Research Article

Pressure Pain and Isometric Strength of Neck Flexors Are Related in Chronic Tension-Type Headache

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Background: In patients with chronic tension-type headache (CTTH) changes in pressure pain in the cervical region are associated with peripheral or central sensitization. It is hypothesized that an increase of isometric strength of neck flexors would lead to a decrease of pressure pain in CTTH, as an expression of reduced peripheral or central sensitization

Objective: In this study we aimed to analyze the correlation between change in isometric strength of the neck flexors and change in pressure pain scores (PPS) in patients with CTTH.

Study Design: Comparative analysis of data from previous study.

Setting: Primary healthcare center.

Methods: Data from 145 patients with CTTH who underwent a manual therapy program including isometric strength training of the neck flexors were analyzed at 8 and 26 weeks post-treatment. PPS were measured as a total of pain scores on a numeric rating scale (score 0 to 10) on application of a pressure stimulus of 3kg/cm at 8 cervical- and suboccipital muscles. Isometric strength of the neck flexors was measured in seconds. Correlations were computed between changes in PPS and isometric neck flexor strength.

Results: Isometric strength of neck flexors scored significantly different compared to baseline measurement (mean 30.0 seconds, sd:25.2), and increased with a mean difference of 17.33 seconds (95%CI: 20.61 to 14.05) at 8 weeks and 19.18 seconds (95%CI: 23.48 to 14.87) at 26 weeks. Similarly, compared to PPS baseline measurement (31.6 points, sd:18.6), mean difference in PPS was significantly decreased at 8 and 26 weeks: -11.3 points (95%CI: -8.77 to -13.83) and -11.15 points (95%CI: -8.31 to -13.99). There is a negative correlation between changes in PPS and changes in isometric strength of neck flexors which is weak at 8 weeks ($r = -0.243$, $P = 0.004$) and moderate at 26 weeks ($r = -0.318$, $P < 0.000$).

Limitations: Correlational analysis.

Conclusion: Decrease in PPS correlates with increases in isometric strength of neck flexors in patients with CTTH in short- and long-term

Key words: Chronic tension-type headache, pressure pain, neck flexors, manual therapy, sensitization, isometric strength, cervical spine

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The prevalence of chronic tension-type headache (CTTH) in adults varies worldwide between 2% and 5% and it affects daily functioning, resulting in limitations in performance and participation (1).

Training of isometric strength of neck flexors appears to be an effective intervention to reduce headache days frequency in CTTH at the short and longer term (2,3). The hypothesized underlying neurophysiological mechanism for this treatment effect was that improvement of muscular function by training of isometric strength of neck flexors would modulate peripheral or central sensitization (3,4). This is based on the current concept that peripheral and central sensitization play an important role in CTTH pathogenesis. In this concept, headache is explained by ongoing nociceptive afferent stimuli from the cervical myofascial structures (peripheral sensitization) which facilitate second order neurons in the neural ganglion in the dorsal horn of the nucleus caudalus nervus trigeminus. Inadequate inhibition at the dorsal horn (central sensitization) can lead to perpetuation of afferent stimuli from the dorsal horn to supraspinal systems by second order neurons and finally by third order neurons to the cortex (5,6).

Pressure pain as a sign of peripheral or central sensitization in CTTH is extensively described in the literature (7-10). In this paper we attempt to investigate the relationship between pressure pain and muscular function by isometric strength of neck flexors in patients with CTTH.

We aimed to test the hypothesized neurophysiological mechanism of training of neck flexors in patients with CTTH by analyzing correlations between change in isometric strength of neck flexors and change in pressure pain (as an expression of sensitization).

Methods

Patients

We used data from a multi-center randomized controlled trial (RCT) (n = 82) (3) and parallel prospective cohort study (n = 104) (4) to determine the correlation between changes in pressure pain and changes in isometric strength of neck flexors in patients with CTTH.

Patients in both studies were required to fulfill the CTTH criteria according to the classification of headaches of the International Headache Society (IHS) and had to be between 18 and 65 years of age. Exclusion criteria were rheumatoid arthritis, suspected malignancy or brain tumor, pregnancy, and not being able to read and write Dutch, or had received manual therapy (MT) treatment in the 2 months before the study.

For this study we used data from 145 patients (RCT and cohort study) who fulfilled the same inclusion and exclusion criteria and received identical measurements and MT.

Manual Therapy Treatment

All patients received MT treatment including a combination of mobilization of the cervical and thoracic spine, postural correction, and training of isometric strength of neck flexors. A program of isometric training of the neck flexors was taught to each patient and consisted of low-load exercises in lying, sitting, and standing positions. All patients received a booklet with self-management exercises and each treatment patient was encouraged and instructed to perform their exercises on a regular basis at home. Patients were asked to continue their exercises after the treatment period of 8 weeks. The MT intervention was restricted to a maximum of 9 sessions of 30 minutes each.

All procedures on selection, informed consent, baseline, and follow-up measurements, and the MT protocol of this study have been previously described (11). The study protocol was approved by the Medical Ethics Committee of the VU University Medical Center in Amsterdam, The Netherlands.

Measurements

Baseline- and follow-up measurements were carried out by an independent research assistant.

Measurement of isometric strength of neck flexors was performed according to a procedure described by Harris et al, (12) reporting good intra- and interrater reliability. The number of seconds on a muscle endurance test was scored where patients were asked to raise their head from the table when lying on their back.

Pressure pain scores (PPS) on the trapezius descendens and the suboccipital muscle were measured with a Wagner FDK algometer with a 3.0 kg/cm pressure at 4 points at the left and right side: 2 points on the upper trapezius muscle and 2 points on the suboccipital muscles (13). Patients rated the severity of pain on a 0 – 10 point numeric rating scale (NRS) (0 = no pain, 10 = most severe pain). Scores for each pressure point were summated into a total score ranging between 0 and 80 points. Pressure algometry has been described as a valid measurement for pressure pain for the trapezius muscle and has a good to excellent reproducibility (ICC 0.85 – 0.96) (14,15).

The Headache Impact Test (HIT-6) consists of 6 items (pain intensity, social functioning, role functioning, vitality, cognitive functioning, and psychological distress) each with 5 response options; never: 6 points, rarely: 8 points, sometimes: 10 points, very often: 11 points, always: 13 points, with a total score ranging from 36 to 78 points. Internal consistency (Cronbach alpha: 0.89) and test-retest reliability (ICC ranging from 0.78 to 0.90) have been demonstrated to be good (16-18).

Statistical Analysis

Patients' descriptive variables such as age, length of the headache history, frequency, and HIT-6 scores are presented as means and standard deviations, except gender. Normality of data is analyzed by means of the one sample Kolmogorov-Smirnov test.

Within group mean differences in isometric strength of neck flexors and in PPS including 95% confidence intervals (CI) from baseline to 8 weeks and after 26 weeks were calculated, and statistical significance of differences was tested using the paired t-test.

Correlations between within-group mean differences in isometric strength and in PPS were analyzed by means of Pearson or Spearman rho correlation coefficients. For all analyses, the significance level was set at $P < 0.05$.

Results

Baseline characteristics of patients are summarized in Table 1. The within-group mean differences of isometric strength of neck flexor and PPS after 8 and 26 weeks are summarized in Table 2. At 8 weeks the analysis of 142 patients showed significantly increased isometric strength of neck flexors with a mean difference of 17.33 seconds (95%CI: 20.61 to 14.05) and significantly decreased pain scores on PPS with a mean difference of -11.3 points (95%CI: -8.77 to -13.83).

At 26 weeks isometric strength of neck flexors of 125 patients was increased with a mean difference of 19.18 seconds (95%CI: 23.48 to 14.87) and pain scores on PPS were decreased with a mean difference of -11.15 points (95%CI: -8.31 to -13.99).

Changes in isometric strength of neck flexor and changes in PPS were significantly negatively related at both follow-up points (Table 2).

Table 1. Characteristics of participants (n = 145) at baseline

	Mean (SD)
Gender male/female (ratio)	27/118
Age years range: 18 - 64	38.7 (11.6)
Headache hours per day	13.3 (9.0)
Headache days per month	22.7 (6.8)
Hit-6 (36 - 78 points)	62.2 (5.3)
Isometric strength neck flexors (in seconds)	30.0 (25.2)
Pressure pain scores (0 - 80 points)	31.6 (18.6)

Table 2. *Within-group mean differences between baseline and 8 weeks and after 26 weeks (means and 95% confidence intervals) and correlations between isometric strength of neck flexors and pressure pain scores.*

	8 weeks n = 142	26 weeks n = 125
Isometric strength neck flexors (95% CI)	17.33 (14.05 to 20.61)	19.18 (14.89 to 23.48)
Pressure pain scores (95% CI)	-11.24 (-13.8 to -8.23)	-11.09 (-13.95 to -8.23)
Correlation	-0.273	-0.317
P-value	0.001	0.000

Correlation coëfficients: Spearman rho, non-parametric.

Discussion

Main Finding

This is the first study that analyzed the relationship between changes in isometric strength of neck flexors and changes in PPS at short and longer term in patients with CTTH. We found a small but significant negative correlation between isometric strength of neck flexors on PPS at short- and long-term.

Comparison with Literature

Similar findings have been reported in studies concerning chronic neck pain, where similar reductions of pressure pain by training of isometric strength of neck flexors on short- and long-term were found. In patients with chronic neck pain, a significant effect was measured on pressure pain immediately after one session of cranio-cervical coordination or strengthening exercises (19). Ylinen et al (20), in a study containing 180 women with chronic neck pain, reported significant differences in pressure pain values in both endurance and strength training groups of the neck and shoulder muscles compared to a control group at 12-month follow-up. Lluch et al (21) compared active exercises of the upper cervical spine to passive exercises in combination with mobilization of the upper cervical spine in a small group of patients (n = 18) with chronic neck pain. A greater reduction in cervical pressure pain was measured in the active exercise group (21).

Central Sensitization

Although there is no consensus on the pathophysiological concept of CTTH, it is assumed that central sensitization plays a role in the evolution from episodic tension-type headache to CTTH. Central sensitization is a chronically increased excitability of neurons in the spinal cord, which can occur after prolonged and repetitive nociceptive stimulation (5,6). In CTTH, this nociceptive stimulation can originate from trigger points in suboccipital muscles (7,22-24).

The degree of sensitization can be measured by means of pressure pain. Increased pressure pain even at headache-free moments is indicative for central sensitization and has been demonstrated extensively in patients with CTTH (7-10,25).

Recent studies have shown that a physical therapy program encompassing training of the deep neck flexors in patients with chronic headache can lead to a reduction of the number of headache days (2,3). This indicates an evolution of chronic to episodic tension-type headache. This evolution might indicate a decrease in central sensitization, which should be reflected in a decrease in pressure pain. The current study provides empirical evidence for the role of central sensitization in CTTH.

Our study demonstrates a correlation between decreased pressure pain and an increased isometric strength of neck flexors in CTTH. Training of neck flexors in CTTH is supposed to reduce (hyper) activity of the suboccipital extensor muscles by reciprocal inhibition and to restore afferent input from mechanoreceptors innervating suboccipital muscles by stabilizing the upper cervical spine (26-29). Modulatory actions of peripherally evoked cervical mechanical afferent input might involve intrinsic brainstem mechanisms (e.g., segmental inhibition), but part of their effect could also be due to the afferent input accessing central sites exerting descending inhibition at the dorsal horn of the nucleus caudalus (6,30). In addition, activation of deep cervical flexors can have beneficial effects on the hardness and tenderness of the suboccipital muscle by stretching them (31). Stretching of suboccipital muscles will deactivate trigger points and can lead to the elimination of peripheral nociceptive input originating from the suboccipital muscles which are innervated by the C1-3 nerves (25,32).

Finally, this may lead to a decrease of sensitization measured by a decrease of pressure pain in CTTH, indicating a reduction of headache frequency.

The present finding of the association between increased neck flexor strength and decreased pressure pain may contribute to the pathophysiological models of CTTH in which cervical afferent input plays an important role.

Limitations

There are several limitations to this study. First, the inclusion of patients was restricted to CTTH and therefore we cannot generalize our results to other forms of headache.

Second, we have not measured pressure pain in extra cephalic areas. As a consequence we might have an incomplete view of signs of peripheral or central sensitization.

Finally, we cannot exclusively attribute the increased neck flexor endurance to endurance training of neck flexors, because endurance training was an integrated part of a MT protocol.

Conclusion

We conclude that changes in PPS are significantly correlated with changes in isometric strength of neck flexors in patients with CTTH in the short- and long-term. Based on this correlation, we premise that increased isometric strength of neck flexors leads to reduction of peripheral or central sensitization, resulting in a reduction of headache days frequency in CTTH.

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