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ORIGINAL ARTICLE

Immediate Effects of the Ashmore Manipulation Technique C5/C6, in Muscle Activity in patients with Mechanical Neck Pain

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ABSTRACT

Introduction: The effects of spinal manipulation are not yet entirely clear. Previous studies have found both increased and decreased electromyographic (EMG) activity of muscles related to the level being manipulated, although few of them have considered the cervical region or symptomatic individuals.

Objetives: To determine the immediate effects of the C5/C6 (Ashmore) manipulation technique on bilateral EMG activity of the middle deltoid muscle at rest and in contractions.

Patients, Materials and Methods: A randomized, controlled, single blind, experimental study was conducted. A total of 30 individuals presenting with mechanical neck pain were assigned randomly to two groups: 15 formed the experimental group (EG), and 15 the control group (CG). All participants completed a data questionnaire and the NDI (Neck Disability Index), and underwent a vertebral artery and EMG evaluation before their participation. After C5/C6 manipulation in the intervention group and no manipulation in the control group, the EMG evaluation was repeated.

Results: All the variables were normally distributed, indicative of the total sample's initial homogeneity. Comparative post-intervention inter-group analyses showed statistically significant differences in the root mean square (RMS) values of the 30-s isometric bilateral EMG measurements of the middle deltoid muscle's activity.

Conclusions: C5-C6 spinal manipulation reduced EMG activity in the longer isometric contractions, but no changes were observed neither in the resting EMG values nor in the isotonic contractions performed.

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INTRODUCTION

Spinal manipulation has been found to have different physiological effects. Among the most important are increased muscle strength^{1,2}, the reduction of pain as evidenced by pressure pain thresholds³⁻⁵, changes in reflexes⁶, the capacity to change inhibitory neural processing and cortical motor control^{7,8}, and control of the production of substance P or tumour necrosis factor⁹.

The musculoskeletal effects of spinal manipulation are not well understood¹⁰, although it is observed to cause facet joint cavitation, and to affect the mobility of the vertebral bodies and the reflex response of the muscles in the vicinity of the manipulation¹¹.

The biomechanical changes caused by spinal manipulation are also considered to have the physiological consequence of affecting the inflow of sensory information to the Central Nervous System (CNS).

The procedure stimulates paraspinal muscle spindles and Golgi tendon organ afferents¹². Small diameter sensory nerve fibres are probably activated, although this has not been demonstrated directly.

Therefore, one of the effects following spinal manipulation should be the capacity to alter central sensory processing by modifying the mechanical or chemical stimulation threshold of the paraspinal tissues⁶ and the change in the excitability of alpha motor neurons^{13,14}. Changes may occur both near and far from the location of the manipulation¹⁴.

There is an association between spinal manipulation and improvement of muscle function,¹⁵ although this relationship is sometimes contradictory^{16,17} and seems more evident in the lumbar than in the cervical spine¹⁸.

It has therefore been proposed to study the effects of cervical manipulation on non-spinal muscle electromyography (EMG) in symptomatic individuals (with neck pain)¹⁹. The purpose of the present study was to determine the immediate effects of the C5/C6 (Ashmore) manipulation technique on the resting and contraction bilateral EMG activity of the middle deltoid muscle in patients with mechanical neck pain (MNP).

MATERIAL AND METHODS

Design

The study design to evaluate the immediate pre- and post-intervention effects was experimental, randomized, single blind, and explanatory.

Study Population

The participants were thirty (n=30) volunteers of both sexes who had presented Mechanical Neck Pain (MNP) in the last 6 months, aged between 22 and 45 years, divided into two groups: the experimental group (EG) (n=15; aged 22-42 years) received the Ashmore Technique, and the control group (CG) (n=15; aged 23-45 years) without intervention.

The volunteers were employees and students of FOP/UNICAMP recruited through in-campus posters and publicity. They all signed an informed consent form.

The exclusion criteria were: pathology of the vertebral artery (detected by screening²⁰), severe osteoarthritis, osteoporosis, presence of a tumour, neck surgery, disk herniation in the neck, joint instability (torsion, fracture, or dislocation), cervical trauma, ingestion of analgesics in the preceding 24 hours, or receiving physiotherapeutic, osteopathic, or chiropractic treatment.

Randomization

The distribution of patients to study groups was random, and it was generated by software - Microsoft Excel 2007® (Microsoft Corporation, Washington, USA).

Assessments

We performed the following assessments:

1.- Neck Disability Index (NDI). The Neck Disability Index (NDI)²¹, translated into Portuguese and validated in Brazil²², was applied at the beginning of the evaluation.

2.- Electromyography (EMG). EMG was used to evaluate the activity of the (middle) deltoid muscle fibres before and after the intervention. We used a Myosystem-Br1 Electromyograph (DataHommis, Uberlândia, MG, Brazil) with active differential electrodes (silver bars 10mm apart, 10mm long, 2mm wide, gain of 20×, input impedance of 10 GΩ, and rejection rate of 130 dB at 60 Hz).

The device is designed in conformance with international standards, and was calibrated according to standard specifications²³.

EMG activity was recorded with the subject seated comfortably in a chair in four situations: at rest for 5 s (with forearms and hands resting on the thighs), isotonic contraction (90° bilateral shoulder abduction, elbow flexed at 90° for 5 s), 5-s isometric contraction (maintaining the 90° abduction with a weight of 1 kg on the arm for 5 s), and 30-s isometric contraction (the same procedure but for 30 s).

To standardize the evaluation, the subjects received instructions from the evaluator as follows: before rests, "relax as much as possible"; before the isotonic contraction, "gradually separate the elbow from the body until it reaches shoulder height"; during the isometric contractions, "keep your position steady, don't move, you're doing good, hold on, ...".

The subjects rested for at least 30 s between evaluations. None of them made any mention of any pain during the evaluation or intervention. To analyze the EMG signals, we took their root mean square (RMS) values (μV_{RMS}). The isotonic and isometric contraction measurements were divided into windows as follows: for the isotonic contraction, the beginning and end of the contraction were discarded; for the isometric contractions, we took one window at the initiation of the contraction and another at the end²⁴. These evaluations have proven to have high reliability^{25,26}.

Experimental Group Intervention

The technique employed was that of Ashmore. This uses anterior and lateral glide, and the greater parameters of extension, ipsilateral lateroflexion, and contralateral rotation.

Adjustment is in the first part of the technique, followed by slightly increasing the tension to take up the soft-tissue slack, and the "thrust" is made in cervical rotation²⁷.

According to Le Corre, this technique can be performed on the C3, C4 to C7, and T1 vertebrae in order to use the possibilities offered by the spine's biomechanics to minimize the maximum rotation and its impact on the vertebrobasilar circulation^{20,28}. The technique was applied to the right side.

Control Group Intervention

The individuals belonging to the CG underwent no intervention, only the vertebral artery test with the same waiting time as the other group.

Statistical Analysis

Statistical analyses were performed using SPSS 16.0 (SPSS, Chicago, Ill). For the descriptive analysis, we calculated the mean and, as appropriate, the standard deviation, standard error, and/or 95% confidence interval.

The Kolmogorov-Smirnov test was used to evaluate the normality of quantitative data. Baseline characteristics were compared between groups using Student's *t*-test, the chi-squared test, and Fisher's exact test.

To analyze the principal effects of the intervention on the EMG, a two-way analysis of variance (ANOVA) was applied for independent samples with the groups (experimental and control) and the inter-subjects factor, and the moment (pre-post) and the intra-subjects factor.

The hypothesis of interest was the inter-group interaction. The analysis was performed for a confidence level of 95%, with values of $p < 0.05$ being considered statistically significant. Intra-group effect sizes were calculated in terms of Cohen's *d*.

An effect size greater than 0.8 was considered large, of around 0.5 moderate, and of less than 0.2 small²⁹.

VARIABLE	GROUP		p-Value
	EXPERIMENTAL (n=15)	CONTROL (n=15)	
AGE (years)	30,41 ± 4,76	30,78 ± 7,43	0,4
WEIGHT (kg)	65,55 ± 12,12	70,5 ± 16,55	0,3
HEIGHT (m)	1,7 ± 0,12	1,73 ± 0,23	0,4
BMI (kg/m ²)	22,68 ± 2,81	23,58 ± 3,8	0,4
NDI	8,12 ± 3,4	7,8 ± 5,72	0,7

Table 1. Demographic Results of both Groups.

BMI: Body Mass Index; NDI: Neck Disability Index; The statistically significant differences were expressed as * p<0.05.

VARIABLE (µV)	GROUP		ANOVA 2 way F (p-value)
	EXPERIMENTAL (n=15)	CONTROL (n=15)	
RMS resting Right PRE	1,7 ± 0,61	1,82 ± 0,62	0,01(0,9)
RMS resting Right POST	1,71 ± 0,65	1,71 ± 0,6	
RMS resting Left PRE	2,22 ± 0,9	2,46 ± 1,51	1,52(0,28)
RMS resting Left POST	2,21 ± 1,32	2,22 ± 1,2	
RMS isot Right PRE	96,87 ± 41,52	91,49 ± 34,20	<0,01(0,9)
RMS isot Right POST	90,52 ± 39,81	86,1 ± 26,78	
RMS isot Left PRE	95,32 ± 43,19	96,01 ± 47,02	0,17(0,71)
RMS isot Left POST	91,84 ± 47,29	89,42 ± 41,54	
RMS Isomet 5 seg Right PRE	90,01 ± 41,76	91,04 ± 33,88	<0,01(0,96)
RMS Isomet 5 seg Right POST	83,82 ± 36,23	85,43 ± 31,04	
RMS Isomet 5 seg Left PRE	83,66 ± 37,27	88,54 ± 38,62	0,05(0,84)
RMS Isomet 5 seg Left POST	81,44 ± 37,39	86,56 ± 42,86	
RMS Isomet 30 seg Right PRE	86,23 ± 33,23	81,67 ± 32,02	4,5(0,04)*
RMS Isomet 30 seg Right POST	81,82 ± 33,58	84,16 ± 34,34	
RMS Isomet 30 seg Left PRE	79,69 ± 32,08	84,50 ± 35,22	4,4(0,04)*
RMS Isomet 30 seg Left POST	74,45 ± 33,56	88,93 ± 40,03	
RMS INITIAL Isomet 30 seg Right PRE	92,23 ± 36,67	89,77 ± 33,02	<0,01(0,9)
RMS INITIAL Isomet 30 seg Right POST	92,07 ± 42,34	89,35 ± 32,67	
RMS INITIAL Isomet 30 seg Left PRE	87,56 ± 39,06	89,33 ± 42,43	6,45(0,02)*
RMS INITIAL Isomet 30 seg Left POST	85,45 ± 44,78	99,67 ± 48,05	
RMS FINAL Isomet 30 seg Right PRE	84 ± 33,67	81,54 ± 34,63	1,14(0,32)
RMS FINAL Isomet 30 seg Right POST	80,57 ± 34,05	80,38 ± 31,63	
RMS FINAL Isomet 30 seg Left PRE	76,6 ± 32,5	79,56 ± 31,02	8,9(0,01)*
RMS FINAL Isomet 30 seg Left POST	70,03 ± 29,23	85,69 ± 31,01	

Table 2. Pre- Post-intervention Results of EMG variables

RMS: Root Mean Square ; Data are expressed as mean ± (SD) standard deviation
The statistically significant differences were expressed as * p<0.05.

VARIABLE	GROUP	COHEN (d)
RMS resting Right	Experimental	-0,04
	Control	-0,13
RMS resting Left	Experimental	0,01
	Control	-0,17
RMS isotonic Right	Experimental	-0,16
	Control	-0,18
RMS isotonic Left	Experimental	-0,1
	Control	-0,16
RMS isometric 5 seg Right	Experimental	-0,18
	Control	-0,18
RMS isometric 5 seg Left	Experimental	-0,08
	Control	-0,08
RMS isometric 30 seg Right	Experimental	-0,11
	Control	0,07
RMS isometric 30 seg Left	Experimental	-0,10
	Control	0,07
RMS INITIAL isometric 30 seg Right	Experimental	0,01
	Control	0,01
RMS INITIAL isometric 30 seg Left	Experimental	-0,04
	Control	0,20
RMS FINAL isometric 30 seg Right	Experimental	-0,13
	Control	-0,05
RMS FINAL isometric 30 seg Left	Experimental	-0,21
	Control	0,19

Table 3. Results of Intra-group Cohen Index (d)

RESULTS

There were no significant differences between the groups by sex, age, BMI, or NDI, nor in the pre-intervention values of the EMG variables, so that one could assume that the two groups could be compared in all the variables. The baseline data of each group are presented in Table 1.

EMG. The two-way ANOVA showed no effect on the short (5-s) activity, whether isometric or isotonic (Table 2). Differences were identified, however, in the longer-time deltoid activities. Thus, the total isometric activity showed a statistically significant lower bilateral electrical activity, with changes greater than 4 μ V. In the initial and final windows, the behaviour was more heterogeneous. Indeed, it was the CG which showed

the greater change in the RMS values, with these changes being more important on the left side. This behaviour is clearly distinct from a result of bilaterality, so that the capacity for any interpretation has to be questioned because of the high variability of the data for these variables.

Finally, although statistically significant differences were found, they constituted aspects of little clinical relevance since the corresponding effect sizes were close to 0. Even in the best of the cases they were low in magnitude, examples being the variables *RMS INITIAL Isometrics 30 s LEFT* (post-intervention increase in the CG) and *RMS FINAL Isometrics 30 s LEFT* (post-intervention decrease in the EG) (Table 3).

DISCUSSION

Cervical manipulation at the C5/C6 level with leftwards rotation in the seated position was able to change muscle activity behaviour during contractions of long duration (30 s) in patients with MNP. Although bilateral, these changes were of low effect size, and lacked uniformity with respect to the window periods at the beginning and end of the contraction.

This behaviour contrasts with the homogeneity and absence of effects found in contractions of short duration (5 s), whether isometric or isotonic.

The results of this study are coherent with those in the literature on asymptomatic subjects, although, to the best of our knowledge, it is one of the first to evaluate the effects of cervical manipulation on EMG in patients with a pathology (MNP). Dunning et al.¹⁹ performed a study that applied a C5/C6 cervical manipulation technique, evaluating the resting electrical activity of the biceps brachii in healthy subjects. They found increased bilateral EMG activity following the manipulation, as also has been reported in other studies¹⁰, contrary to the findings of the present study.

In contrast, Sterling et al.³⁰, also observed a decrease in EMG activity of the neck flexor muscles following a C5/C6 joint mobilization technique. They explained this decrease as being a possible indirect effect of facilitation of the deep neck flexor muscles, leading to an improved motor pattern during the action of craniocervical flexion³⁰.

This lack of uniformity in behaviour is also manifest in the lumbar spine, a region which has been investigated in greater depth, and with a greater diversity of research techniques, evaluation tools, and subjects than has the cervical spine^{2,17,18,31-33}.

There are at least three proposed theoretical mechanisms of how spinal manipulation acts – as a mechanical arthrokinetic effect, as a neuroendocrine effect (e.g., endorphin release), and as a neurophysiological or reflex effect¹⁶.

Some authors have argued that changes in muscle activity after mobilization of the cervical spine can be explained by the reduction in pain, which has been associated with a sympathetic excitatory effect resulting in decreased muscle activity³⁰.

These data are consistent with the hypothesis that spinal manipulation activates the descending inhibitory pathways through the midbrain periaqueductal gray area⁴, which also could be responsible due to the associated motor response to manipulation.

It was not possible to test these mechanisms in the present study because of the painlessness of the application of the protocols and the sample's low NDI values.

Study Limitations

Although the 5-s and the 30-s results were consistent, it is possible to identify certain limitations and imprecisions in the study. The variability of the initial and final windows of the 30-s contractions reduced the power of the results to reject a null hypothesis, and the consistency of the negative results was limited (as in the CG). Several sample sizes are required to draw more decisive conclusions on these variables.

The diversity of the methods used in the literature makes it hard to draw stable conclusions that can be carried over to clinical practice, and limits the comparability of results between studies. The low NDI of our patients shows that in their cases the disease is not acute. It might be interesting to know what happens with spinal manipulation at different stages of MNP in the medium and long terms.

We propose long-term evaluation studies, including other variables as well as those of EMG, in different

conditions, and with larger samples, so as to achieve more consistent results.

CONCLUSIONS

The Ashmore technique C5-C6 significantly reduced the bilateral EMG activity of the middle deltoids during 30-s isometric contraction, enhancing muscle recruitment and fatigue resistance, compared with the electrical activity in the control subjects, but no changes were observed neither in the resting EMG values nor in the isotonic contractions performed.

These changes were absent, however, in the shorter (5 s) activities, with small effect size.

ETHICS RULES

This research meets the ethical standards established in the Declaration of Helsinki³⁴.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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REFERENCES

- 1 Cleland JA, Selleck B, Stowell T, Browne L, Caron T. Short-Term Effects of Thoracic Manipulation on Lower Trapezius Muscle Strength. *J Manipulative Physiol Ther.* 2004; 12: 82-90.
- 2 Colloca CJ, Keller TS, Harrison DE, Moore RJ, Gunzburg R, Harrison DD. Spinal manipulation force and duration affect vertebral movement and neuromuscular responses. *Clin Biomech.* 2006; 21: 254-262.
- 3 Fernández-de-las-Peñas C, Pérez-de-Heredia M, Brea-Rivero M, Miangolarra-Page JC. Immediate effects on pressure pain threshold following a single cervical spine manipulation in healthy subjects. *J Orthop Sports Phys Ther.* 2007; 37: 325-329.
- 4 Vicenzino B, Collins D, Benson H, Wright A. An investigation of the interrelationship between manipulative therapy-induced hypoalgesia and sympathoexcitation. *J Manipulative Physiol Ther.* 1998; 21: 448-453.

- 5 Vernon H. Qualitative review of studies of manipulation-induced hypoalgesia. *J Manipulative Physiol Ther.* 2000; 23: 134-138.
- 6 Pickar JG. Neurophysiological effects of spinal manipulation. *Spine J.* 2002; 2: 357-371.
- 7 Taylor HH., Murphy B. Altered sensorimotor integration with cervical spine manipulation. *J Manipulative Physiol Ther.* 2008; 31: 115-126.
- 8 Haavik-Taylor H, Murphy B. Cervical spine manipulation alters sensorimotor integration: a somatosensory evoked potential study. *Clin Neurophysiol.* 2007; 118: 391-402.
- 9 Brennan P, Triano J, McGregor M. Enhanced neutrophil respiratory burst as a biological marker for manipulation forces: duration of the effect and association with substance P and tumor necrosis factor. *J Manipulative Physiol Ther.* 1992; 15: 83-89.
- 10 Suter E, McMorland G. Decrease in elbow flexor inhibition after cervical spine manipulation in patients with chronic neck pain. *Clin Biomech (Bristol, Avon).* 2002; 17: 541-544.
- 11 Herzog W. The biomechanics of spinal manipulative treatments. *JCCA.* 1994; 38: 216-222.
- 12 Pickar JG, Kang YM. Paraspinal muscle spindle responses to the duration of a spinal manipulation under force control. *J Manipulative Physiol Ther.* 2006; 29: 22-31.
- 13 Dishman JD, Bulbulian R. Spinal reflex attenuation associated with spinal manipulation. *Spine.* 2000; 25: 2519-2525 discussion 2525.
- 14 Suter E, McMorland G, Herzog W, Bray R. Conservative lower back treatment reduces inhibition in knee-extensor muscles: a randomized controlled trial. *J Manipulative Physiol Ther.* 2000; 23: 76-80.
- 15 Keller TS, Colloca CJ. Mechanical force spinal manipulation increases trunk muscle strength assessed by electromyography: a comparative clinical trial. *J Manipulative Physiol Ther.* 2000; 23: 585-595.
- 16 Herzog W, Scheele D, Conway PJ. Electromyographic responses of back and limb muscles associated with spinal manipulative therapy. *Spine.* 1999; 24: 146-153 discussion 153.
- 17 Lehman GJ, McGill SM. Spinal manipulation causes variable spine kinematic and trunk muscle electromyographic responses. *Clinical Biomech.* 2001; 16: 293-299.
- 18 Colloca CJ, Keller TS. Stiffness and neuromuscular reflex response of the human spine to posteroanterior manipulative thrusts in patients with low back pain. *J Manipulative Physiol Ther.* 2001; 24: 489-500.
- 19 Dunning J, Rushton A. The effects of cervical high-velocity low-amplitude thrust manipulation on resting electromyographic activity of the biceps brachii muscle. *Man Ther.* 2009; 14: 508-513.
- 20 Arnold C, Bourassa R, Langerb T, Stonehamc G. Doppler studies evaluating the effect of a physical therapy screening protocol on vertebral artery blood flow. *Man Ther.* 2004; 9: 13-21.
- 21 Vernon H, Mior S. The neck disability index: a study of reliability and validity. *J Manipulative Physiol Ther.* 1991; 14: 409-415.
- 22 Cook C, Richardson JK, Braga L, Menezes A, Soler X, Kume P, et al. Cross-cultural adaptation and validation of the Brazilian Portuguese version of the neck disability index and neck pain and disability scale. *Spine.* 2006; 31: 1621-1627.
- 23 Merletti R, Rainoldi A, Farina D. Surface electromyography for noninvasive characterization of muscle. *Exerc Sport Sci Rev.* 2001; 29: 20-25.
- 24 Larivière C, Arsenault AB, Gravel D, Gagnon D, Loisel P. Median frequency of the electromyographic signal: effect of time-window location on brief step contractions. *J Electromyogr Kinesiol.* 2001; 11: 65-71.
- 25 CastrolforioT, Farina D, Bottin A, Piacino MG, Bracco P, Merletti R. Surface EMG of jaw elevator muscles: effect of electrode location and inter-electrode distance. *J Oral Rehabil.* 2005; 32: 411-417.
- 26 Cecere F, Ruf S, Pancherz H. Is quantitative electromyography reliable? *J Orofac Pain.* 1996; 10: 38-47.
- 27 Ricard F. Tratamiento Osteopático de las algias de origen craneo-cervical. Madrid: Mandala, 1991.
- 28 Le Corre F, Rageot E. Atlas práctico de osteopatía. Porto Alegre: Artmed, 2004.
- 29 Cohen J. Statistical power analysis for the behavioural sciences. Hillsdale (NJ): Lawrence Erlbaum Associates, 1988.
- 30 Sterling M, Jull G, Wright A. Cervical mobilisation: concurrent effects on pain, sympathetic nervous system activity and motor activity. *Man Ther.* 2001; 6: 72-81.
- 31 Colloca CJ, Keller TS. Electromyographic reflex responses to mechanical force, manually assisted spinal manipulative therapy. *Spine.* 2001; 26: 1117-1124.
- 32 DeVocht JW, Pickar JG, Wilder DG. Spinal manipulation alters electromyographic activity of paraspinal muscles: a

- descriptive study. *J Manipulative Physiol Ther* ;28:465-471. 2005; 28: 465-471.
- 33 Lehman GJ, Vernon H, McGill SM. Effects of a mechanical pain stimulus on erector spinae activity before and after a spinal manipulation in patients with back pain: a preliminary investigation. *J Manipulative Physiol Ther*. 2001; 24: 402-406.
- 34 Carlson RV, Boyd KM, Webb DJ. The revision of the Declaration of Helsinki: past, present and future. *Br J Clin Pharmacol* 2004;57(6):695-713.

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