

Short-term changes in median nerve neural tension after a suboccipital muscle inhibition technique in subjects with cervical whiplash: a randomised controlled trial[☆]

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Abstract

Objectives To assess the immediate effect of a suboccipital muscle inhibition (SMI) technique on: (a) neck pain, (b) elbow extension range of motion during the upper limb neurodynamic test of the median nerve (ULNT-1), and (c) grip strength in subjects with cervical whiplash; and determine the relationships between key variables.

Design Randomised, single-blind, controlled clinical trial.

Setting Faculty of Nursing, Physiotherapy and Podiatry, University of Seville, Spain.

Participants Forty subjects {mean age 34 years [standard deviation (SD) 3.6]} with Grade I or II cervical whiplash and a positive response to the ULNT-1 were recruited and distributed into two study groups: intervention group (IG) ($n=20$) and control group (CG) ($n=20$).

Interventions The IG underwent the SMI technique for 4 minutes and the CG received a sham (placebo) intervention. Measures were collected immediately after the intervention.

Main outcome measures The primary outcome was elbow range of motion during the ULNT-1, measured with a goniometer. The secondary outcomes were self-perceived neck pain (visual analogue scale) and free-pain grip strength, measured with a digital dynamometer.

Results The mean baseline elbow range of motion was 116.0° (SD 10.2) for the CG and 130.1° (SD 7.8) for the IG. The within-group comparison found a significant difference in elbow range of motion for the IG [mean difference -15.4° , 95% confidence interval (CI) -20.1 to -10.6 ; $P=0.01$], but not for the CG (mean difference -4.9° , 95% CI -11.8 to 2.0 ; $P=0.15$). In the between-group comparison, the difference in elbow range of motion was significant (mean difference -10.5° , 95% CI -18.6 to -2.3 ; $P=0.013$), but the differences in grip strength ($P=0.06$) and neck pain ($P=0.38$) were not significant.

Conclusion The SMI technique has an immediate positive effect on elbow extension in the ULNT-1. No immediate effects on self-perceived cervical pain or grip strength were observed.

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Keywords: Whiplash injuries; Median nerve; Manipulation, Spinal; Pain

Introduction

Cervical whiplash injury is a common disorder, mainly defined by persistent neck and upper limb pain. Following

cervical whiplash, neck pain can radiate to the spinal cord roots and has been linked with slight changes in median nerve function [1]. Cervical whiplash may also influence intervertebral discs, muscles, facet joints and ligaments, which may irritate surrounding nerve roots [2]. Therefore, neural responses and dysesthetic pain can appear in the absence of apparent nerve fibre or tissue damage [3].

Upper limb neurodynamic tests (ULNTs) are used to assess the functionality of the brachial plexus and to

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diagnose peripheral neuropathic pain [4]. A pathological response to the ULNT of the median nerve (ULNT-1) is based on reproduction of the patient's symptoms, along with the presence of resistance to movement and decreased elbow joint range of motion at pain onset or pain tolerance [4]. Hence, mechanosensitivity of the median nerve can be evaluated by detecting differences in elbow range of motion [5]. In addition, an abnormal response to the ULNT-1 has been linked to increased protective muscle activity in the cervical region and restrained joint movement to avoid overextensibility of neural tissue [6]. The involvement of sensitive cervical nerve tissues is present in 89% of subjects suffering persistent arm pain and paresthesia in chronic cervical whiplash [7]. Irritation of the brachial plexus, with constant diffuse pain and/or paraesthesia in the upper limb, was observed in 38% of subjects suffering from cervical whiplash between 1 and 12 weeks after the injury [8].

Lowered pain thresholds have been reported locally in the nerve trunks in the upper extremities, and distal to the injured area in subjects with chronic cervical-whiplash-associated disorders [9]. This finding suggests that local diffuse neck pain in cervical whiplash is related, in part, to sensitisation of the cervical nerve roots, but also to a central sensitisation process that may affect distal areas (e.g. wrist) where no tissue damage is required to provoke pain and alter functionality [9]. Grip strength has been included as a tool to measure functional capacity in cervical whiplash [10]. Entrapment of the median nerve in the carpal tunnel has been suggested as an associated component to the chronic pain of the upper limb in patients with cervical whiplash [11]. Furthermore, reduced movement of the median nerve has been reported proximal to the carpal tunnel in subjects with non-specific arm pain [12]. To the best of the authors' knowledge, this is the first study to report the effect of manual therapy on grip strength in patients with cervical whiplash.

Myofascial induction aims to relax muscular excitability, which may be linked to the perpetuation of central sensitisation in cervical whiplash [13]. It has also been shown to have a positive impact on joint range of motion [14], pain relief [15] and overall physical function [16]. This study hypothesised that a suboccipital muscle inhibition (SMI) procedure would reduce the muscle guarding in this region in patients with cervical whiplash. Therefore, the objective of this study was to assess the immediate effect of the SMI technique on the subject's response to the ULNT-1, self-perceived neck pain and grip strength, and determine the relationship between key variables.

Materials and methods

Design and randomisation procedure

A randomised [using a randomised number table designed by an Internet website (randomized.com)], single-blind (no relationship between the evaluator and the therapist in charge

of the intervention, also see 'Blinding' section) controlled clinical trial was undertaken. An external consultant prevented access to the sequence for those participating in the study.

Blinding

Before randomisation, all participants were informed of the general aspects of the trial (possible benefits, risks, side effects of assessments and interventions, and that different types of treatments would be compared). Subjects and evaluators, who collected or analysed data, were unaware of the treatment allocation group.

Sampling process

The subjects were selected according to non-probabilistic convenience sampling techniques. The results of a previous pilot study [17] were analysed using the program Ene 2.0 (Universidad Autónoma de Barcelona, Spain). Taking into account a one-tailed hypothesis, a sample size of 17 subjects per group was necessary for a mean between-group difference in elbow range of motion of 5°, an α value of 0.05 and statistical power of 90%.

Inclusion and exclusion criteria

The inclusion criteria for participants were: (a) age 18 to 55 years; (b) medical diagnosis of Grade I or II cervical whiplash according to the Québec Task Force [18]; and (c) positive response to the ULNT-1 for both evaluator and therapist. Patients with any of the following characteristics were excluded: (a) neck pain within 3 months preceding cervical whiplash; (b) medical diagnosis of at least Grade III cervical whiplash according to the Québec Task Force [18]; (c) malformations, previous surgery or injury in the cervical spine or the upper limbs that could prevent the subject from performing the ULNT-1; (d) history of neurological and/or rheumatic disorders; (e) soft tissue therapy within 3 months preceding the study; and (f) any contraindication to the intervention technique (e.g. tumoral disease, osteitis).

Participants

Fifty-six ($n=56$) subjects with Grade I or II cervical whiplash were recruited for the study from one of the researcher's practices. After the allocation phase, the final sample included 40 subjects (17 women and 23 men) with a mean age of 34 years [standard deviation (SD) 3.6, range 19 to 55 years]. The participants were randomised into two study groups: intervention group (IG) ($n=20$) and control group (CG) ($n=20$). No loss to follow-up was recorded during the data collection or analysis phases (Fig. A, see online Supplementary material) [19]. The study protocol followed the CONSORT guidelines, was designed according to the institutional review board, and registered in the Australian and

Box 1: Standard sequence of movements during median nerve upper limb neurodynamic test (ULNT-1)

- Shoulder girdle depression/stabilisation
- Shoulder girdle abduction (slightly >90°)
- Wrist/fingers extension (90°)
- Maximal forearm supination
- Shoulder external rotation
- Elbow extension
- Structural differentiation (cervical sidebending)

New Zealand Clinical Trials Registry (Registration Number ACTRN 12611001238965).

Measurement protocol

After a consulting physician had diagnosed cervical whiplash, patients were selected if they qualified under the inclusion/exclusion criteria. A clinical neurological examination was performed on all subjects. The subject filled in an informed consent form, as established by the Declaration of Helsinki. The study was conducted in the same room at a constant temperature. Participants received the evaluation and intervention protocol together in one session. Both the therapist and the evaluator were senior physical therapists with over 6 years of experience in the field of manual therapy. The evaluator had been trained previously in management of the assessment tools. The assessment protocol was conducted in the following order.

Self-perceived neck pain

A visual analogue scale (VAS) was used. The subject remained seated on the treatment table with both feet on the ground, and was asked to mark the current intensity of pain on a horizontal 100-mm line (0 mm indicating no pain, 100 mm indicating the maximum possible pain). The VAS is a precise, effective, sensitive and reliable measurement tool for the evaluation of acute and chronic pain [20].

Evaluation of elbow range of motion during the ULNT-1

The participant was placed in the supine position with the upper limbs resting along the body, and the elbow of the tested side flexed 90°. The therapist asked the subject to ‘Let me know when you start feeling pain or discomfort in the painful area’. The ULNT-1 was performed according to recognised methods (Box 1) [4]. The first step of the sequence was gentle shoulder girdle depression; this was standardised using an air-filled pressure sensor (Stabiliser, Chattanooga Group Inc., Chattanooga, TN, USA) placed between the evaluator’s forearm and the upper surface of the subject’s shoulder, and then inflated to a baseline of 40 mmHg [6]. Shoulder

girdle depression was continued until the pressure reached 60 mmHg, whereupon the sequence continued as shown in Box 1. When the subject reported pain or discomfort, the therapist stopped and measured the elbow extension range of motion. A universal goniometer was used, aligned along the mid humeral shaft, medial epicondyle and ulnar styloid. Intra-tester reliability of elbow extension with a goniometer is reported to be high [intra-class correlation coefficient 0.97, 95% confidence interval (CI) 0.95 to 0.99] [21], with a mean difference from a gold standard of 1.1° (SD 5.1, 95% CI 9.2 to –11.4) and a maximal error of 10.3° [21].

The evaluator assessed which side had the more painful upper trapezius or the ULNT-1 provoked more severe symptoms or discomfort according to the subject’s perception. The evaluation was only made on the more painful side. The ULNT-1 has been shown to have high intra- and inter-examiner reliability (intra-class correlation coefficient >0.95) in patients with cervicobrachial pain [22] and in asymptomatic subjects [23]. It has been suggested that differences greater than 4.5° represent a slight improvement when the ULNT-1 is repeated several times; when a single test is performed, differences should be greater than 7.5° to show a relatively meaningful clinical change [22].

Grip strength

Pain-free grip strength was measured with a digital dynamometer (JAMAR 5030J1, Chicago, IL, USA) on the same side as that used to evaluate elbow range of motion. The subject was in a seated position, with the shoulder adducted and neutrally rotated, the elbow flexed to 90°, the forearm in the neutral position, and the wrist with a ‘subtle’ dorsal flexion, if needed, or in the neutral position [24]. The subject was instructed to ‘Grasp it as strongly as you can without feeling pain or discomfort’. Three measurements were made, taking the mean as the reference value. Dynamometric evaluation of grip strength has proven to be valid [24].

Suboccipital muscle inhibition technique in the intervention group

The subject was in the supine position, and the therapist sat at the head of the table and placed both hands under the subject’s head, contacting the space between the occipital condyles and the spinal process of the second cervical vertebra with the fingertips. Constant and painless pressure was exerted upward, towards the therapist [25]. A review of the literature indicated that 4 minutes was required to attain tissue relaxation at the suboccipital level [17,26]. Participants were asked to keep their eyes closed to avoid eye movements that might affect suboccipital muscle tone.

Sham intervention in the control group

The sham (placebo) intervention consisted of performing active movement of flexion/extension of the hip and knee

Table 1
Baseline characteristics of participants.

	Control group (n = 20)	Intervention group (n = 20)	P-value
Age (years)	36 (5.3)	(5.2)	0.21
Gender			
Female, n (%)	6 (30)	11 (55)	0.18
Male, n (%)	14 (70)	9 (45)	
Affected upper limb (ULNT-1)			
Dominant side, n (%)	12 (60)	8 (40)	0.28
Non-dominant side, n (%)	8 (40)	12 (60)	
Grip strength (kg)	25.9 (6.3)	25.1 (6.3)	0.84
Perceived neck pain (VAS) (mm)	56.2 (10.6)	52.0 (9.0)	0.52
Elbow extension (°)	116.0 (10.2)	130.1 (7.8)	0.02

Data are expressed as mean (standard deviation) or as n (%).

ULNT-1, upper limb neurodynamic test of the median nerve; VAS, visual analogue scale; P, statistical significance of the between-group difference.

joints on the opposite side to which the measurement was taken, according to the response to the ULNT-1. The intervention time was also set at 4 minutes.

Statistical analysis

PASW Advanced Statistics Version 18.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Mean (SD), mean difference and 95% CI of the difference were calculated for each variable. The Kolmogorov–Smirnov test showed a normal distribution of all quantitative variables ($P > 0.05$). Baseline characteristics in the study groups were compared using Student's *t*-test for quantitative variables and Chi-squared test for categorical variables.

Inferential analysis of variance for repeated measures (ANOVA test) for group (CG or IG) and time (pre- or post-intervention) allowed between-group differences to be observed. The effect size was evaluated using Cohen's test, and Pearson's correlation coefficients were used to evaluate the association between variables. $P < 0.05$ was taken to indicate statistical significance.

Results

The study sample ($n = 40$) was evaluated to compare between-group differences in physical and clinical characteristics at baseline (Table 1). Significant differences were only found for elbow goniometry ($P = 0.02$).

Elbow range of motion and grip strength improved in both groups after the intervention, but neck pain was slightly worse after the intervention in both groups (Table 2). In the within-group comparison, only elbow range of motion was found to differ significantly for the IG ($P = 0.01$). When comparing between-group differences following the intervention (Table 2), a significant difference was found for elbow range of motion [$P = 0.01$; $F(1,38) = 6.81$; $R^2 = 0.15$]. However, no significant between-group differences were found for grip strength ($P = 0.06$) or neck pain and/or discomfort ($P = 0.38$).

The correlation study showed an association between neck pain and the other measured variables. A positive correlation was found between age and neck pain ($P < 0.01$; $r = 0.49$), and a negative correlation was found between pain and grip strength ($P < 0.01$; $r = -0.54$), and pain and elbow range of motion ($P = 0.01$; $r = -0.38$).

Table 2

Change scores, and within- and between-group post-intervention comparisons for grip strength (kg), neck pain (mm) and elbow extension (°) during the upper limb neurodynamic test of the median nerve.

	Pre-intervention Mean (SD)	Post-intervention Mean (SD)	Within-group difference Mean (95% CI)	Between-group difference Mean (95% CI)	P-value
Grip strength					
Control group	25.9 (6.3)	28.0 (7.3)	−2.1 (−3.6 to −0.5)	1.67	0.06
Intervention	25.1 (6.3)	25.5 (7.9)	−0.4 (−1.4 to 0.5)	(−0.1 to 3.45)	
Neck pain (VAS)					
Control group	56.2 (10.6)	55.2 (10.5)	1.0 (−1.8 to 3.8)	−2.2	0.39
Intervention	52.0 (9.0)	48.7 (10.8)	3.2 (−1.5 to 8.0)	(−7.5 to 3.0)	
Elbow extension					
Control group	116.0 (10.2)	120.9 (14.8)	−4.9 (−11.8 to 2.0)	−10.5	0.01
Intervention	130.1 (7.8)	145.5 (11.5)	−15.4 (−20.1 to −10.6)	(−18.6 to −2.3)	

SD, standard deviation; CI, confidence interval; VAS, visual analogue scale; P-value, statistical significance of the between-group difference.

Discussion

The SMI technique had a positive effect on elbow extension during the ULNT-1 in subjects with cervical whiplash. Elbow range of motion increased immediately after the intervention in the IG by 15.4° (SD 10.2°). This result exceeds the threshold (4 to 7.5° improvement in elbow mobility) that has been suggested to indicate a clinical change [22]. Nonetheless, SD estimates for elbow range of motion at pain onset during the ULNT-1 in symptomatic and asymptomatic subjects has been observed to range from 14° to 20° [4]. Furthermore, the potential maximal error for measurement of elbow extension with a universal goniometer is approximately 10° [21], which means that the clinical relevance of the present results needs to be considered with caution. Although the goniometer is a simple, reliable and commonly used tool in clinical practice, the findings must be interpreted with caution when slight changes are found, due to the variability between subjects, the overlap in range of motion and the amount of measurement error [4]. Nevertheless, the aim of this study was not to compare the ULNT-1 range of motion between both upper limbs or with asymptomatic subjects, but to assess the changes between pre- and post-intervention.

The SMI technique has previously reported positive results distal to the area of treatment. Quintana Aparicio *et al.* [25] found an increase in hamstring flexibility after the SMI manoeuvre, and they considered that fascial continuity in the muscle and neural level would be a possible explanation for this phenomenon. The dura mater establishes a direct link with the musculoskeletal system through the rectus capitis posterior minor muscle in the suboccipital region, the so-called ‘myodural bridge’ [27]. A manual technique that may achieve a release of tension at this level would affect peripheral tension according to the tensegrity theory [28]. This theory proposes a structural concept of the body that explains how release of fascial tension in one part may involve the whole structure, being the main biomechanical basis to explain the results of myofascial techniques [28]. Furthermore, fascial continuity through neuromuscular chains has been hypothesised to elucidate a relationship between neck and upper limb muscles [29]. That would explain the release of distal tension and, consequently, the improvement of joint mobility after a local technique at the suboccipital level.

The myodural bridge also represents a potential explanation for the effect of manual therapy at the suboccipital region on craniocervical pain, as the increase of fatty infiltration in the rectus capitis posterior minor muscle of subjects with chronic neck pain after cervical whiplash suggests damage to the suboccipital musculature [27]. Nonetheless, no differences in VAS scores were observed in the IG. In fact, according to the results of correlations, an improvement in elbow mobility should have implied a decrease in cervical pain. On the one hand, local changes after myofascial induction in the cervicmandibular area have been observed

regarding neck mobility [14], and neural and muscular mechanosensitivity [15,26]. On the other hand, no changes in pressure pain threshold at a local level were reported after fascial induction manoeuvres in the cervical region [14]. However, all these studies evaluated short-term effects in asymptomatic subjects, and they all concluded that the results were below the minimum detectable change to assume clinical significance. In a pilot study with subjects with subacute cervical-whiplash-associated disorders who underwent the Fascial Manipulation[®] technique, Picelli *et al.* [30] observed a significant decrease in neck pain in a 2-week follow-up. Nevertheless, the Fascial Manipulation technique is different from the procedure used in the present trial, and was not performed solely within the cervical region, making comparison between the two studies difficult.

Vernon *et al.* [31] reported that irritability of the deep cervical paraspinal tissues, as happens after cervical whiplash, may cause hyperalgesia linked to a central sensitisation process. This may explain why the SMI technique was not sufficient to activate the descendent inhibitory system and relieve pain. Central sensitisation can be perpetuated by psychological aspects that increase pain at the central nervous system level [32]. Psychological and cognitive factors also play a role in cervical whiplash influencing pain perception, and may contribute as a perpetuating factor of cervical-whiplash-associated disorders [33]. In conclusion, concerning neck pain relief, there is limited evidence for most of the therapies used for cervical whiplash, although active interventions seem to have more effect than passive modalities [34].

Regarding grip strength, there were no between-group differences after the intervention. Immediate changes in pain-free grip strength have been observed in the affected upper limb after end range high-velocity low-amplitude spinal manipulation, either in the cervical or thoracic region, in subjects with lateral epicondylalgia [35,36]. Spinal manipulation has been reported to produce hypoalgesic effects related to its influence on central mechanisms of processing and controlling pain [37]. However, this effect has not been found with the SMI technique.

Study limitations

Measurements of grip strength and elbow extension were only made in one upper limb. Therefore, it was not possible to compare the results between dominant and non-dominant sides. It was hypothesised that some of the participants may have been expecting financial compensation following a road traffic accident. Self-reported pain and symptoms during the ULNT-1 could have been influenced by this aspect, as being part of a compensation process has been associated with poorer outcomes [38]. Finally, all the effects were evaluated in the short term. It would be interesting to assess results over the medium to long term to observe results of higher clinical significance.

Conclusion

The SMI technique immediately improves elbow extension during the ULNT-1 in subjects with cervical whiplash. However, no immediate effect on grip strength or neck pain was observed.

Ethical approval: Ethical Committee of Experimentation of the University of Seville, Spain.

Conflict of interest: None declared.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.physio.2013.09.005>.

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