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Bilateral Pressure Pain Hypersensitivity over the Hand as Potential Sign of Sensitization Mechanisms in Individuals with Thumb Carpometacarpal Osteoarthritis

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Abstract

Objective. To investigate whether bilateral deep tissue pressure hyperalgesia exists in individuals with unilateral thumb carpometacarpal osteoarthritis (CMC OA).

Methods. A total of 32 patients with CMC OA (29 females and 3 males, aged 69–90 years old) and 32 healthy matched controls (29 females and 3 males, aged 70–90 years) were recruited. Pressure pain thresholds (PPTs) were bilaterally assessed over the first CMC joint, the hamate bone and the lateral epicondyle in a blinded design. Mixed models analyses of variance were conducted to determine the differences in pressure pain sensitivity between groups and sides.

Results. The results showed that PPTs were significantly decreased over the first CMC joint ($F = 6.551$, $P = 0.012$) and the hamate bone ($F = 9.783$, $P = 0.002$) but not over the lateral epicondyle ($F = 2.712$, $P = 0.102$) in patients with thumb CMC OA as compared with healthy controls; patients with unilateral thumb CMC OA exhibited bilateral pressure pain hyperalgesia in both hands compared with healthy people. PPTs were not significantly associated to the intensity of pain (all, $P > 0.05$).

Discussion. This study revealed bilateral localized pressure pain hypersensitivity over the hand in individuals with unilateral thumb CMC OA, suggesting spinal cord sensitization mechanisms in this population. Future studies should analyze the presence of widespread pressure pain sensitivity in patients with thumb CMC OA to further determine the presence of central sensitization mechanisms.

Key Words. Pressure Pain Threshold; Sensitization; Thumb; Osteoarthritis; Sensitization

Introduction

Osteoarthritis (OA) is the leading cause of chronic pain in Europe, accounting for 34% of chronic pain [1]. Thumb carpometacarpal (CMC) OA constitutes a major cause of hand disability after the age of 50, particularly in 30–40% of postmenopausal women [2,3]. In thumb CMC OA, pain is generally experienced in the proximity of the afflicted first CMC joint [3]. Factors characterizing OA usually include damage of the articular cartilage, changes in subchondral and marginal bone, synovial joint inflammation, and capsular thickening [4]. However, there is often a discrepancy between the presence of these factors and pain symptoms [5]. In fact, pain in OA is considered a complex integration of sensory and cognitive processes involving several abnormal cellular mechanisms at peripheral and central levels of the nervous system [5,6]. The inflammatory modulators present in the OA progressive joint deterioration may be responsible for a nociceptive sensitization that would reduce their thresholds [5,7]. Neuroimmune responses can potentiate this sensitization because pro-inflammatory cytokines trigger the release of chemical mediators that may sensitize nociceptors and maintain neuronal excitability and sensitization [8].

The reduction in high-threshold sensory neurons that respond to noxious stimuli is called peripheral sensitization, and it is the cause of primary hyperalgesia zone close to the injured area [5,7]. Nociceptors activation can increase synaptic efficacy in nociceptive neurons in the dorsal horn of the spinal cord that remains autonomous for some time after the conditioning stimuli. In addition, subsequent stimuli by low-level nociceptors can sustain this facilitation that can also be triggered by non-nociceptive stimuli [7]. Therefore, a continuous and intense sensory input from the OA-damaged joint may change patterns of neurochemical secretion and neural reorganization in spinal cord segments, involving the phenomenon of central sensitization [5,7,9]. Central sensitization is a mechanism in which injured and non-injured parts of the body exhibit lowered pain thresholds due to an alteration within the central pain processing and may be perpetuated by peripheral sources of nociception [10]. However, this dysfunctional activity at the dorsal horn is not the only mechanism responsible for central nervous system hyperexcitability because an alteration of descending pain inhibitory mechanisms has been also postulated [11]. One of the main manifestations of central sensitization is the presence of pressure pain hyperalgesia in non-symptomatic and non-injured areas [12–15].

Several studies have reported the presence of generalized pressure pain hypersensitivity in patients with different chronic pain conditions such as fibromyalgia [16], temporomandibular disorders [17], whiplash-associated disorders [13–15,18], headache [19,20], low-back pain [21], lateral epicondylalgia [22], carpal tunnel syndrome [23], shoulder impingement [24], or neck pain [25]. In addition, the importance of central sensitization as an underlying mechanism for chronic pain has recently gained interest also in OA. Some studies have found the involvement of central pain processing in knee OA. Arendt-Nielsen et al. [26] showed that subjects with painful knee OA had pressure pain hyperalgesia at the affected joint and in distal pain-free areas when compared with healthy controls. This study also found an increased temporal summation to repeated pressure pain stimulation and a significant correlation between pain and pressure pain thresholds [26]. Bajaj et al. [27] described enhanced pain intensity, pain duration, and increased referred pain areas in subjects with chronic knee or hip OA after an intramuscular injection of hypertonic saline. Wylde et al. [28] found in a sample of 107 patients with knee OA that 70% of the subjects exhibited at least one somatosensory abnormality, of which tactile hypoaesthesia and pressure pain hyperalgesia (both locally and distally) were reported as the most prevalent. Lundlab et al. [29] showed that patients with high preoperative pain scores and higher pressure pain hypersensitivity exhibited higher risk of developing persistent pain after total knee replacement for knee OA than those with lower levels of pain and pressure pain hyperalgesia. Additionally, pressure hyperalgesia was significantly associated with pain intensity, disability, and quality of life in patients with knee OA [30]. The presence of pressure pain hyperalgesia in pain-free areas and the absence of correlation between pain and radiological findings [4,5,26] suggest that central sensitization mechanisms may play a key role in knee OA-related pain.

Central sensitization can lead to the presence of contralateral sensitized structures. In fact, contralateral sensitization has been shown in unilateral local pain syndromes of the upper extremity such as carpal tunnel syndrome [23] and lateral epicondylalgia [22]. Farrell et al. [31] found lower thermal and mechanical pain thresholds over the thumb relative to the forearm in subjects with CMC OA with persistent pain. In contrast, those patients with CMC OA with incident pain or asymptomatic CMC OA subjects did not exhibit this regional difference in sensitivity to thermal and mechanical pain thresholds [31]. However, it is difficult to draw any clear conclusion regarding sensitization mechanisms from this study because there was a lack of comparison between thresholds of patients with CMC OA and healthy controls, and a lack of comparison between the symptomatic and non-symptomatic areas. Additionally, this study used von Frey filaments to assess sensitivity to superficial punctuate stimuli, a different construct if compared with pressure pain thresholds that assess deep tissue sensitivity [18,28,31]. To the best of the authors' knowledge, no previous study has investigated the presence of pressure pain hyperalgesia over deep tissues and the presence of bilateral pain hyperalgesia in individuals with unilateral thumb CMC OA. Therefore, the aim of our study was to investigate whether bilateral deep tissue hypersensitivity is a feature of patients with symptomatic unilateral thumb CMC OA. We hypothesized that these patients will exhibit bilateral pressure pain hyperalgesia as compared with healthy controls.

Methods

Participants

Consecutive patients diagnosed by a medical doctor with thumb CMC OA were screened for eligibility criteria at the Department of Physical Therapy, Residenze Sanitarie Assistenziali "A. Maritano," Sangano, Italy. Each patient underwent subjective and physical examination conducted by a physical therapist experienced in musculoskeletal physiotherapy in order to evaluate inclusion and exclusion criteria. Participants were included if they had a diagnosis of stage III or IV CMC OA in the dominant hand confirmed radiographically according to Eaton–Littler–Burton classification [32]. In addition, patients had to report pain at the base of the thumb as their main symptom. In fact, the combination of radiological and clinical changes has been proposed as the main diagnostic criteria for CMC OA [33]. They were excluded in case they exhibited any of the following criteria: 1) previous treatment interventions with surgery in the hand or the forearm; 2) corticosteroid injection or any physical therapy intervention within 6 months before the study; 3) multiple pain diagnoses of the upper extremity, e.g, carpal tunnel syndrome, de Quervain's tenosynovitis, shoulder pathology, cervical radiculopathy; 4) evidence of systemic illness (rheumatoid arthritis, psoriatic arthritis, systemic lupus erythematosus); 5) fibromyalgia; 6) complex regional pain syndrome; 7) degenerative or non-degenerative neurological conditions in which pain perception could be altered; 8) presence of any pain symptoms in the non-dominant hand; 9) evidence of radiographic alterations at the first CMC joint in the non-dominant hand; 10) presence of a score greater than 6 points in the Beck Depression Inventory (BDI-II); or 11) presence of a score >30 points on the State Trait Anxiety Inventory (STAI).

Healthy controls were recruited from volunteers of the same department, and they were excluded if they exhibited a history of upper extremity or neck pain, fractures or neurological disorders, and any systemic disease or diagnosis compatible with symptoms over both hands.

The protocol (N°93571/c) was approved by the Ethical Committee in Azienda Sanitaria Locale (ASL) 3, Collegno, Italy. Eligible subjects signed an informed consent prior to their inclusion.

Pressure Pain Threshold Assessment

Pressure pain threshold (PPT) is defined as the minimal amount of pressure where a sense of pressure first changes to pain [34]. A mechanical pressure algometer (Pain Diagnosis and Treatment, Inc., Great Neck, NY, USA) was used in this study. The device consists of a round rubber disk (1 cm^2) attached to a pressure gauge. The gauge displays values in kg/cm^2 ranging from 0–10 kg. Pressure was applied at a rate of approximately 1 $kg/cm^2/s$ with the algometer placed perpendicular to the point. Participants were instructed to inform when the sensation changed from pressure to pain. PPTs were tested three times over each point, and the mean was used for the analysis. A 1-minute resting period was allowed between each measure. This procedure showed a high intraclass correlation coefficient (ICC = 0.91 [95% confidence interval {CI} 0.82–0.97]) [35].

Sample Size Determination

The sample calculation was based on detecting significant clinically significant differences of 20% on PPT between groups [36] with an alpha level of 0.05, a desired power of 80%, and an estimated interindividual coefficient of variation for PPT of 20%. This generated a sample size of at least 16 subjects per group. Before conducting the study, we decided to double the sample size in order to increase its statistical power.

Study Protocol

The study protocol was the same for patients and healthy controls. All examinations were performed in a quiet and draught-free laboratory. Participants were asked not to take analgesics, muscle relaxants or anti-inflammatory drugs for 48 hours before the examination. Participants rest in a comfortable sitting position with the examined arm relaxed over a table. They were allowed to familiarize with PPT assessment for some minutes over a standardized point at the neck. PPT was measured bilaterally over the first CMC joint, the unciform apophysis of the hamate bone, and the lateral epicondyle by an assessor blinded to the subjects' condition. The sequence of the tested sites was randomized between each participant.

All the tested points were identified by manual palpation and marked by the assessor with a pencil as follows: the articular rhyme of the first CMC joint was detected at the bottom of the anatomic snuffbox; the apophysis of the hamate bone was identified by palpating the hypothenar eminence laterally to the ulnar nerve; and the lateral epicondyle was localized by moving caudally from the humerus-radial joint avoiding to be over the radial nerve. The articular rhyme of the first CMC joint was chosen because it is the symptomatic area, whereas the apophysis of the hamate bone was evaluated as an asymptomatic bone landmark locally at the hand. Finally, the lateral epicondyle was chosen as a distant pain-free point. In addition, it was already used in a previous investigation in subjects with thumb CMC OA as a remote landmark [32]. After PPTs assessment, pain intensity was assessed. Patients were required to rate their pain on an 11-point numerical rating scale [37] ranging from 0 (no pain at all) to 10 (the worst pain imaginable) while executing a key pinch between the thumb and the index finger.

Statistical Analysis

Data were analyzed with SPSS statistical package (20.0 version, IBM, Armonk, NY, USA). Results are expressed as mean ± standard deviation and 95% CI. The Kolgomorov–Smirnov test was used to analyze the normal distribution of the variables ($P > 0.05$). Quantitative data without a normal

Table 1 Demographic characteristics in subjects with unilateral symptomatic thumb CMC OA and healthy controls

	Patients with Thumb CMC OA	Healthy Controls
Age*	80 ± 7 (95%CI 77–82)	80 ± 6 (95%CI 78–82)
Male/female	3/29	3/29
BMI (kg/m^2)*	23.2 ± 2.4 (95%CI 19.3–28.6)	23.7 ± 2.7 (95%CI 19.7–28.3)
Pain intensity while executing a key pinch*	4.2 ± 1.4 (95%CI 3.7–4.7)	NA

* Values are expressed as mean ±standard deviation (95% CI).
NA = not applicable; BMI = body mass index; CI = confidence interval; CMC OA = carpometacarpal osteoarthritis.

distribution (pain intensity) were analyzed with non-parametric tests, whereas data with a normal distribution (PPT) were analyzed with parametric tests. The ICC was used to assess the intraexaminer reliability of PPTs over each point. In addition, the standard error of measurement (SEM) was calculated. Demographic characteristics of both study groups were compared using unpaired *t*-test in case of normally distributed data and Mann–Whitney *U* test in case of not-normally distributed data. PPTs values displayed a normal distribution; therefore, a two-way analysis of variance (ANOVA) was used to evaluate differences in PPTs levels assessed over each point (first CMC joint, hamate, and lateral epicondyle) with side (affected/unaffected in patients or dominant/non-dominant in controls) as the within-subjects factor and group (patients or controls) as the between-subject factor. The Spearman's rho (r_s) test was used to analyze the association between PPT and pain intensity within the CMC OA group. The statistical analysis was conducted at a 95% CI, and a $P < 0.05$ was considered statistically significant.

Results

Demographic and Clinical Data of Participants

Between November 2011 and April 2012, a total of 32 subjects presenting with unilateral thumb CMC OA satisfied all the eligibility criteria and agreed to participate. As reported in Table 1, patients were 29 women and 3 men, with a mean age of 79.7 ± 6.6 (95% CI 77.3–82.1). All the patients displayed unilateral CMC OA in their right (dominant) hand. The key outcome variables (PPTs) were normally distributed. The mean intensity of pain while executing a key pinch was 4.2 ± 1.4 (95% CI 3.7–4.7). No significant association between the pain intensity and age ($r_s = 0.236$; $P = 0.193$) was found within the patient group. Further, 32 age- and sex-healthy matched controls 29 women and 3 men, mean age 80 ± 6 (95% CI 77.8–82.2), were also included. No clinical differences regarding age, sex and body mass index were found between the groups (Table 1).

Pressure Pain Sensitivity over the CMC Joint

The intraexaminer reliability of PPT readings was 0.91 for the affected/dominant hand and 0.93 for the unaffected/non-dominant hand. The SEM was 0.24 kg/cm^2 for the affected/dominant hand and 0.35 kg/cm^2 for the unaffected/non-dominant hand, respectively.

The ANOVA revealed significant differences between groups ($F = 6.551$, $P = 0.012$), but not between sides ($F = 0.647$, $P = 0.423$), for PPT over the first CMC joint. No significant group * side interaction was found ($F = 0.626$, $P = 0.43$). Patients with thumb CMC OA showed bilaterally lower PPTs as compared with healthy controls ($P < 0.01$). Table 2 summarizes PPT over the first CMC joint for both sides within each group.

Table 2 Differences in pressure pain thresholds over first carpometacarpal (CMC) joint, hamate bone, and lateral epicondyle between patients with unilateral symptomatic thumb CMC osteoarthritis (OA) and healthy controls

	First CMC Joint*	Hamate Bone*	Lateral Epicondyle
Patients with thumb CMC OA			
Affected side	3.2 ± 1.0 (95% CI 2.8–3.6)	5.4 ± 1.7 (95% CI 4.8–6.0)	5.6 ± 1.3 (95% CI 5.2–6.1)
Non-affected side	3.2 ± 1.2 (95% CI 2.7–3.6)	5.4 ± 2.1 (95% CI 4.6–6.2)	4.9 ± 1.4 (95% CI 4.4–5.4)
Healthy controls			
Dominant side	4.0 ± 1.4 (95% CI 3.5–4.5)	6.8 ± 2.0 (95% CI 6.1–7.5)	5.9 ± 1.9 (95% CI 5.2–6.6)
Non-dominant side	3.6 ± 1.6 (95% CI 3.0–4.2)	6.2 ± 2.3 (95% CI 5.4–7.1)	5.6 ± 2.0 (95% CI 4.9–6.3)

* Significant differences between patients and controls (two-way analysis of variance test).
Values (kg/cm^2) are expressed as mean ± standard deviation (95% confidence interval [CI]).

Pressure Pain Sensitivity over the Hamate Bone

The intraexaminer reliability of PPT readings was 0.83 and 0.79 for the affected/dominant and unaffected/non-dominant hand, respectively. The SEM was 0.4 and 0.3 kg/cm^2 for the affected/dominant and unaffected/non-dominant hand, respectively.

The ANOVA revealed significant differences between groups ($F = 9.783$, $P = 0.002$), but not between sides ($F = 0.656$, $P = 0.419$), for PPTs over the uncinate apophysis of the hamate bone. No significant group * side interaction was found ($F = 0.692$, $P = 0.407$). Similarly, patients with thumb CMC OA exhibited bilateral lower PPT than healthy controls ($P < 0.01$). Table 2 shows PPT over the hamate bone for both sides in patients with thumb CMC OA and healthy controls.

Pressure Pain Sensitivity over the Lateral Epicondyle

The intraexaminer reliability of PPT readings was 0.83 for the affected/dominant hand and 0.79 for the unaffected/non-dominant hand. The SEM was 0.30 kg/cm^2 for both sides.

The ANOVA did not reveal significant differences between groups ($F = 2.712$, $P = 0.102$) or between sides ($F = 2.872$, $P = 0.930$), or group * side interaction ($F = 0.496$, $P = 0.483$) for PPT over the lateral epicondyle. Table 2 shows PPT over the lateral epicondyle for both sides on each group.

Pressure Pain Sensitivity and Pain Intensity in Patients with Thumb CMC OA

No significant correlations between the intensity of pain and PPT levels over the CMC joint (affected side: $r_s = -0.156$, $P = 0.395$; non-affected: $r_s = 0.045$, $P = 0.806$), hamate bone (affected: $r_s = -0.209$, $P = 0.251$; non-affected: $r_s = -0.161$, $P = 0.378$), and lateral epicondyle (affected: $r_s = -0.26$, $P = 0.151$; non-affected: $r_s = -0.153$, $P = 0.403$) were found in individuals with thumb CMC OA.

Discussion

The main finding of the present study was a bilateral pressure pain hyperalgesia locally over the first CMC joint and over the unciform apophysis of the hamate bone in individuals with unilateral thumb CMC OA as compared with age- and sex-matched healthy controls. No significant differences in pressure pain sensitivity over a pain-free area, such as the lateral epicondyle, were found. Our findings may suggest that patients with unilateral thumb CMC OA exhibit sensitization mechanisms at the neurons of the spinal cord but probably not central sensitization. In addition, no significant association between pressure pain sensitivity and pain intensity was found.

Sensitization Mechanisms in Thumb CMC OA-Related Pain

The presence of bilateral pressure pain hyperalgesia over the hand in patients with thumb CMC might argue for the hypothesis that sensitization mechanisms at the dorsal horn level are involved in the pathogenesis of CMC OA-related pain.

In agreement with current results, previous studies have also demonstrated the presence of bilateral pressure pain hyperalgesia in unilateral local pain disorders of the upper extremity, e.g., lateral epicondylalgia [22] and carpal tunnel syndrome [23]. Similarly to our study, these studies found mirror sensitization mechanisms in unilateral local pain syndromes, suggesting the presence of, at least, sensitization at the dorsal horn neurons. The hypothesis that sensitization mechanisms are involved in OA-related pain is not new. Previous studies have reported central sensitization in patients with knee OA. Arendt-Nielsen et al. [26] found that patients with severe painful knee OA exhibited enhanced temporal summation of pain and impaired diffuse noxious inhibitory controls. Additionally, sensitization mechanisms at the contralateral side have been also reported in knee OA. Imamura et al. [30] found that patients with moderate-to-severe persistent knee OA pain and disability exhibited bilateral lower PPT than controls. Bajaj et al. [27] showed deep hyperalgesia and increased referred pain areas in the tibialis anterior muscle in patients with knee OA observing also bilateral effects. Creamer et al. [38] reported that injection of local anesthetic into one knee relieved pain in the contralateral non-injected knee. These clinical results in humans agree with findings previously reported in animals where unilateral musculoskeletal pain also spreads contralaterally [39]. Current and previous findings support the presence of sensitization at the dorsal horn neurons in patients with OA-related pain.

Nevertheless, in our study, we did not find pressure pain hypersensitivity over distant pain-free areas, e.g., the lateral epicondyle, in patients with thumb CMC OA. Our results are in contrast with previous studies reported generalized pressure pain hyperalgesia over the symptomatic area and over distal pain-free points in other musculoskeletal pain conditions [13,26,30]. Similarly to our findings, Uthaikhup et al. [40] did not also find differences in pressure pain sensitivity over symptomatic (upper neck) and distal pain-free points (forehead and tibialis anterior) in headache elder people. On the contrary, others have found that younger headache population exhibits widespread pressure hyperalgesia than healthy people [19,20,41]. Uthaikhup et al. [40] explained discrepancies on pressure pain sensitivity by age due to changes in anatomical, physiological, and biomechanical structure of peripheral pathways involved in pain processing mechanisms [42]. In fact, it has been recently shown that although there may be functional changes along neural pathways in elderly, the cortex of elderly people is still capable of plastic changes that may compensate for the alterations naturally occurring with age

[43]. Because the mean age of the population included in our study was 80 years, it is possible that age influenced the results related to the absence of pressure pain hypersensitivity over distant pain-free areas. However, there is no published study investigating pain mechanisms in musculoskeletal disorders including patients with this age; therefore, a comparison of our data is difficult at this moment.

Thus, our results support the presence of sensitization mechanisms supported by the presence of bilateral pressure pain hypersensitivity over both hands; however, it is difficult to establish if findings over the lateral epicondyle are a feature of thumb CMC OA in this aged population or if they are the consequence of functional are related changes in the central nervous system.

The presence of sensitization mechanisms in local pain syndromes suggests that sustained peripheral noxious input to the central nervous system may play an important role in initiating and maintaining central sensitization [22,23]. However, we found a lack of association between pressure pain sensitivity and intensity of pain suggesting that peripheral sensitization might not play a key role in this sample population. This may be also related to aging differences in pain perception and pain processing. Future studies are now needed to determine the relationship between peripheral and central sensitization mechanisms in individuals with thumb CMC OA.

Methodological Considerations

Although the results of the current study are relevant for a better understanding of pain mechanisms in thumb CMC OA, some potential limitations should be considered.

First, it is known that pressure pain sensitivity can be influenced by depression or anxiety. However, this is unlikely in our study as we excluded individuals with depression (>6 points in the BDI-II) and/or anxiety symptoms (>30 in the STAI). Second, another limitation can be related to the lack of blinding of the subjects to the assessment procedure. This pitfall of quantitative sensory testing might have introduced confounding in current results. Third, we cannot completely exclude that all individuals with CMC OA did not exhibit any sign of early structural X-ray changes over the non-dominant hand. Although subjects with radiographic alterations over the non-dominant hand were excluded from this study, early asymptomatic changes might be undetected by standard X-rays. The odd of developing radiographic CMC OA at the contralateral side has been found to be very high in a sample of Japanese women [44]. Additionally, Caspi et al. [45] showed that elderly individuals with thumb CMC OA tended to exhibit a high prevalence for this disorder in the non-dominant hand with time. However, the evidence deriving from these studies is not applicable to our study because we excluded individuals with radiographic evidence of OA over the non-dominant hand. In addition, there is no evidence investigating if early asymptomatic OA changes can influence PPT. Although Finan et al. [46] observed reduced PPTs in subjects with knee OA who presented mild structural changes and elevated clinical pain intensity, their findings cannot be generalized to the subjects of our study who did not display any pain symptoms in the non-dominant hand. Fourth, pressure pain sensitivity was only assessed over local areas and the lateral epicondyle (segmental related area to the radial nerve). Therefore, it would be necessary to investigate if other distant pain areas (e.g., the cervical spine or the tibialis anterior muscle) also exhibit pain sensitivity to pressure to further confirm the presence of widespread sensitization in this pain population. Additionally, it would also be interesting to investigate other somatosensory tests, e.g., thermal pain thresholds or stimulus-response functions to determine the presence of central sensitization in individuals with thumb CMC OA. At last, we included a very old sample population. Considering age-related changes in pain processing [42,43], a similar study should be conducted in younger subjects who exhibit thumb CMC OA.

Conclusions

The current study found bilateral pressure pain hypersensitivity over the CMC joint and the hamate bone, but not over the lateral epicondyle, in individuals with unilateral thumb CMC OA. Our results suggest that sensitization mechanisms at the spinal cord neurons are involved in this population. Future studies should analyze the presence of widespread pressure pain sensitivity in patients with thumb CMC OA to further confirm or refute the presence of central sensitization in this population.

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