Association Between Clinical and Neurophysiological Outcomes in Patients With Mechanical Neck Pain and Whiplash-associated Disorders

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Objectives: To investigate the association between pain, disability, trigger points (TrPs), and pressure pain thresholds (PPTs) in patients with mechanical neck pain (MNP) or whiplash-associated disorders (WAD).

Materials and Methods: In total, 46 MNP and 51 WAD patients underwent a physical examination consisting of cervical range of motion, PPTs in the upper trapezius and tibialis anterior muscles, TrPs examination in the upper trapezius, and collection of clinical data including disability, pain intensity, and spontaneous symptomatic pain area.

Results: A significantly moderate positive association between pain and disability was found in both groups ($P < 0.01$). Significantly negative associations between pain intensity and PPT in the upper trapezius ($P = 0.008$ and 0.041), pain and PPT in tibialis anterior ($P = 0.015$ and 0.038), disability and PPT in upper trapezius (both, $P = 0.006$) were also found in both MNP and WAD groups. Individuals with MNP showed significantly positive association between pain area and disability ($P = 0.034$) and negative association between disability and PPT in the tibialis anterior ($P = 0.003$). Patients with active TrPs in the upper trapezius exhibited higher intensity of neck pain, higher neck disability, and lower PPTs than those with latent TrPs in upper trapezius in both groups.

Discussion: The association between pain, disability, and PPTs is common in patients with neck pain regardless of the origin of neck pain. The presence of active TrPs was related to higher pain intensity and related-disability and lower PPTs.

Key Words: neck pain, whiplash, trigger points, pain, disability

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Neck pain is a frequent musculoskeletal disorder associated with disability and economic health costs[1] and it is classified as the 4th highest cause of years lived with disability by the Global Burden of Disease studies.[2] It has been estimated that around 70% of the general population will experience neck pain symptoms at some time during their lives.[2] The prevalence of cervical spine symptomatology in the general population ranges between 10% and 15%, with a higher prevalence in females.[3]

Neck pain can have 2 different forms of main pathogenesis: traumatic (ie, whiplash-related neck pain) or mechanical neck pain (MNP). MNP, which affects 45% to 54% of the general population at some time during their lives, has a multifactorial origin including ≥ 1 of the following: poor posture, anxiety, depression, or neck strain.[4] In contrast, whiplash-associated disorders (WAD) are mainly associated with motor vehicle accidents affecting up to 83% of the individuals involved in car collisions.[5] WAD represents a significant public health problem, both in terms of direct and indirect health care costs,[6,7] and may lead to psychological disorders in some patients.[8]

Regardless of the origin of the pain, a substantial proportion of individuals develop chronic symptoms (especially middle-aged women[9,10]) with the influence of multifactorial aspects (eg, pain duration, psychological factors, post-traumatic stress in WAD).

Myofascial trigger points (TrPs) are suggested to play an important role in both MNP[11] and WAD[12] by acting as peripheral sources of nociception. The peripheral nociceptive drive can facilitate central sensitization mechanisms in these patients.[13,14]

The duration of the peripheral nociceptive input seems to play a crucial role in the maintenance of sensitization.[15]

A previous study observed that individuals with MNP exhibit less active TrPs in the neck-shoulder muscles than those with WAD.[16] This may be 1 potential factor explaining the higher sensitization exhibited in WAD.[17,18] Previous studies reported that MNP is associated with localized, but not widespread, pressure pain hypersensitivity, whereas WAD is featured by both conditions.[17,18] It is important to consider that development of widespread pressure pain hypersensitivity is present in patients with WAD as early as 1 month after the car accident.[19] Therefore, it would be relevant to identify potential common features associated with this widespread pressure pain sensitivity to prevent its development by applying early therapeutic interventions.

Pressure pain thresholds (PPTs) are often used as a quantitative pain assessment tool to determine the presence of widespread pressure pain hypersensitivity in both clinical and research settings. It is well accepted that decreased PPTs in the injured area, that is, the cervical spine, potentially reflect mainly peripheral sensitization, whereas decreased PPT in uninjured tissue (eg, tibialis anterior muscle) may indicate mainly widespread pressure pain hypersensitivity (central sensitization).[19,20]

Since MNP (nontraumatic) and WAD (traumatic) potentially have different pathogenesis, a better understanding of the possible influence of clinical features (pain intensity, related-disability, spontaneous pain area) and the presence of active and/or latent TrPs in widespread pressure pain hypersensitivity can assist clinicians in determining better therapeutic programs. To the best of the authors' knowledge, no previous study has investigated if the associations between clinical features, TrPs, and widespread pressure pain hypersensitivity are different in individuals with MNP and WAD.

The aims of the current study were to investigate the associations between clinical features in MNP and WAD. It was hypothesized that the associations between pain, disability, and TrPs with widespread pressure pain hypersensitivity would be higher in patients with WAD than in those with MNP.

MATERIALS AND METHODS

Participants

Consecutive patients with neck pain for at least 3 months who sought treatment were screened in a private physical therapy clinic, Poliambulatorio Dalla Rosa Prati, Parma (Italy). For the WAD group, patients were eligible if they met grade I or II (pain and musculoskeletal signs, but absence of neurological signs) of the Quebec Task Force Classification of Whiplash Associated Disorders.[21] MNP was defined as generalized neck and any shoulder pain with cervical symptoms provoked by sustained neck postures, neck movement, or palpation of the cervical musculature not associated with whiplash.[22] Patients from both groups were included if they had neck pain for at least 3 months and if they presented with neck pain at the evaluation (at least "1" on numerical pain rating scale [NPRS] scale). Patients from both groups were excluded if they exhibited any of the following criteria: (1) previous history of neck surgery; (2) any therapeutic intervention for the cervical spine the previous 3 months; (3) "red flag" (eg, infections, malignancy, fracture, rheumatoid arthritis, osteoporosis); (4) diagnosis of fibromyalgia syndrome according to the American College of Rheumatology. Written informed consent was obtained from all patients according to the Declaration of Helsinki. The study was approved by the local Ethics Committee. All examinations were performed by an assessor blinded to the patient's diagnosis.

Cervical Range of Motion (Physical Outcome)

Cervical range of motion was recorded in flexion, extension, both lateral-flexion and both rotations with a goniometer.[23] Two measurements were recorded for each motion and the mean was used in the main analysis. Recently, it has been determined that the SE of measurement for cervical range of motion ranges from 5.3 to 9.9 degrees.[24]

PPTs (Neurophysiological Outcomes)

PPT, defined as the amount of pressure applied for the pressure sensation to first change to pain, was assessed using an electronic algometer (Somedic AB, Sösdala, Sweden) with a probe of 1 cm^2. PPTs were assessed over the upper trapezius muscle (at a fixed point in the middle of the muscle) to determine localized pressure hypersensitivity and over the tibialis anterior muscle (fixed point in the middle of the muscle) to detect widespread pressure pain hypersensitivity. Participants were instructed to press a button when the sensation changed from pressure to pain. The pressure was increased at a rate of 30 kPa/s. For each assessed point, PPT was performed 3 times with at least 30 seconds between each trial and the mean was used for the analysis. Walton and colleagues reported that PPT over the neck assessed with algometer exhibited excellent intrarater reliability (intraclass correlations, 0.94 to 0.97), good to excellent interrater reliability (intraclass correlations, 0.79 to 0.900) and determined a minimal detectable change of 47.2 and 97.9 kPa for PPT over the neck and tibialis anterior muscle in patients with neck pain.[25] Chesterton et al[26] suggested that differences in PPTs should be around 1.5 kg/cm^2 (around 150 kPa) to be considered as clinically relevant.

TrPs Evaluation

TrPs in the upper trapezius muscle were bilaterally explored[27] according to the following criteria: (1) presence of a palpable taut band in the muscle; (2) presence of a tender spot in the taut band; (3) local twitch response on palpation of the taut band; and (4) reproduction of referred pain to manual compression.[28] Criteria 1 and 2 were considered mandatory, whereas 3 and 4 were considered secondary criteria that strengthen the diagnosis. TrPs were considered active if the referred pain elicited during the examination reproduced any symptoms experienced by the patients, whereas TrPs were considered latent if the pain elicited during the examination did not reproduce any symptoms of the patient.[28] TrPs diagnosis in the upper trapezius muscle has shown good intrarater and interrater reliability when performed by a trained clinician.[29]

Self-reported Clinical Outcomes (Clinical Outcomes)

Disability was assessed with the Italian version of the Neck Disability Index (NDI).[30] The questionnaire consisted of 10 questions to be rated on a 6-point scale ranging from 0 (no disability) to 5 (full disability). The total score ranged from 0 to 50 points and was transformed to a percentage from 0% to 100% where high values represented high disability. The NDI is a valid, reliable, and responsive instrument to measure disability in patients with neck pain.[31,32]

A systematic review concluded that differences in score of 7 of 50 points in the NDI should be considered as clinically relevant.[31]

The participants rated the intensity of their neck pain on an 11-point NPRS (0, no pain; 10, maximum pain)[33,34] and were asked to draw the distribution of their symptoms on an anatomic body map. The spontaneous pain symptomatic area extension was measured with a digitizer (ACECAD D9000, New Taipei City, Taiwan) and analyzed with Vistametrix software (SkillCrest, Tucson).[35] In general, it is suggested that differences in score of 2 points of 10 can be considered clinically relevant for the intensity of pain in patients with chronic musculoskeletal conditions.[36,37] This has been particularly confirmed for patients with neck pain.[33]

TABLE 1. Clinical, Physical, and Neurophysiological Outcomes Between Patients With Mechanical Neck Pain and Whiplash-associated Disorders

	Mechanical Neck Pain (n = 46)	Whiplash-associated Disorders (n = 51)	*P*
Sex (male/female)	10/36	8/43	0.2888
Age (y)	43 ± 13	43 ± 12	0.772
Neck pain (NPRS, 0-10)	3.5 ± 2.9	3.7 ± 2.5	0.828
Neck Disability Index (0-100)	23.7 ± 13.6	29.4 ± 14.1	0.061
Pain area (AU)	1972 ± 1612	2622 ± 1758	0.131
Cervical flexion (deg.)	29.9 ± 9.0	26.9 ± 8.5	0.070
Cervical extension (deg.)	36.8 ± 7.3	35.9 ± 7.1	0.604
Cervical lateral-flexion left (deg.)	25.8 ± 7.3	23.4 ± 6.9	0.183
Cervical lateral-flexion right (deg.)	26.2 ± 6.7	24.9 ± 6.5	0.448
Cervical rotation left (deg.)	64.6 ± 9.4	64.0 ± 10.6	0.735
Cervical rotation right (deg.)	63.9 ± 8.8	60.1 ± 11.5	0.099
PPT tibialis anterior (kPa)	441.6 ± 201.8	392.3 ± 240.6	0.198
PPT upper trapezius (kPa)	305.0 ± 140.1	294.1 ± 178.6	0.640

Data are expressed as mean ± SD.

AU indicates arbitrary units; NPRS, deg, degrees; numerical pain rating scale; PPT, pressure pain thresholds.

Sample Size Calculation

The sample size was calculated using Ene 3.0 software (Autonomous University of Barcelona, Spain). The sample calculation was based on detecting significantly moderate associations ($r = 0.5$) between the studied variables with a 2-sided alpha level (α) of 0.05 and a desired power (β) of 95%. This generated a sample size of 41 patients in each group.

Statistical Analysis

Data were analyzed with SPSS software Version 21.0 (Chicago, IL). The Shapiro-Wilks test was used to analyze normal distribution of the data ($P > 0.05$). Quantitative continuous data without a normal distribution were analyzed with nonparametric tests, whereas data with normal distribution were analyzed with parametric tests. Differences in continuous variables with normal distribution between groups were analyzed with independent student *t* test, whereas differences in continuous variables without a normal distribution were analyzed with Mann-Whitney *U* test. Differences in the distribution of categorical variables between both groups were assessed with the χ^2 tests of independence. The Pearson correlation test (r) or the Spearman ρ (r_s) test was used to determine the association between pain, disability, and PPTs in either the MNP or WAD group. Associations were considered weak when $r < 0.3$; moderate when $0.3 < r < 0.7$, and strong when $r > 0.7$.[38] In addition, a mixed-model analysis of variance (ANOVA) with type of TrPs (active or latent) as within-subject factor and group (MNP or WAD)as between-subject factor was used to determine differences in pain, disability, spontaneous pain area, and PPTs according to the presence of active or latent TrPs within the upper trapezius muscle. The statistical analysis was conducted at a 95% confidence level. A $P < 0.05$ was considered statistically significant.

RESULTS

In total, 101 consecutive patients with neck pain were screened for eligibility from April 2014 to December 2014. A total of 97 (96%) satisfied the inclusion criteria, 46 (47%) with MNP and 51 (53%) with WAD, and agreed to participate. Independent student *t* test, Mann-Whitney *U* test, and χ^2 tests of independence showed no significant differences between the groups; although individuals with WAD tended to exhibit higher disability, larger spontaneous pain areas, and lower PPT in the tibialis anterior muscle than

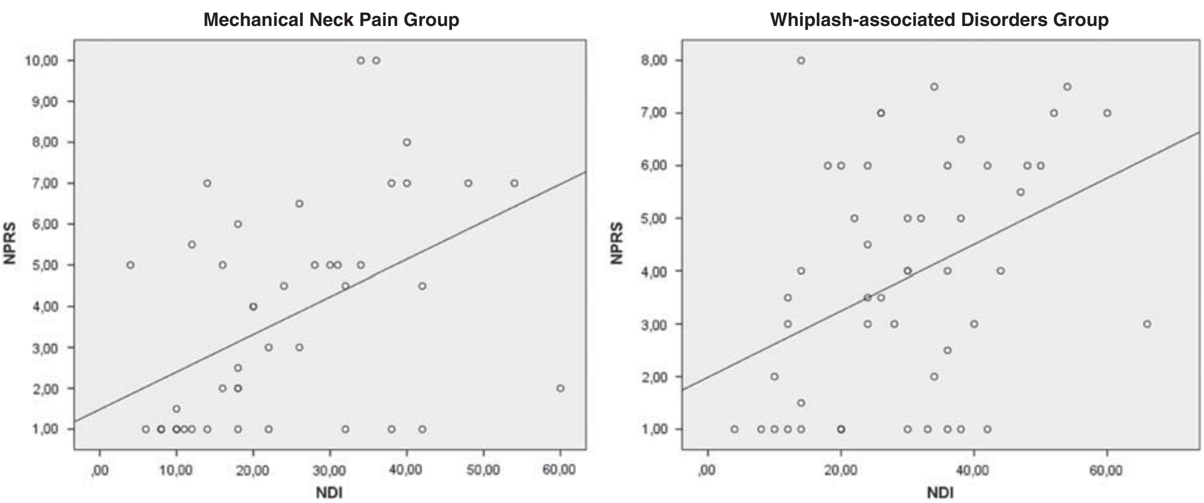

FIGURE 1. Scatter plot of the relationship between the intensity of neck pain and disability in both MNP (n = 46) and WAD (n = 51) groups. Note that some points are overlapping. A positive linear regression line is fitted to the data. MNP indicates mechanical neck pain; NDI, Neck Disability Index; NPRS, numerical pain rating scale; WAD, whiplash-associated disorders.

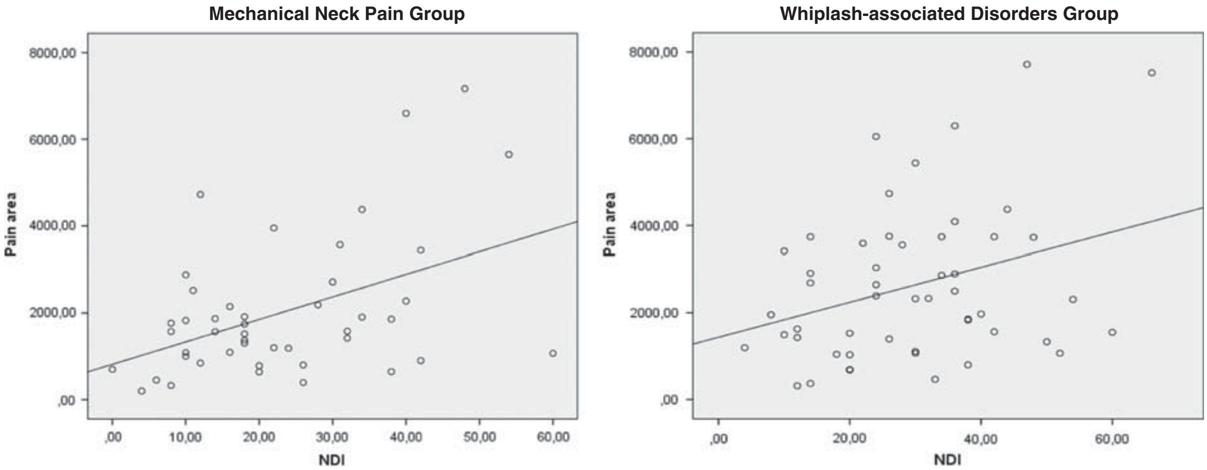

FIGURE 2. Scatter plot of the relationship between spontaneous symptomatic pain area and disability in both MNP (n = 46) and WAD (n = 51) groups. Note that some points are overlapping. A positive linear regression line is fitted to the data. MNP indicates mechanical neck pain; NDI, Neck Disability Index; WAD, whiplash-associated disorders.

those with MNP (all $0.05 < P < 0.1$). The clinical, physical, and neurophysiological data are summarized in Table 1 for both groups.

Associations Between Variables According to the Neck Pain Group

Spearman ρ showed significantly moderate positive associations between pain and disability in both MNP ($r_s = 0.544$; $P < 0.001$) and WAD ($r_s = 0.406$; $P = 0.003$) groups (Fig. 1): the higher the intensity of neck pain, the higher the disability. Further, a small to moderate positive association between spontaneous pain area and disability was also found in the MNP group ($r_s = 0.314$; $P = 0.034$), but not in the WAD ($P = 0.065$) group: the larger the pain extension area, the higher the disability (Fig. 2).

Significantly small to moderate associations between pain and localized and widespread pressure pain hypersensitivity were observed in both the MNP (localized: $r_s = -0.397$, $P = 0.008$; widespread: $r_s = -0.365$, $P = 0.015$) and the WAD (localized: $r_s = -0.290$, $P = 0.041$; widespread: $r_s = -0.294$, $P = 0.038$) groups (Figs. 3, 4).

Statistically significantly small to moderate negative associations between disability and localized PPT were also found in both the MNP ($r_s = -0.397$; $P = 0.006$) and the WAD ($r_s = -0.380$; $P = 0.006$) groups (Fig. 5). In addition, a significantly moderate negative association between disability and widespread pressure pain hypersensitivity was found in the MNP ($r_s = -0.428$; $P = 0.003$), but not in the WAD group ($P = 0.112$) (Fig. 6). Associations between clinical and neurophysiological outcomes of both groups are shown in Table 2.

Differences Between Groups Depending on the Presence of Active or Latent TrPs

In total, 62 (64%) patients of the total sample exhibited active TrPs in the upper trapezius muscle; 30 within the MNP group and 32 in the WAD group ($\chi^2 = 0.030$; $P = 0.863$).

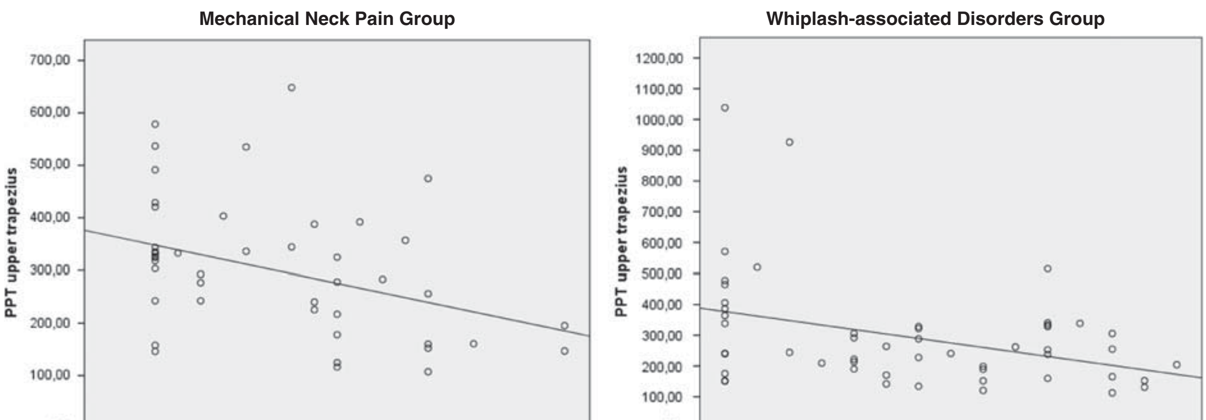

FIGURE 3. Scatter plot of the relationship between the intensity of neck pain and PPT (kPa) in the upper trapezius muscle in both MNP (n = 46) and WAD (n = 51) groups. Note that some points are overlapping. A negative linear regression line is fitted to the data. MNP indicates mechanical neck pain; NPRS, numerical pain rating scale; PPT, pressure pain thresholds; WAD, whiplash-associated disorders.

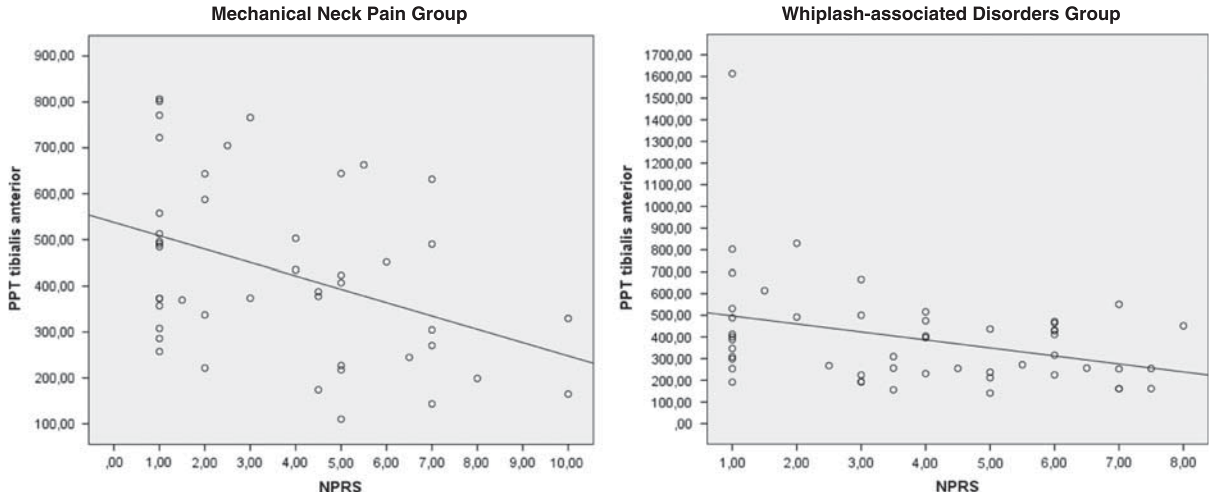

FIGURE 4. Scatter plot of the relationship between the intensity of neck pain and PPT (kPa) in the tibialis anterior muscle in both MNP (n = 46) and WAD (n = 51) groups. Note that some points are overlapping. A negative linear regression line is fitted to the data. MNP indicates mechanical neck pain; NPRS, numerical pain rating scale; PPT, pressure pain thresholds; WAD, whiplash-associated disorders.

The ANOVA revealed significant TrPs type effect, but not a group × TrPs effect, for pain (TrPs: F = 7.476, P = 0.008; group × TrPs: F = 0.659, P = 0.419), disability (TrPs: F = 7.902, P = 0.006; group × TrPs: F = 1.351, P = 0.248), PPT over upper trapezius (TrPs: F = 8.475, P = 0.005; group × TrPs: F = 0.273, P = 0.602), and PPT over tibialis anterior (TrPs: F = 6.102, P = 0.015; group × TrPs: F = 0.608, P = 0.438). Patients with active TrPs in the upper trapezius exhibited a higher intensity of pain, higher disability, and lower PPTs than those with latent TrPs in both groups. No significant effect of the presence of active or latent TrPs was observed for spontaneous symptomatic pain area (F = 0.073, P = 0.788) or cervical range of motion (flexion: F = 1.045, P = 0.309; extension: F = 0.079, P = 0.779; left lateral-flexion: F = 0.026, P = 0.872; right lateral-flexion: F = 1.523, P = 0.220; left rotation: F = 0.70, P = 0.395; right rotation: F = 0.248, P = 0.620). Table 3 summarizes clinical and neurophysiological outcome differences between groups depending on the presence of active or latent TrPs.

DISCUSSION

The present study showed that pain, disability, and widespread pressure pain hypersensitivity were similarly associated in patients with MNP and WAD, suggesting that the complex relationship between these outcomes in these subgroups of patients is not influenced by the origin of neck pain. In addition, the presence of active TrPs in the upper trapezius muscle was statistically associated with higher levels of pain, disability, and widespread pressure pain hypersensitivity in both groups.

Association Between Pain and Disability

The association between pain and disability found in both groups suggests that this relationship goes beyond the

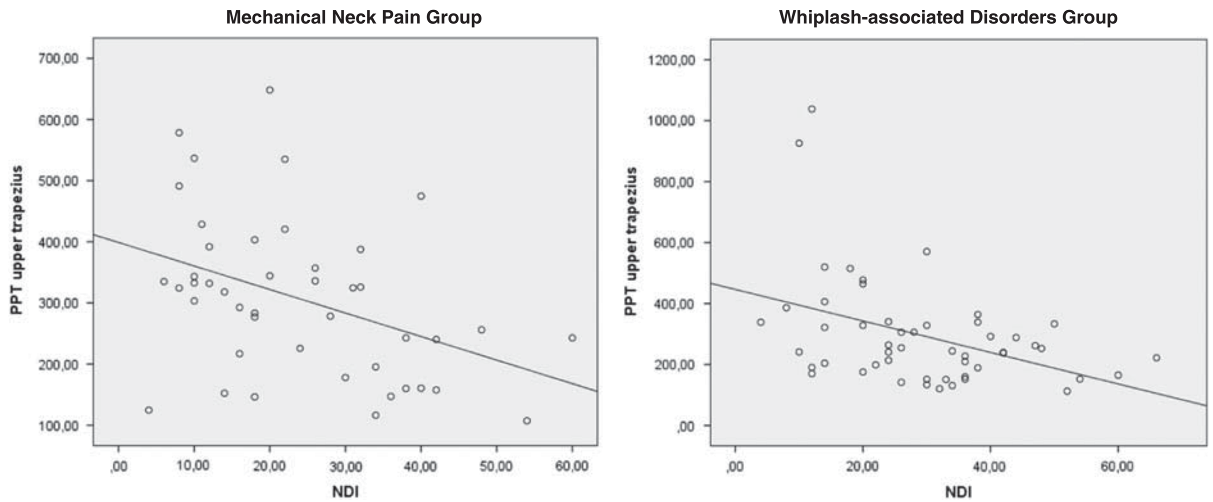

FIGURE 5. Scatter plot of the relationship between PPT (kPa) in the upper trapezius muscle and disability in both MNP (n = 46) and WAD (n = 51) groups. Note that some points are overlapping. A negative linear regression line is fitted to the data. MNP indicates mechanical neck pain; NDI, Neck Disability Index; PPT, pressure pain thresholds; WAD, whiplash-associated disorders.

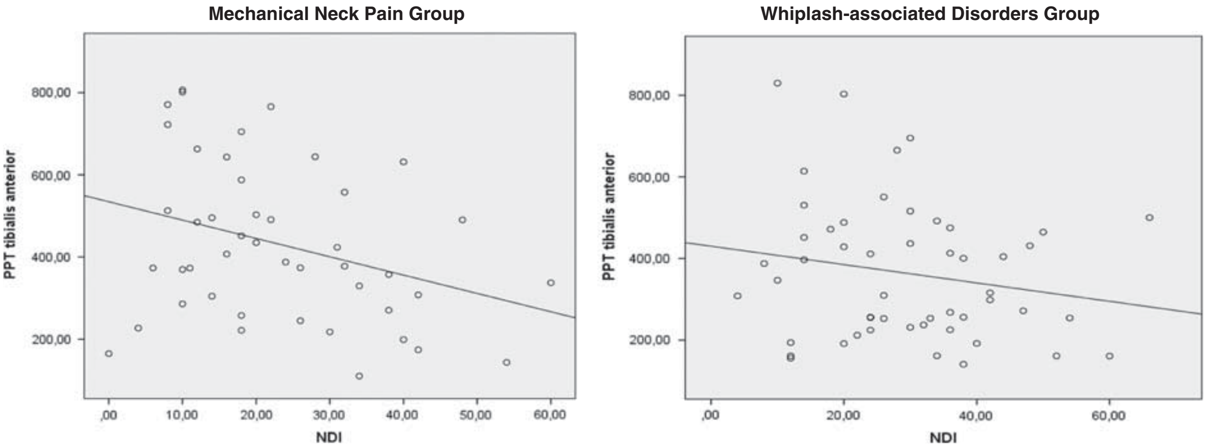

FIGURE 6. Scatter plot of the relationship between PPT (kPa) in the tibialis anterior muscle and disability in both MNP (n = 46) and WAD (n = 51) groups. Note that some points are overlapping. A negative linear regression line is fitted to the data. MNP indicates mechanical neck pain; NDI, Neck Disability Index; PPT, pressure pain thresholds; WAD, whiplash-associated disorders.

origin of neck pain. In fact, moderate associations between pain and disability have previously been found in similar studies.[39,40] Chiu et al[41] found moderate correlations between pain and disability in chronic neck pain patients and Clair et al[42] demonstrated a moderate correlation between pain and the "Neck Pain and Disability Scale." In some populations it may be useful to consider pain and disability as a unitary construct of the pain experience; although it is important to consider that the relationship between pain and disability is not always straightforward as both may be influenced by physiological, psychosocial, and environmental factors.[43] Leboeuf-Yde and Manniche[44] concluded that pain and disability should be considered and measured separately to avoid the risk of overlooking specific groups. Although pain and disability showed moderate associations in the present sample of individuals, it seems that both outcomes should be included for a better understanding of the pain experience.

Association Between Pain and Disability With PPTs

An interesting finding was the association of PPT over the upper trapezius muscle with pain and disability in both groups. Nevertheless, the association between pain, disability and PPT is conflicting. For instance, Farasyn and Meeusen[45] did not find correlations between disability and PPTs in individuals with nonspecific low back pain, whereas Imamura et al[46] reported an association between pain and PPTs in chronic nonspecific low back pain. This study also observed significant, but weak, associations between PPT over the tibialis anterior muscle and neck pain in both groups; the higher the intensity of neck pain, the higher widespread pressure pain hypersensitivity. The association between PPTs in the tibialis anterior muscle and disability was only significant within the MNP group. Again, the results are conflicting as Kamper et al[47] found a weak correlation between neck pain and PPT over the cervical spine, but not between neck pain and PPT in the tibialis anterior muscle in a sample of patients with WAD. In contrast, Herren-Gerber et al[48] observed a correlation between change in PPT and changes in neck pain after anesthetic injection in patients with chronic WAD. These findings would suggest that the peripheral input is important for driving the sensitization processes; particularly in the MNP group. However, a systematic review by Hubscher et al[49] concluded that the association between PPT and pain and disability in spinal pain syndromes is weak and further studies are needed. It is possible that widespread pressure pain hypersensitivity does not play a major role in the experience of pain or disability after a traumatic event. The association between PPTs, pain, and disability found in this study in both groups would suggest that regardless of the origin of the neck pain, a higher intensity of pain may be related to greater widespread pressure pain hypersensitivity in both MNP and WAD. However, due to the inconsistency of previous results this assumption should be considered with caution at this stage.

TABLE 2. Associations Between Clinical and Neurophysiological Outcomes by Neck Pain Group

	Mechanical Neck Pain (n = 46)	Whiplash-associated Disorders (n = 51)
Neck pain (NPRS)—NDI	$r_s = 0.544$; $P < 0.001$	$r_s = 0.406$; $P = 0.003$
Pain area—NDI	$r_s = 0.314$; $P = 0.034$	$r_s = 0.261$; $P = 0.065$
Neck pain (NPRS)—PPT upper trapezius	$r_s = -0.397$; $P = 0.008$	$r_s = -0.290$; $P = 0.041$
Neck pain (NPRS)—PPT tibialis anterior	$r_s = -0.365$; $P = 0.015$	$r_s = -0.294$; $P = 0.038$
NDI—PPT upper trapezius	$r_s = -0.397$; $P = 0.006$	$r_s = -0.380$; $P = 0.006$
NDI—PPT tibialis anterior	$r_s = -0.428$; $P = 0.003$	$r_s = -0.255$; $P = 0.112$

NDI indicates Neck Disability Index; NPRS, numerical pain rating scale; PPT, pressure pain thresholds.

Active TrPs in the Upper Trapezius Muscle and Neck Pain

A relevant finding of the current study was that the presence of active TrPs was statistically associated with higher pain, higher disability and lower PPTs in the upper trapezius and tibialis anterior muscles independently of the neck pain group. Nevertheless, the clinical relevance of these findings should be considered with caution as the

TABLE 3. Differences in Clinical and Neurophysiological Outcomes in Both Groups Depending on the Presence of Active or Latent TrPs in the Upper Trapezius Muscle

	NPRS (0-10)	NDI (0-100)	Pain Area (AU)	PPT Upper Trapezius (kPa)	PPT Tibialis Anterior (kPa)
Mechanical neck pain					
Active TrPs	3.9 ± 3.1 (2.9–4.9)	25.6 ± 15.0 (20.7–30.5)	2173 ± 1839 (1547–2799)	259.2 ± 102 (202.1–316.3)	398.2 ± 186.7 (319.4–477.1)
Latent TrPs	2.8 ± 2.5 (1.5–4.2)	20.9 ± 10.5 (14.3–27.6)	1732 ± 1044 (890–2575)	372.3 ± 162.7 (295.4–449.3)	491 ± 190.8 (384.8–597.2)
Whiplash-associated disorders					
Active TrPs	4.5 ± 2.3 (3.5–5.4)	33.6 ± 14.6 (29.0–38.3)	2713 ± 1863 (2117–3309)	264.8 ± 151.7 (210.4–319.2)	343.2 ± 157.5 (268.1–418.3)
Latent TrPs	2.5 ± 2.4 (1.2–3.6)	22.4 ± 10.1 (16.3–28.4)	2468 ± 1603 (1695–3241)	343.5 ± 211.8 (272.9–414.1)	475.1 ± 326.5 (377.7–572.6)

Data are expressed as mean ± SD.
95% Confidence intervals are shown in parentheses.
AU indicates arbitrary units; NDI, Neck Disability Index; NPRS, numerical pain rating scale; PPT, pressure pain thresholds; TrPs, trigger points.

differences within the MNP group were relatively small and did not surpass the cut-off determined for pain intensity, related-disability, and PPTs.[26,31,32] Interestingly, the differences in pain and disability between patients with active and latent TrPs within the WAD group were higher than in the MNP and may be considered clinically relevant since they reached the cut-off established for related-disability (7 points) and pain intensity (2 points), although again, these results should be considered as preliminary.

The presence of active TrPs in neck pain has previously been documented in the literature.[11,13,14,16] Active TrPs exhibit greater concentrations of inflammatory and nociceptive substances (substance P, cytokines, etc.) compared with latent TrPs.[50] These substances sensitize local nociceptors suggesting an explanation for higher neck pain and lower PPTs in active TrP areas. These results would be further supported by the fact that the injection of algogenic substances has been used to mimic muscle pain and to induce pressure hypersensitivity in healthy participants.[51] Further, if the nociceptive input from the periphery is long-lasting, this may lead to an increased barrage to the central nervous system that can finally increase excitability and synaptic efficacy of neurons in central nociceptive pathways developing central sensitization and therefore lowering PPTs in distant pain-free areas.[46,50] The fact that nociceptive stimulation of latent TrPs can induce central sensitization in pain-free participants would support this hypothesis.[52] The results suggest that active TrPs can contribute to the development of pain, disability and local as well as widespread pressure pain hypersensitivity in patients with neck disorders. This would support the importance of a treatment directed toward active TrPs deactivation as this may reduce pain and increase pressure pain sensitivity both locally and widespread, as previously found in patients with shoulder pain.[53]

Limitations

Although this is the first study investigating differences in association between patients with MNP and WAD, some potential limitations should be recognized. First, the clinical relevance of these results should be considered with caution, particularly in the MNP group as differences between active and latent TrPs were small in this group. This may be related to the fact that the sample of patients exhibited pain levels considered to be of mild intensity (< 4 points)[54] and this could indicate that the associations observed may be influenced by this level of pain intensity. Therefore, this will limit the generalization of our results which should be considered with caution at this stage. Second, PPTs from more locations could have been assessed to obtain a more detailed description of sensitization manifestations. The trapezius muscle was chosen as it is considered the muscle with the highest prevalence of active TrPs.[36] Third, active TrPs were only assessed over the upper trapezius muscle. A previous study has shown that patients with MNP or WAD have active TrPs in several neck muscles.[20] Therefore, to determine the potential role of active TrPs in the cervical musculature, future studies should include a greater number of muscles. Investigating the association between the number of active TrPs in neck muscles and other variables would give a more complete picture of the factors potentially relevant for sensitization mechanisms. Finally, other potential confounding factors, particularly psychological factors, such as anxiety, depression, and posttraumatic stress, may be also related to the findings observed in this study. It would be important to determine the role of these factors in the associations found in this study, particularly the role of active TrPs.

CONCLUSIONS

The results of this suggest that neck pain, disability, and widespread pressure pain hypersensitivity may be associated in a similar manner in patients with MNP and WAD. Patients with active TrPs in the upper trapezius muscle exhibited higher levels of pain, disability, and widespread pressure pain hypersensitivity independently of the neck pain group. Future studies considering the limitations of the current study are needed to determine the clinical role of these associations in neck pain.

REFERENCES

1. Cote P, van der Velde G, Cassidy JD, et al. The burden and determinants of neck pain in workers: results of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. *Spine (Phila Pa 1976)*. 2008;33:S60–S74.
2. Vos T, Flaxman AD, Naghavi M, et al. Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet*. 2012;380:2163–2196.
3. Borghouts JA, Koes BW, Vondeling H, et al. Cost-of-illness of neck pain in The Netherlands in 1996. *Pain*. 1999;80:629–636.

4. Hoy DG, Protani M, De R, et al. The epidemiology of neck pain. *Best Pract Res Clin Rheumatol*. 2010;24:783–792.
5. Yadla S, Ratliff JK, Harrop JS. Whiplash: diagnosis, treatment, and associated injuries. *Curr Rev Musculoskelet Med*. 2008;1:65–68.
6. Kamper SJ, Rebbeck TJ, Maher CG, et al. Course and prognostic factors of whiplash: a systematic review and meta-analysis. *Pain*. 2008;138:617–629.
7. Hogg-Johnson S, van der VG, Carroll LJ, et al. The burden and determinants of neck pain in the general population: results of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. *Spine (Phila Pa 1976)*. 2008;33:S39–S51.
8. Andersen TE, Karstoft K-I, Brink O, et al. Pain-catastrophizing and fear-avoidance beliefs as mediators between post-traumatic stress symptoms and pain following whiplash injury—a prospective cohort study. *Eur J Pain*. 2016; 20:1241–1252.
9. Hoy D, March L, Woolf A, et al. The global burden of neck pain: estimates from the Global Burden of Disease 2010 study. *Ann Rheum Dis*. 2014;73:1309–1315.
10. Carroll LJ, Hogg-Johnson S, Cote P, et al. Course and prognostic factors for neck pain in workers: results of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. *Spine (Phila Pa 1976)*. 2008;33:S93–100.
11. Fernandez-de-Las-Penas C, Alonso-Blanco C, Miangolarra JC. Myofascial trigger points in subjects presenting with mechanical neck pain: a blinded, controlled study. *Man Ther*. 2007;12:29–33.
12. Curatolo M, Bogduk N, Ivancic PC, et al. The role of tissue damage in whiplash-associated disorders: discussion paper 1. *Spine (Phila Pa 1976)*. 2011;36:S309–S315.
13. Dommerholt J. Persistent myalgia following whiplash. *Curr Pain Headache Rep*. 2005;9:326–330.
14. Freeman MD, Nystrom A, Centeno C. Chronic whiplash and central sensitization; an evaluation of the role of a myofascial trigger points in pain modulation. *J Brachial Plex Peripher Nerve Inj*. 2009;4:2.
15. Baron H, Hans G, Dickenson AH. Peripheral input and its importance for central sensitization. *Ann Neurol*. 2013;74: 630–636.
16. Castaldo M, Ge HY, Chiarotto A, et al. Myofascial trigger points in patients with whiplash-associated disorders and mechanical neck pain. *Pain Med*. 2014;15:842–849.
17. Scott D, Jull G, Sterling M. Widespread sensory hypersensitivity is a feature of chronic whiplash-associated disorder but not chronic idiopathic neck pain. *Clin J Pain*. 2005;21:175–181.
18. Chien A, Sterling M. Sensory hypoaesthesia is a feature of chronic whiplash but not chronic idiopathic neck pain. *Man Ther*. 2010;15:48–53.
19. Sterling M, Jull G, Kenardy J. Physical and psychological factors maintain long-term predictive capacity post-whiplash injury. *Pain*. 2006;122:102–108.
20. Stude P, Nebel K, Ludecke C, et al. Quantification of acute neck pain following whiplash injury by computer-aided pressure algesimetry. *Cephalalgia*. 2004;24:1067–1075.
21. Spitzer WO, Skovron ML, Salmi LR, et al. Scientific monograph of the Quebec Task Force on Whiplash-Associated Disorders: redefining "whiplash" and its management. *Spine (Phila Pa 1976)*. 1995;20:1S–73S.
22. Fritz JM, Brennan GP. Preliminary examination of a proposed treatment-based classification system for patients receiving physical therapy interventions for neck pain. *Phys Ther*. 2007;87:513–524.
23. Williams MA, McCarthy CJ, Chorti A, et al. A systematic review of reliability and validity studies of methods for measuring active and passive cervical range of motion. *J Manipulative Physiol Ther*. 2010;33:138–155.
24. Hanney WJ, George SZ, Kolber MJ, et al. Inter-rater reliability of select physical examination procedures in patients with neck pain. *Physiother Theory Pract*. 2014;30:345–352.
25. Walton DM, Macdermid JC, Nielson W, et al. Reliability, standard error, and minimum detectable change of clinical pressure pain threshold testing in people with and without acute neck pain. *J Orthop Sports Phys Ther*. 2011;41:644–650.
26. Chesterton LS, Sim J, Wright CC, et al. Interrater reliability of algometry in measuring pressure pain thresholds in healthy humans, using multiple raters. *Clin J Pain*. 2007;23: 760–766.
27. Chiarotto A, Clijsen R, Fernandez-de-Las-Penas C, et al. Prevalence of myofascial trigger points in spinal disorders: a systematic review and meta-analysis. *Arch Phys Med Rehabil*. 2016;97:316–337.
28. Simons DG, Travell JG, Simons L. *Myofascial Pain and Dysfunction The Trigger Point Manual*. Philadelphia, PA: Lippincott, Williams & Wilkins; 1999.
29. Barbero M, Bertoli P, Cescon C, et al. Intra-rater reliability of an experienced physiotherapist in locating myofascial trigger points in upper trapezius muscle. *J Man Manip Ther*. 2012;20: 171–177.
30. Monticone M, Ferrante S, Vernon H, et al. Development of the Italian version of the Neck Disability Index: cross-cultural adaptation, factor analysis, reliability, validity, and sensitivity to change. *Spine (Phila Pa 1976)*. 2012;37:E1038–E1044.
31. Macdermid JC, Walton DM, Avery S, et al. Measurement properties of the Neck Disability Index: a systematic review. *J Orthop Sports Phys Ther*. 2009;39:400–417.
32. Schellingerhout JM, Verhagen AP, Heymans MW, et al. Measurement properties of disease-specific questionnaires in patients with neck pain: a systematic review. *Qual Life Res*. 2012;21:659–670.
33. Cleland JA, Childs JD, Whitman JM. Psychometric properties of the Neck Disability Index and Numeric Pain Rating Scale in patients with mechanical neck pain. *Arch Phys Med Rehabil*. 2008;89:69–74.
34. Dworkin RH, Turk DC, Farrar JT, et al. Core outcome measures for chronic pain clinical trials: IMMPACT recommendations. *Pain*. 2005;113:9–19.
35. Lee H, Nicholoson LL, Adams RD, et al. Body chart pain location and side-specific physical impairment in subclinical neck pain. *J Manipulative Physiol Ther*. 2005;28:479–486.
36. Farrar JT, Young JP Jr, Lamoreaux L, et al. Clinical importance of changes in chronic pain intensity measured on an 11-point numerical pain rating scale. *Pain*. 2001;94:149–158.
37. Salaffi F, Stancati A, Silvestri CA, et al. Minimal clinically important changes in chronic musculoskeletal pain intensity measured on a numerical rating scale. *Eur J Pain*. 2004;8: 283–291.
38. Dancey CP, Reidy J. *Statistics Without Maths for Psychology: Using SPSS for Windows*. New York, NY: Prentice Hall; 2004.
39. Carvalho GF, Chaves TC, Goncalves MC, et al. Comparison between neck pain disability and cervical range of motion in patients with episodic and chronic migraine: a cross-sectional study. *J Manipulative Physiol Ther*. 2014;37:641–646.
40. Fejer R, Hartvigsen J. Neck pain and disability due to neck pain: what is the relation? *Eur Spine J*. 2008;17:80–88.
41. Chiu TT, Lam TH, Hedley AJ. Correlation among physical impairments, pain, disability, and patient satisfaction in patients with chronic neck pain. *Arch Phys Med Rehabil*. 2005; 86:534–540.
42. Clair D, Edmondston S, Allison G. Variability in pain intensity, physical and psychological function in non-acute, non-traumatic neck pain. *Physiother Res Int*. 2004;9:43–54.
43. Von Korff M, Ormel J, Keefe FJ, et al. Grading the severity of chronic pain. *Pain*. 1992;50:133–149.
44. Leboeuf-Yde C, Manniche C. Low back pain: time to get off the treadmill. *J Manipulative Physiol Ther*. 2001;24:63–66.
45. Farasyn A, Meeusen R. The influence of non-specific low back pain on pressure pain thresholds and disability. *Eur J Pain*. 2005;9:375–381.
46. Imamura M, Alfieri FM, Filippo TR, et al. Pressure pain thresholds in patients with chronic nonspecific low back pain. *J Back Musculoskelet Rehabil*. 2016;29:327–336.

47. Kamper SJ, Maher CG, Hush JM, et al. Relationship between pressure pain thresholds and pain ratings in patients with whiplash-associated disorders. *Clin J Pain*. 2011;27:495–501.
48. Herren-Gerber R, Weiss S, Arendt-Nielsen L, et al. Modulation of central hypersensitivity by nociceptive input in chronic pain after whiplash injury. *Pain Med*. 2004;5:366–376.
49. Hubscher M, Moloney N, Leaver A, et al. Relationship between quantitative sensory testing and pain or disability in people with spinal pain-a systematic review and meta-analysis. *Pain*. 2013;154:1497–1504.
50. Shah JP, Danoff JV, Desai MJ, et al. Biochemicals associated with pain and inflammation are elevated in sites near to and remote from active myofascial trigger points. *Arch Phys Med Rehabil*. 2008;89:16–23.
51. Svensson P, Cairns BE, Wang K, et al. Glutamate-evoked pain and mechanical allodynia in the human masseter muscle. *Pain*. 2003;101:221–227.
52. Xu YM, Ge HY, Arendt-Nielsen L. Sustained nociceptive mechanical stimulation of latent myofascial trigger point induces central sensitization in healthy subjects. *J Pain*. 2010; 11:1348–1355.
53. Hidalgo-Lozano A, Fernandez-de-Las-Penas C, Diaz-Rodriguez L, et al. Changes in pain and pressure pain sensitivity after manual treatment of active trigger points in patients with unilateral shoulder impingement: a case series. *J Bodyw Mov Ther*. 2011;15:399–404.
54. Hawker GA, Mian S, Kendzerska T, et al. Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). *Arthritis Care Res (Hoboken)*. 2011;63:S240–S252.