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THE EXTENT OF PAIN IS ASSOCIATED WITH SIGNS OF CENTRAL SENSITIZATION IN PATIENTS WITH HIP OSTEOARTHRITIS

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ABSTRACT

Background: Central sensitization may be present in some patients with hip osteoarthritis (OA), often reflected as widespread pain. We examine the association between pain extent with signs of central sensitization and other clinical and psychological features in patients with hip OA.

Methods: Thirty patients with hip OA were recruited for this cross-sectional observational study. Participants completed pain drawings on a digital tablet, which displayed frontal and dorsal views of the body. The pain extent (%) for each participant was determined by combining the frontal and dorsal pixels shaded and dividing by the total pixels of the body chart area. Participants completed patient reported outcome measures to assess for signs and symptoms of central sensitization and psychosocial factors. Quantitative sensory testing including pain pressure thresholds (PPTs) and Thermal Pressure Thresholds (TPTs) was performed at points anatomically local and distant from the hip.

Results: Women had significantly greater pain extent (6.71%) than men (2.65%) ($z= -2.76$, $p <0.01$). Across all participants, increased pain extent was significantly associated with higher scores on the Widespread Pain Index ($r_2=0.426$, $p<0.05$), Pain Detect ($r_2=0.394$, $p<0.05$) and Pain Catastrophising Scale ($r_2=0.413$, $p<0.05$), and with lower PPTs at the thenar eminence ($r_2=-0.410$, $p<0.05$), vastus lateralis ($r_2 =-0.530$, $p<0.01$), vastus medialis ($r_2=0.363$, $p<0.05$) and greater trochanter ($r_2=-0.373$, $p<0.05$).

Conclusions: Greater pain extent was associated with several measures of signs and symptoms of central sensitization in patients with hip OA. These results support the utility of the pain drawing for identifying signs of central sensitization in patients with hip OA.

INTRODUCTION

Osteoarthritis (OA) is the largest cause of individual level disability and costs for healthcare systems worldwide.[1] With populations living longer, healthcare costs related to OA are likely to escalate further.[2] The hip is the second most common site for OA after the knee[3,4] with a lifetime prevalence of approximately 25% in adults.[5] The prevalence of hip OA increases with age with women generally more likely to have painful hip OA and to seek treatment than men.[4] In addition to pain, patients with hip OA complain of physical symptoms including stiffness and muscle weakness[3], and may present with psychological features including anxiety and low mood, which negatively affect quality of life.[6] Early diagnosis of OA is critical to successful management. Diagnosis of OA can however be challenging as symptoms do not always correlate well with the degree of articular damage present on imaging.[7] There is increasing evidence that central sensitization may be present in a sub-group of patients with hip OA,[8-10].

Central sensitization involves several complex neurological reactions ultimately leading to an increased responsiveness of the neurons within the central nervous system to painful stimuli.[11] Patients who present with central sensitization as their dominant pain mechanism likely require specific/tailored treatment strategies to improve clinical outcomes.[8] Features of central sensitization include symptoms of high severity and irritability,[12] including an increased sensitivity to painful stimuli (hyperalgesia),[13,14] and the maintenance of symptoms in the absence of associated physical damage.[15] A further feature of central sensitization is widespread pain, which is pain experienced beyond the expected anatomical distribution of the pathology.[16] Widespread pain has been identified as a common symptom in patients with hip OA[10,17,18]. And

enlarged pain extent has been associated with magnified pain levels[19-21] and psychological distress[21] in patients with knee OA .

Pain drawings offer a practical way of quantifying pain extent and have been used to quantify the distribution of pain in patients with hip[22] and knee[23] OA, greater trochanteric pain syndrome,[24] low back pain,[25] fibromyalgia,[26] carpal tunnel syndrome,[27] chronic spinal pain,[28] whiplash associated disorder,[29] migraine,[30] and tension type headaches.[31] To date, only one study has examined the association between pain extent and clinical features of central sensitization in patients with OA.[23] Lluch Girbres et al.,[23] found that pain extent was greater in women, and associated with increased local pain severity and stiffness and reduced local and distant pain pressure thresholds in patients with knee OA. The authors suggested that pain drawings could be used easily in the clinic and recommended that further research was needed to better understand the association between greater pain extent and other clinical features in patients with OA.[23]

Although pain drawings have been used in patients with hip pain,[17,18,22,32,33] these studies have used pain drawings to describe but not quantify the distribution of symptoms. The most common pain distributions found in patients with hip OA were the groin, gluteal area, and anterior thigh,[17,18,22,32,33] with the greater trochanter also documented as an important site of symptoms.[18,22] Interestingly, larger pain areas were noted in approximately half of patients with hip OA who were either awaiting arthroplasty,[17] or had dysplasia.[18]

In this study we use a contemporary method to quantify the location and extent of pain in people with hip OA from a digital pain drawing and evaluate the association between pain extent and both clinical and psychological features. Specifically, we aimed to investigate whether an association exists between pain extent and perceived symptom severity, disability, and psychological features (through patient reported outcome measures) and physical measures of

pain perception (through quantitative sensory testing) in people with hip OA. Additionally, we evaluated whether differences in pain extent exists between men and women with hip OA.

METHODS

Study Design and setting

This cross-sectional observational study was conducted in the Pain Clinic of the Department of Anesthesiology, University Medical Center Gottingen, in the Georg-August-University of Gottingen in Germany, and is reported in line with the Strengthening the Reporting of Observational Studies in Epidemiology statement (STROBE).[34] The study was approved by the University Medical Center Gottingen ethics committee (reference number 27815) and was conducted according to the Declaration of Helsinki.

Participants

A convenience sample of thirty participants with hip OA were recruited via flyers placed in the University Hospital Gottingen Orthopedic Department, local orthopedic and physiotherapy practices, and by advertisements taken out in local newspapers. Based on the primary study aim of investigating associations between pain extent and signs and symptoms of central sensitization, a power level of 95% (β), an alpha level of 0.05 (α) and a significant 'moderate' correlation (r =0.6) , a minimum sample of 25 participants was originally targeted. Participants were aged between 40-70 years, with a primary diagnosis of hip OA based on the International Classification of Diseases (ICD). Participants were excluded if they had other painful conditions (e.g. chronic cervical or lumbar pain, fibromyalgia, or rheumatic conditions). co-morbidities, such as severe cardiovascular, cognitive or neurological dysfunctions, or if their body-mass index (BMI) was >32. Those who were ingesting centrally acting analgesics were excluded,

while those taking non-opioid medication in moderate doses, or as needed, were included. Participants were requested to not take any non-opioid medications on the day of testing and were required to be able to give informed written consent to participate.

Digital pain drawings

Participants used a stylus pen (CS100B, Wacom, Vancouver, WA, USA) to define areas of pain on a digital tablet (iPad 2, Apple Computer, Cupertino, CA, USA) using a commercially available sketching software (SketchBook Pro) as previously described.[28] Different body charts showing either a male or female body chart with different views (frontal, dorsal) were selected and opened in the sketching software. The type, size, and color of the pen stroke were standardized for all participants. One researcher (MS) instructed the participants on the use of the digital tablet to complete the pain drawing and gave a brief demonstration and training to aid familiarization. The researcher emphasized the importance of comprehensively shading all painful areas, irrespective of their intensity or type.[23] The pain drawing was presented to the participant and the researcher used the standardized instruction 'Please draw where you felt your usual pain during the last week on this body chart and try to be as precise as possible'.[23] Once the participant had completed the drawing, the researcher asked the participant to confirm that the pain drawing fully corresponded to their pain distribution, and the participants were given an opportunity to edit the drawing prior to being saved.[23] This method has shown good test-retest reliability within lumbar (intraclass correlation coefficients (ICC = 0.97) and cervical (ICC = 0.92) pain populations previously.[28]

Pain extent expressed as the combined number of pixels coloured inside the frontal and dorsal body charts (the total area of pain for each participant) was measured using custom software for the analysis of pain drawings which was developed in Matlab®.[26,28,29,35] Pain

frequency and pain location maps were also computed as previously described[26,28,29,35]. The pain frequency map is a function in which all the pain drawings are overlaid and analyzed simultaneously to indicate the most frequently reported location of pain across all included participants. Pain location was determined by dividing the body charts into 45 anatomical regions (22 frontal and 23 dorsal). The number of participants who reported pain in each region was illustrated using coloured Histograms.[28] Pain extent, frequency, and location were computed for women and men separately.

Patient Reported Outcome Measures

All participants were asked to complete the German version of several patient reported outcome measures including:

Measures of signs and symptoms of central sensitization and neuropathic pain:

- Fibromyalgia Survey Questionnaire (FSQ): A validated measure which evaluates physical and emotional distress based on the preliminary American College of Rheumatology (ACR) criteria, indicating a survey based diagnosis of fibromyalgia to be made through patient self-report which, however, may differ from the clinical diagnosis.[36] The FSQ combines the symptom severity score (SSS) with the widespread pain index (WPI). The SSS evaluates symptoms relating to sleep, fatigue, troubled thoughts and any additional symptoms on a 0-3 scale (0=not present to 3=extreme), with a score ranging from 0 to 12. Patients were also asked if they experienced headaches, depression, or pain in lower abdomen, which were coded to be present (1) or not present (0). The WPI includes 19 non-articular pain sites, with each site being rated as 1 point.

Patients who score ≥ 7/19 on the WPI and ≥5/12 on the SSS or 3-6/19 on the WPI and ≥ 9/12 on the SSS are considered to have a diagnosis of fibromyalgia according to the Fibromyalgia Survey Diagnostic Criteria (FSDC).[37]

- PainDETECT (PD-Q): A validated measure that can be used as a screening tool for neuropathic pain,[38] the PD-Q evaluates pain intensity, characteristics, pattern and distribution to give a combined score out of 38, with a higher score being related to increased pain. A total score of ≥19 is indicative of neuropathic involvement with a 90% probability.[38] For the purpose of this study, only the descriptive items were analyzed, indicating the level of neuropathic pain like chracteristics.[39]

Hip Symptoms:

- Oxford Hip Score (OSH-D): A 12-item measure which assesses stiffness, pain and physical disability in patients with hip OA with the German version demonstrating reliability and validity. Each item has 5 possible responses (scored 1-5), giving a maximum score of 60, with higher scores indicating increased difficulties with activities of daily living.[40]
- The Von Korff Scale (VKS): A measure of chronic pain[41] which grades pain intensity and disability and its German version has shown to be reliable and valid. The tool incorporates 6 items detailing pain intensity and impairment which are measured on 11-point numerical scales (0-10) and the number of disability days.[42] Patients are then ‘graded’ as chronic pain grade I

(low disability, low pain intensity), II (low disability, high pain intensity), III (high disability, moderately limiting) or IV (high disability, severely limiting).[41,42]

- Visual Analogue Scale (VAS): A widely used measure that evaluates pain intensity[43] that has demonstrated reliability and validity for patients with OA.[44] The VAS uses a 10cm line with 'no pain' and 'worst possible pain' located at each end and participants were asked to indicate their average pain over the past four weeks by applying a vertical mark on the line.[43]

Psychosocial symptoms:

- Pain Catastrophizing Scale (PCS): A measure that evaluates pain catastrophizing, an important maladaptive psychological mechanism.[45] The German version has been validated on patients with chronic pain[45] and has been used extensively to assess knee OA populations.[46,47] The PCS has 13 items which are rated on a 5 point scale (scored 0-4) for a total score up to 52 points with higher scores equating to increased catastrophizing.[46]
- Tampa Scale for Kinesiophobia (TSK): A tool to evaluate fear of movement or re-injury in patients that has been validated and demonstrated reliability in German.[48] The TSK is a 17 item self-rated measure which uses a 4-point likert scale (1: 'Strongly disagree; 4: Strongly agree) with higher scores indicating increased apprehension.[49,50]
- Chronic Pain Acceptance Questionnaire (CPAQ): A valid and reliable tool[51] which is the most commonly used self-report method to quantify pain acceptance in chronic pain populations.[23] The CPAQ incorporates two

factors: activity engagement and pain willingness, measured on a 7 point scale, from 0 (never true) to 6 (always) across 20 items, with higher scores indicating higher acceptance of chronic pain (Range 0-120).[52]

- Depression, Anxiety, Stress 21 Scale (DASS): A valid[53] and reliable[54] self-report measure to detect psychological factors affecting patients pain experience.[54] The tool consists of the 21 questions (7 each for depression, anxiety and stress respectively) which are scored on 4-point ordinal scales from 0 'did not apply to me at all' to 3 'applied very much to me most of the time'. A total score for each domain can be calculated by summing ordinal values and multiplying by 2 and each domain graded as normal, mild, moderate, severe or extremely severe.[53]

Quantitative Sensory Testing

One investigator (MS) conducted Quantitative Sensory Tests on all participants adapting a standardized protocol from the German Research Network on Neuropathic pain (DFNS).[55] All participants were instructed by the investigator using standardized instructions[55] and were familiarized with the testing procedures on neutral body sites. Testing was performed ipsilateral to the side of the painful hip with a mean of three scores taken as the final score for each reading.[55] A 30 second rest period was provided between repetitions.[56,57]

Pain Pressure Thresholds: Pain pressure thresholds (PPTs) were measured using a digital pressure algometer (Somedic Production, Stockholm, Sweden, Probe tip 1cm2) with pressure stimulation increasing at 50 kPa/s. PPTs were assessed at the greater trochanter (5cm distal and 2cm anterior to Greater trochanter)[9], gluteus medius muscle (3cm distally from the Iliac crest of

the proximal part of the muscle belly),[58] vastus medialis (3cm medial to the central point on medial aspect of patella)[59], vastus lateralis (3cm lateral to the central point of lateral aspect of patella)[59], tibialis anterior (2.5cm lateral and 5 cm inferior to the tibial tubercle)[60], and thenar eminence. Participants were asked to state the moment the sensation on their skin changed from one solely of pressure to an additional "burning", "stabbing", "piercing" or "tearing" sensation, as described in the protocol of the DFNS. The participants were advised to indicate, by pushing a button, when the sensation on the skin changed from just pressure to pain.

Thermal detection and pain thresholds: thermal testing was performed with a Thermal Sensory Analyser II (Medoc, Israel).[55] A 3x3 cm thermode which applies warm and cold stimuli was placed over the skin and starting at 32°C, the device decreased or increased the temperature by 1°C/s. Thermal detection thresholds and pain thresholds were tested over the greater trochanter (5cm distal and 2cm anterior to greater trochanter),[9] and the thenar eminence. A temperature limit was set for 50°C and 0°C. For the cold and warm detection thresholds (CDT, WDT respectively), the participant was asked to press a stop button as soon as the perception of cold/warmth occurred respectively. For the cold and heat pain thresholds (CPT, HPT respectively), the participant was advised to press a button as soon as the feeling changed from just cold/heat into an additional "burning", "stabbing", "piercing" or "tearing" sensation, as described in the protocol of the DFNS.

Statistical Analysis

Descriptive statistics outlined participant symptom characteristics including their pain, hip functional, and psychosocial levels. For descriptive purposes, pain frequency and location maps

were created. The data distribution was initially assessed with the Shapiro-Wilk test which demonstrated a non-normal distribution. Therefore, a Mann-Whitney U test was used to assess for differences in pain extent (shown in pain drawings) between men and women and Spearman (non-linear) correlation coefficients were used to investigate the relationship between pain extent and:

1) Patient reported outcome measures, including measures of widespread pain and neuropathic pain (FSQ-WPI and PD-Q), hip symptoms (VAS, OHS and VKS), and psychosocial variables (PCS, TSK, CPAQ, and DASS).
2) QST data (PPTs and TPTs).

The statistical analysis was conducted using International Business Machines Statistical Package for the Social Sciences (IBM Corp, Armonk, NY, USA) version 25 and the level of significance was set at <0.05.

RESULTS

Thirty participants with hip OA (15 female) were enrolled in the study. Participant characteristics including their descriptive information (gender, age, BMI, VAS score), patient reported outcome scores, and QST data are included in Table 1. Figures 1 and 2 detail the pain frequency and location maps respectively, with dorsal and frontal views for men and women displayed separately. The mean pain extent was 6.71% (of the total body chart area) for women and 2.65% for men respectively. The Mann Whitney U test demonstrated a statistically significant difference ($z= -2.76$, $p<0.01$) in mean pain extent between men and women . The pain frequency (Figure 1) and location maps (Figure 2) demonstrated that the most common site of symptoms were located around the hip joints, gluteal region and lumbar spine for both male and female

participants. However, several participants experienced pain beyond the immediate anatomical regions with women showing higher levels of bilateral and widespread pain than men. In particular, the male participants did not report pain anteriorly above the abdomen or down either arm. Male participants also reported cases of shoulder (4), neck (3), head (2), and distal leg symptoms compared with females. No significant correlation was found between pain extent and participant age (r_s = -0.1682) or BMI (r_s = -.009) (Table 2).

Relationship between pain extent and patient reported outcome measures

Pain extent scores demonstrated statistically significant positive associations with scores on the Widespread Pain Index (r_s = 0.426, p< 0.05), Pain Detect (r_s = 0.394, p<0.05) and the pain catastrophizing Scale (r_s = 0.413, p<0.05). No statistically significant associations were found between pain extent and VAS (r_s,= 0.187), FMS-SSS (r_s = 0.354), OHS (r_s = 0.314), VKS (r_s = 0.308), TSK (r_s = 0.172), DASS-D (r_s = 0.316), DASS-A (r_s = 0.312) or DASS-S (r_s = 0.245).

Relationship between pain extent and QST data

Pain extent scores were significantly associated with lower PPTs at the thenar eminence (r_s = -0.410, p<0.05), vastus lateralis (r_s = -0.530, p<0.01), vastus medialis (r_s = -0.363, p<0.05) and greater trochanter (r_s =-0.373, p<0.05). Pain extent was also associated with higher CPTs at the greater trochanter (r_s = 0.503, p<0.01), reduced HPTs at the greater trochanter (r_s= -0.382, p<0.05), and reduced WDTs over the thenar eminence (r_s = -0.390, p<0.05). No significant associations were observed between pain extent and PPTs measured over the tibialis anterior (r_s,= -0.354) or gluteus medius (r_s,=-0.345). No significant association was measured between pain extent and HPTs (r_s= -0.337), CPTs (0.259), or CDTs (r_s= 0.079) over the thenar eminence. No

significant association was calculated between pain extent and WDTs (r_s = -0.085) or CDTs (r_s = -0.134) measured over the greater trochanter.

DISCUSSION

This is the first study to evaluate pain extent and relate it to symptoms of central sensitization in participants with hip OA. The use of digital pain drawings has been shown to be reliable in patients with chronic spinal pain[28] and was recommended to reduce errors in transferring images to a digital medium, while allowing for corrections to be made by patients prior to being uploaded.[22] Based on our results and similar studies[22,23], digital pain drawings offer a convenient method for researchers and clinicians to quantify pain extent in patients with OA. Other studies using pain drawings on patients with hip pain have utilized participants awaiting, or having had, operative procedures with unclear[33] or heterogenous clinical populations.[17,32,61,62] Only one study has targeted patients with mild to moderate hip OA specifically[22], but focused on description of symptom distribution only.

The pain frequency maps demonstrated that participants experienced pain beyond the hip region and immediate surrounding anatomical regions. The pain location map demonstrated that the most common areas of pain in both genders were the buttock, lumbar spine, and anterior thighs. Interestingly there were few participants who reported pain in the posterior thigh which is similar to other studies examining pain extent in patients with hip OA.[22] In general, women demonstrated greater pain extent bilaterally, anteriorly proximal to the abdomen, and distal to the knee. However men reported minimal symptoms in the thoracic region (especially anteriorly), arms and head or face. The descriptive detail from the pain frequency and location maps was reinforced by the pain

extent calculations, which demonstrated that women presented with larger pain extent compared to men. This is consistent with results from studies investigating patients with whiplash[29] and knee OA.[23] As an exclusion criteria for this study was other painful conditions, these results have potentially important clinical implications. Therefore, clinicians and researchers should be aware that patients with hip OA, especially women, often present with symptoms of widespread pain.

Patient reported outcomes assess components of central sensitization but currently, due to the complexity of patient presentations, the inclusion of key subjective indicators and physical examination techniques are required for diagnosis.[16] The Fibromyalgia Survey Questionnaire (FSQ), which was designed for a patient population with well-recognized signs and symptoms of central sensitization (i.e. fibromyalgia),[63,64] was chosen as an indirect measure of signs and symptoms of central sensitization for this study. While, no association was found between pain extent and the Symptom Severity Subscale, a significant association was found with the WPI.[36] As the WPI determines the extent and location of pain distribution it is perhaps not surprising that a significant association was found with pain extent. Increased pain extent was also significantly associated with higher PainDETECT scores. This is consistent with other studies in patients with hip[9] and knee OA[65,66] which showed that increased PainDETECT scores were associated with clinical signs of central sensitization.

Although this study shows significant associations between increased pain extent and these indirect measures of signs and symptoms of central sensitization, further research is required to consolidate these findings. Currently, there is a lack of consensus over the most appropriate patient reported outcome measure to assess for signs of central sensitization and therefore, the validation of an appropriate tool in patients with hip OA is a research priority.

Larger pain extent was associated with reduced PPTs at four of six sites (thumb, vastus lateralis, vastus medialis, and greater trochanter), three of which were remote sites. These results suggest that the participants in this study demonstrated secondary hyperalgesia, which is a key indicator of central sentitization[15] and is in agreement with other studies on patients with hip OA.[9,67] Taken collectively, these results suggest digital pain drawings could be used clinically as an appropriate screening tool for central sensitization in patients with hip OA.

No significant association was found between pain extent and pain intensity (measured on the VAS) or levels of function and disability (measured on the VKS or the OHS respectively) which contrasts studies conducted on patients with knee OA,[23] and women with fibromyalgia.[26] This may be associated with the mild to moderate symptoms of this studies cohort, or could suggest that the primary pain mechanism underlying hip OA is not from peripheral nociceptive input.[26,68] The presence of secondary hyperalgesia highlighted above has been associated with dysfunction in the descending inhibitory systems and adds further evidence to the suggestion that central changes may be present in patients with hip OA.[24]

Overall TPT testing showed inconsistent results with with three of eight sites (37.5%) demonstrating a significant correlation with pain extent. Interestingly, local thermal pain threshold (greater trochanter HPT and CPT) showed a significant correlation with pain extent while detection thresholds (greater trochanter WDT and CDT) did not. Although altered processing of thermal stimulus has been associated with both central sensitization[69] and small fibre dysfunction in neuropathic pain states[26,28], these TPT values appeared to be within normal limits. Therefore, limited conclusions can be drawn from the TPT. TPT testing represents a gap in the evidence base that could be explored more thoroughly in future studies.

A significant correlation was observed between larger pain extent and the degree of pain catastrophizing, an indication of whether participants fixate on, or feel despondent about their ability to control their pain.[46] Apprehension to movement has been identified as a predictors for developing chronic pain,[70] and a previous study demonstrated differences in the Tampa Scale of Kinesiophobia (TSK) scores between patients with hip OA and controls.[9] However, our study found no correlation between pain extent and TSK scores, which is consistent with previous knee OA[23] or whiplash[29] studies. Furthermore, no other significant correlations were identified with the other psychosocial patient reported outcome measures (PAQ and DASS sub-scores). Carnes et el., (2006)[71] systematically reviewed the value of pain drawings in predicting psychosocial distress but found insufficient evidence to support this. Of 19 included studies, only 3 showed significant associations between pain drawings and levels of psychological distress and no studies included patients with hip OA.

Central sensitization involves the altered functioning in several overlapping components of the nervous system, including the facilitatory and inhibitory aspects of the descending neurons which moderate nociceptive input,[64] and increased activity in several supra-spinal centres such as the such as the anterior cingulate cortex , prefrontal cortex, and limbic system.[72] This neurological complexity leads to great heterogeneity in clinical symptom presentation and although a classification system has been suggested for identification of central sensitization,[16] it has not been validated in OA populations to date. Therefore, the underlying complexity of central sensitization may reflect the infrequent associations measured between increased pain extent and the potential presence of neuropathic pain and psychosocial distress.

Methodological considerations

To date, no data exists on pain drawing reliability in patients with hip OA. However, test-retest reliability of pain drawings has already been established for patients with spinal pain[28] and during provoked pain in asymptomatic subjects[35], which suggests that pain drawings may well be reliable in this study too. The sample size was relatively small in this study and the participants had mild to moderate hip OA. Furthermore, there were no matched control participants in this study. Therefore, the results may not be generalizable to all patients with hip OA, especially those with more severe symptoms, and future research could determine normative TPT values both local and distant to the hip in asymptomatic participants so these results can be placed in context.

Conclusion

Increased pain extent in people with hip OA was associated with higher scores on the Widespread Pain Index, PainDETECT, and the Pain Catastrophising Scale. Additionally, larger pain extent was associated with lower PPT measured both locally and at remote sites. Pain drawings may be useful clinically to identify increased pain extent, thereby contributing to early diagnosis of central sensitization. Future research should determine the reliability and validity of pain drawings and establish a validated patient reported outcome measure to evaluate for the presence of central sensitization in patients with hip OA.

Declaration of interest

All authors declare no conflicts of interest.

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FIGURE LEGENDS

Figure 1: Pain frequency maps generated by superimposing the pain drawings of all participants included in the study. Pain frequency maps have been generated separately for men and women and include the dorsal and ventral view. The color grid indicates both the number and the percentage of individuals that reported pain in that specific area. Darker colors represents the most frequently reported area of pain.

Figure 2: Pain location analysis which shows the number of individuals reporting pain in a specific body region. Darker colors represent a higher number of people reporting pain in a specific body region.