lower ribs and iliac crest; hip circumference was measured at the widest part of the buttocks. WHR has been used in numerous studies as an indicator of obesity [17,96]; consistent with this literature, cut scores were used to categorize men and women as normal (men <0.9 and women <0.8), overweight (men 0.9–0.99 and women 0.8–0.84), or obese (men $\geqslant$1 and women $\geqslant$0.85).