Altered Central Pain Processing in Patients With Chronic Plantar Heel Pain: A Critically Appraised Topic

Dhinu J. Jayaseelan, Cesar Fernandez-de-las-Penas, Taylor Blattenberger, and Dean Bonneau

Clinical Scenario: Plantar heel pain is a common condition frequently associated with persistent symptoms and functional limitations affecting both the athletic and nonathletic populations. Common interventions target impairments at the foot and ankle and local drivers of symptoms. If symptoms are predominantly perpetuated by alterations in central pain processing, addressing peripheral impairments alone may not be sufficient. **Clinical Question:** Do individuals with chronic plantar heel pain demonstrate signs potentially associated with altered central pain processing? **Summary of Key Findings:** After searching 6 electronic databases (PubMed, CINAHL, Scopus, SportDiscus, Cochrane, and PEDro) and filtering titles based on predetermined inclusion and exclusion criteria, 4 case-control studies were included. All studies scored highly on the Newcastle-Ottawa Scale for quality assessment. Using pressure pain thresholds, each study found decreased pressure pain hypersensitivity locally and at a remote site compared to control groups, suggesting the presence, to some extent, of altered nociceptive pain processing. **Clinical Bottom Line:** In the studies reviewed, reported results suggest a possible presence of centrally mediated symptoms in persons with plantar heel pain. However, despite findings from these studies, limitations in appropriate matching based on body mass index and measures used suggest additional investigation is warranted. **Strength of Recommendation:** According to the Oxford Centre for Evidence-Based Medicine, there is evidence level C to suggest chronic plantar heel pain is associated with alterations in central pain processing.

Keywords: pain mechanisms, plantar fasciitis, plantar fasciopathy

Plantar heel pain is a highly prevalent condition accounting for between 20% and 39% of lower-extremity painful disorders affecting both athletic^{1,2} and nonathletic³ populations. Conservative treatment represents the first therapeutic line for this condition. Several interventions, including corticosteroid injections, exercise, extracorporeal shockwave therapy, or manual therapy, are proposed for the treatment of plantar heel pain. However, current evidence is equivocal regarding which treatment is the most effective.⁴ Most treatment approaches proposed for the management of plantar heel pain—for example, corticosteroid injections or extracorporeal shockwave therapy—are mainly based on localized interventions targeting the foot and/or ankle.⁴ Local treatments mainly target peripheral (localized) nociceptive input, although an indirect effect on the central nervous system is also feasible. If plantar heel pain is primarily mediated by peripheral mechanisms, therapeutic strategies targeting tissues potentially related to the peripheral input and local exercises should be encouraged. It has been recently proposed that individuals with plantar heel pain may exhibit altered nociceptive processing involving a hyperexcitability of the central nervous system or inhibition of conditioning pain modulation systems. The presence of an altered nociceptive central pain processing would lead to changes in the clinical reasoning for the management of these patients, because in those individuals primarily mediated by central mechanisms, multimodal integrative

treatments including physical, psychological, or cognitive and educational approaches should be applied.

Therefore, the purpose of this critically appraised topic was to review current evidence regarding the presence of altered nociceptive central processing in people with plantar heel pain.

Focused Clinical Question

Do individuals with chronic plantar heel pain demonstrate signs associated with altered central pain processing?

Summary of Search, Best Evidence Appraised, and Key Findings

Six electronic databases were searched from inception through July 1, 2020, using relevant keywords and Medical Subject Heading (MeSH) terms for studies related to the clinical question, yielding 275 results.

After applying all inclusion and exclusion criteria; 4 studies, all case-control trials, were included in this review.⁵⁻⁸

Each study used some form of quantitative sensory testing (QST), typically pressure pain thresholds (PPTs) applied to both local and distant pain-free areas, to detect possible alterations in central pain processing in individuals with chronic plantar heel pain.

Clinical Bottom Line

The results of 4 well-performed case-control studies suggest altered central pain processing, demonstrated by widespread pressure pain hyperalgesia, may be present in people with plantar heel pain. Other methods of QST did not consistently reveal altered central

Jayaseelan and Bonneau are with the Department of Health, Human Function, and Rehabilitation Sciences, George Washington University, Washington, DC, USA. Fernandez-de-las-Penas is with the Department of Physical Therapy, Occupational Therapy, Rehabilitation, and Physical Medicine, Universidad Rey Juan Carlos, Alcorcon, Spain. Jayaseelan and Blattenberger are also with Virginia Orthopedic Manual Physical Therapy (VOMPTI), Orthopaedic Residency, Charlottesville, VA, USA. Jayaseelan (dhinuj@gwu.edu) is corresponding author.

pain processing, suggesting that findings may be test specific. If individuals present clinically with nervous system sensitization, treatment plans directed toward the peripheral pain location may not be as effective as more comprehensive programs also targeting central mechanisms. Clinical assessment of predominant pain mechanisms is warranted in order to inform decision making in this population.

Strength of Recommendation

According to the Oxford Centre for Evidence-Based Medicine's strength of recommendation, there is evidence Level C suggesting that chronic plantar heel pain may be associated with altered central pain processing. Level C evidence in this case is the result of level 4 studies (diagnostic case-control designs).

Search Strategy

The example keywords for each item of the clinical question used during electronic searches are as follows. Specific search strategies were modified as needed for different databases in order to obtain relevant results.

Terms Used to Guide Search Strategy

- Population—patients with chronic plantar heel pain (plantar fasciitis OR plantar fasciosis OR plantar fasciopathy OR plantar fasci* OR plantar heel pain OR policeman's heel OR policeman's heel)
- Intervention—N/A
- Comparison—healthy controls
- Outcome—evaluation of altered central pain processing (central sensitisation OR central sensitization OR centrally mediated OR nociplastic OR nociplasticity OR pressure pain threshold* OR PPT OR algometry OR hyperalgesia OR hypersensitivity OR allodynia OR quantitative sensory testing OR QST OR windup OR wind-up OR hyperexcitability OR somatosensory)

Sources of Evidence Searched (Number of Results)

- PubMed (n = 51)
- CINAHL (n = 37)
- Scopus (n = 33)
- SportDiscus (n = 16)
- Cochrane Library (n = 38)
- PEDro (n = 100)

Inclusion and Exclusion Criteria

Inclusion Criteria.

- Peer-reviewed article, full-text available
- English language
- Clinical diagnosis of plantar heel pain in one or more groups
- Symptom duration ≥ 3 months
- Clinical assessment of central pain processing was performed
- Control group present

Exclusion Criteria.

- No plantar heel pain diagnosis
- Acute pain reports (< 3 mo)
- No full-text available in English (eg, abstract only)
- No outcome measurement of central pain processing
- Single-arm design

Results of Search

In total, 275 titles were retrieved from electronic searches. After filtering titles based on predetermined criteria, 4 studies reporting on a total of 211 participants were retained for inclusion. Each study used a case-control design, as can be seen in Table 1. The primary reasons for exclusion were the lack of an assessment of central pain processing (eg, local PPT only) or no control group.

Best Evidence

The included studies most closely matched the established PICO question of all retrieved titles. Study characteristics, participant demographics, methodology, and results were extracted and are presented in Table 2. Each study was also appraised for quality using the Newcastle–Ottawa Scale. Each study was independently appraised by 2 authors (TB, DB), and in the case of discrepancy, a third reviewer (DJ) blinded to the previous voting was used to get a consensus. Quality appraisal scoring for each study can be found in Table 3.

Implications for Practice, Education, and Future Research

Plantar heel pain, classically termed plantar fasciitis or plantar fasciopathy, is a common condition affecting both athletic and non-athletic individuals. The condition often is a chronic problem, with mean symptom durations reported between 13.3 and 14.1 months.^{9,10} Given the high prevalence and persistence of symptoms in many individuals, it is important to identify possible factors contributing to the condition. In each study evaluated in this review, when compared to a control group, individuals with plantar heel pain demonstrated reduced PPT locally and at a remote pain-free site, suggesting the presence of altered central pain processing in some capacity.

A number of conditions with local pain reports have been linked to altered central pain processing, such as patellofemoral pain.¹¹ A substantial percentage of individuals with patellofemoral pain (57% in 1 study)¹² complain of persistent pain despite extensive research guiding best practice. Less than optimal outcomes may be linked to movement coordination impairments, muscle performance deficits, mobility impairments, or an inability

Table 1 Best Evidence

Author	Level of evidence	Study design
Fernandez-Lao, <i>Pain Med</i> , 2016	4	Case control
Plaza-Manzano, <i>J Pain</i> , 2019	4	Case control
Riel, <i>Scand J Pain</i> , 2020	4	Case control
Ríos-León, <i>J Orthop Sports Phys Ther</i> , 2019	4	Case control

Table 2 Summary of Evidence

Primary author	Fernandez-Lao, 2016 ⁶	Plaza-Manzano, 2019 ⁸	Riel, 2020 ⁵	Ríos-León, 2019 ⁷
Title	Assessment of pressure pain hypersensitivity, ultrasound image, and quality of life in patients with chronic plantar pain: a preliminary study	Widespread pressure pain hypersensitivity in musculoskeletal and nerve trunk areas as a sign of altered nociceptive processing in unilateral PHP	Local hyperalgesia, normal endogenous modulation with pain report beyond its origin: a pilot study prompting further exploration into plantar fasciopathy	Topographical pressure pain sensitivity maps of the feet reveal bilateral sensitivity in patients with unilateral PHP
Study design	Case control	Case control	Case control	Case control
Inclusion criteria	(1) First-time primary diagnosis of unilateral PHP based on pain during first steps after a period of rest when standing long durations (2) Lessened symptoms during low levels of activity such as walking (3) Tenderness to palpation around the medial calcaneal tuberosity (4) Radiographs ruling out other diagnoses	(1) Clinical PHP diagnosis: insidious onset of sharp pain on the plantar heel surface upon weight-bearing after a period of non-weight-bearing, heel pain increasing in the morning with the first step after waking up and pain with palpation of the proximal insertion of the plantar fascia (2) PHP duration > 3 mo (3) Unilateral symptoms (4) ≥ 18 y old	(1) PHP for ≥ 3 mo before enrollment (2) Average PHP intensity ≥ 2 on an 11-point numerical rating scale during the previous week (3) Thickness of the plantar fascia ≥ 4.0 mm measured by ultrasonography (4) Pain with palpation of the medial calcaneal tubercle or the proximal plantar fascia	(1) Clinical PHP diagnosis: insidious onset of sharp pain on the plantar heel surface upon weight-bearing after a period of non-weight-bearing, heel pain increased in the morning with the first step after waking up, and pain with palpation of the proximal insertion of the plantar fascia (2) PHP duration ≥ 3 mo (3) Unilateral symptoms (4) ≥ 18 y old
Participants	n = 44 (22 females) PHP group: n = 22, mean age: 47.9 (11.0) y Control group: n = 22, mean age: 47.2 (11.1) y *BMI not reported	n = 70 (34 females) PHP group: n = 35, mean age: 41.7 (37.5–45.9) y Control group: n = 35, mean age: 40.0 (35.9–44.1) y *BMI significantly higher in PHP group ($P < .01$)	n = 27 (18 females) PHP group: n = 16, median age (IQR): 47.0 (9.4) y Control group: n = 11, median age: 45.7 (12.8) y *BMI significantly higher in PHP group ($P < .002$)	n = 70 (34 females) PHP group: n = 35, mean age: 42 (10) y Control group: n = 35, mean age: 41 (11) y *BMI significantly higher in PHP group ($P = .04$)
Assessment of altered central pain processing	PPT	PPT	PPT, CPM, CPT, HPT, pain diagram	PPT
Testing sites	(1) Origin of plantar fascia (calcaneus bone) (2) A point in the middle of the plantar fascia (3) First metatarsal (4) Fifth metatarsal at the insertion of the plantar fascia (5) Soleus muscle belly (6) C5–C6 zygoapophyseal joint (7) Second metacarpal	(1) Origin of plantar fascia (calcaneus bone) (2) Medial gastrocnemius muscle belly (midpoint) (3) Tibialis anterior muscle belly (upper third) (4) Second metacarpal (5) Median nerve trunk in the cubital fossa (6) Ulnar nerve trunk in the cubital tunnel (7) Radial nerve trunk at the triceps intramuscular septum (8) Common peroneal nerve trunk posterior to the fibular head (9) Tibial nerve trunk at the popliteal fossa (10) Sural nerve trunk posterolateral to the Achilles myotendinous junction	(1) Plantar heel (2) Ipsilateral elbow	(1) First metatarsal (2) Third metatarsal (3) Fifth metatarsal (4) Abductor digiti minimi muscle belly (5) Flexor digitorum brevis muscle belly (6) Calcaneus bone
Main findings	PPT values were significantly lower bilaterally at all testing points in patients with PHP compared with the control group ($P < .001$). There was a significant interaction between group and side for PPT at the calcaneus bone ($F = 4.723$, $P \leq .033$)	ANCOVA revealed lower PPT at nerve trunks and musculoskeletal structures in persons with PHP compared with controls ($P < .001$). Female patients showed lower PPT than male patients in almost all points ($P < .001$). Significant between group differences in nerve trunk sensitivity were found but not between sides	The PHP group demonstrated lower PPTs at the plantar heel (effect size; $d = 1.8$), the lateral elbow (effect size; $d = 0.7$) compared with controls. Effect sizes for the thermal pain thresholds ranged from very small to medium (CPT: $d = 0.1$ – 0.5 ; HPT: $d = 0.2$ – 0.5). There was no difference in CPM between groups. Half of the PHP group self-reported widespread pain extending beyond the plantar heel	Subjects with PHP demonstrated lower PPTs bilaterally at all assessed points when compared with healthy controls ($P < .001$). Female subjects had lower PPTs than male subjects in all locations ($P < .001$)

(continued)

Table 2 (continued)

Primary author	Fernandez-Lao, 2016 ⁶	Plaza-Manzano, 2019 ⁸	Riel, 2020 ⁵	Ríos-León, 2019 ⁷
Level of evidence	IV	IV	IV	IV
Quality score (NOS)	9/9	9/9	9/9	9/9
Conclusion	Patients with chronic PHP exhibited bilateral and widespread hypersensitivity compared with healthy controls	Patients with unilateral PHP demonstrated widespread pressure pain hypersensitivity over both nerve trunks and musculoskeletal structures	Patients with PHP demonstrated mechanical hyperalgesia at local and remote sites compared with controls and pain extending beyond the plantar heel; however, CPM was not different between groups	Patients with unilateral PHP had generalized plantar region pressure sensitivity bilaterally

Abbreviations: ANCOVA, analysis of covariance; BMI, body mass index; CPM, conditioned pain modulation; CPT, cold pressure threshold; HPT, heat pressure threshold; IQR, interquartile range; NOS, Newcastle–Ottawa Scale; PHP, plantar heel pain; PPT, pressure pain threshold.

Table 3 Newcastle–Ottawa Quality Appraisal Scale

Primary author	Selection				Comparability		Exposure			Total score
	S1	S2	S3	S4	Ca	Cb	E1	E2	E3	
Fernandez-Lao ⁶	*	*	*	*	*	*	*	*	*	9/9
Plaza-Manzano ⁸	*	*	*	*	*	*	*	*	*	9/9
Riel ⁵	*	*	*	*	*	*	*	*	*	9/9
Ríos-León ⁷	*	*	*	*	*	*	*	*	*	9/9

Abbreviations: Ca and Cb, comparability of cases and controls; E1, ascertainment of exposure; E2, same method of ascertainment of cases and controls; E3, nonresponse rate; S1, adequate case definition; S2, representative of the cases; S3, selection of controls; S4, definition of controls.

to tolerate load demands.¹³ However, while additional research is necessary, persistent symptoms with peripheral conditions may be related to targeted interventions not appropriately matching the predominant pain mechanisms at fault.¹⁴ Similarly, plantar heel pain is notorious for having an extended symptom duration. The plantar fascia is consistently strained during weight-bearing activities,¹⁵ yet for many individuals, prolonged weight-bearing is a functional necessity that may perpetuate symptoms. Alternatively, the presence of sensitized nociceptive pathways or impaired descending pain modulation may contribute to the persistence of pain,¹⁶ suggesting that an investigation into pain processing in plantar heel pain is necessary.

In the athletic population, having persistent pain in weight-bearing activities can substantially limit performance capacity. There are numerous factors that play a role in return to play, whether physical, psychological, or externally driven. A variety of modes of exercise can reduce pain in people with plantar heel pain; however, exercise commonly prescribed for athletes in or out of season may not have systemic analgesic effects.^{17,18} Without addressing pain processing or descending inhibitory pathways, exercise may offer a temporary benefit, but long-term symptom modification may be limited. The findings of this review have important clinical implications, because if athletes are found to have altered pain processing, a multimodal approach integrating additional interventions should be used rather than strictly addressing the peripheral tissue(s) at fault.¹⁴

To clinically evaluate for altered central pain processing, PPT can be measured using a pressure algometer. The device is gradually and progressively directed toward the target tissue until the patient/client subjectively reports pain. With primarily peripherally presenting

conditions, such as plantar heel pain, local pressure sensitivity is expected.¹⁹ However, when PPT values are lower than available normative data at a matched site contralaterally or at a remote pain-free site, the individual likely has dysfunction centrally with pain processing in addition to peripherally at the target tissue.²⁰ With appropriate equipment, PPT can be easily measured in the clinical setting using an algometer or hand-held dynamometer, with good–excellent interrater and intrarater reliability reported.^{21,22}

In each study reviewed, PPT was significantly reduced at the involved foot in the plantar heel group compared to controls. Compared to the control groups, PPT was also significantly lower in the hand and neck (remote pain-free points) of the plantar heel group in 2 studies^{6,8} and the contralateral foot in 3 studies.^{6–8} In one study,⁵ PPT values were lower in the plantar heel pain group with a medium effect size (0.7) but not at a level of statistical significance. The same authors found that half of the individuals with heel pain reported widespread pain on their body charts; however, no significant between-groups differences were found in heat or cold thresholds or conditioned pain modulation. This suggests that pain processing in this population may be more sensitive to specific stimuli (ie, in this population, mechanical stimuli), but not to all stimuli or through descending pain modulation.⁵ In addition, 2 studies found females to have statistically significant lower PPT compared to males, implying that widespread hyperalgesia in this population may be correlated to gender.^{7,8} Identification of peripheral versus central nociceptive pathway sensitization in plantar heel pain would benefit from additional studies incorporating similar testing protocols.

While PPT was a measure of QST consistently found to be reduced locally and remotely in each study, results should

be interpreted with caution. Identifying central pain processing dysfunction in humans is challenging, so the use of multiple testing modalities is preferred in this detection. In the included studies, 3 studies used PPT as the primary assessment of central pain processing,^{6–8} while one study used additional QST measures.⁵ Additionally, the demographics of participants should be considered. Elevated body mass index (BMI) has been reported to be a risk factor in developing plantar heel pain.²³ In this review, 1 of the 4 studies did not report BMI or enough data to calculate BMI,⁷ and in 3 of the 4 studies, the chronic plantar heel pain group had significantly higher BMI than the controls.^{5,6,8} While plantar heel pain is common in the athletic and nonathletic populations, it is possible that participant morphology also plays a role in the results. Similarly, it is important to consider many variables that affect central sensitization or nociplastic pain presentations. For example, negative psychological variables have been linked to common peripheral overuse conditions of patellofemoral pain and tendinopathy.^{24,25} The role of psychological variables in plantar heel pain should be examined.

Based on the results of this review, there is preliminary evidence to suggest that central pain processing may be altered in individuals with chronic plantar heel pain. Despite its peripheral presentation, clinicians should not discount the possibility of altered central pain processing in the plantar heel pain population. Additional research into pain input and processing mechanisms associated with plantar heel pain is warranted.

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