Effects of cervical manipulation on pain, grip force control, and upper extremity muscle activity: a randomized controlled trial

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ABSTRACT

Objectives: Individuals with neck pain experience disrupted grip force control when performing manipulative tasks. Manipulative physical therapy might decrease pain and change the activity of surrounding muscles; however, its effect on upper limb motor control remains undetermined. This study aims to analyze the effects of cervical manipulation on pressure pain threshold (PPT), upper extremity muscle activity along with grip force control in individuals with neck pain.

Methods: Thirty subjects with neck pain were instructed to grasp and lift an object before and after cervical ($n = 15$) or sham ($n = 15$) manipulation. The patients' PPT, electromyographic (EMG) activity of the upper extremity/scapular muscles, and grip force control were analyzed before and after one session of manipulation.

Results: No significant differences were found in the grip force control, PPT and EMG activity variables between groups.

Discussion: These results suggest that a single session of cervical manipulation may not modify upper limb motor control, more specifically grip force control and EMG activity, in patients with cervical pain. Future studies should investigate potential changes in grip force control in patients with different features of neck pain and/or by applying long-term treatment.

Level of Evidence: 1b.

KEYWORDS

Grasping; lifting; neck pain; thrust; grip force control; EMG

Introduction

It is known that approximately 70% of individuals will have cervical pain at some point in their lives [1], and a large part of these patients will develop chronic symptoms [2] and functional disability [3]. Even though the cause of cervical pain can be associated with degenerative processes such as osteoarthritis or diseases identified in imaging examinations [4], the main cause is usually unknown and cannot be clearly established [4,5]. There is evidence that neck pain causes alterations in motor activity [6], leading to changes of motor control strategies during static and dynamic activities [7]. Regardless of the main cause, functional disability can be the result of motor changes affecting the ability to manipulate objects properly.

Grip force control consists of applying adequate force to neither deform the object nor allow it to slip from the grasping fingers. This applied force depends on the object's characteristics (weight, shape, and weight distribution), speed of movement, and the friction coefficient that exists between the object's contact surface and the person's fingertips [8–10]. Studies involving grip force control usually evaluate grip force at lift-off (GFLO) and grip force peak (GFP), which represent anticipatory (planned force) and

feedback-based grip force control, respectively [11,12]. It has been suggested that the increased GFP observed in patients with cervical pain may be due to pain, disrupted sensorial information or both [13]. For example, patients with neck and upper extremity pain showed unnecessary high levels of grip force compared to healthy individuals, while repeatedly elevating and holding an object [13,14]. Therefore, an intervention technique that improves these symptoms, especially decreasing pain, might change grip force control in these patients.

Vertebral manipulation is defined as the passive application of a high-velocity, low-amplitude (HVLA) thrust at the limit of the available joint movement [15,16]. This technique has been proposed for improving neck pain, function, and satisfaction of patients with cervical pain [5,17]. In addition, studies have shown that this technique modifies the activity of upper extremity muscles [18–20], which may lead to changes in grip force control. Studying the effects of cervical manipulation on both activities of upper extremity muscles and grip force control may benefit the rehabilitation process in patients with cervical pain.

Therefore, the purpose of this study was to determine the effects of cervical manipulation on pressure

pain threshold (PPT), the activity of upper extremity muscles and on grip force control in patients with neck pain during a functional task of grasping and lifting an object. Particularly, PPT, EMG activity of the muscles, and different variables of grip force control were evaluated before and after cervical manipulation in thirty patients with neck pain. Based on the aforementioned studies, we hypothesized that cervical manipulation will improve PPT and decrease the magnitude of EMG activity and grip force control.

Methods

Subjects

The sample included 30 individuals between 18 and 50 years old (27 females and three males, mean age 27.90 ± 4.87 years). The sample size was calculated based

on previous studies using a G*Power 3 software [21]. Only nine subjects in each group were enough to detect statistically significant differences between conditions in grip force peak [13], with 80% of power and 95% of confidence. We included 15 subjects in each group (see details below) to account for the potential differences in the subjects' characteristics and experimental tasks between the previous study [13] and the present investigation (Figure 1). The definitions of neck pain and chronic pain followed International Association for the Study of Pain (IASP) criteria [22]. The sample included individuals who fulfilled the following criteria: a history of three or more episodes of cervical pain in the last three months, with or without pain radiating to the upper extremities. The exclusion criteria included: (1) a previous history of rheumatic disease, cervical myelopathy, tumors, central or peripheral neurological disorders, (2) a history of major trauma, fracture or surgery

Figure 1. Participant flow chart.

in the cervical region, shoulder and/or upper extremities, (3) signs of nerve root compression such as major muscle weakness affecting upper extremity, decrease in biceps and triceps reflexes, decreased sensitivity in upper extremity dermatomes, and (4) 'red flags' against cervical manipulation such as vertebrobasilar insufficiency, vertigo and diplopia [23]. All participants were informed about the study's objectives and procedures and signed the informed consent form approved by the local Ethics Committee (protocol 206/2011). This study was registered in a recognized Registry of Clinical Trials.

Clinical examination

An initial interview, clinical evaluation before and after treatment, and data processing of all participants was conducted by an experimenter who was blinded to the treatment allocation. A physical therapist who performed the treatments (placebo and manipulation, see below) had no knowledge of the above-mentioned data contents. Tactile sensitivity was evaluated with Semmes-Weinstein monofilaments (Touch-Test™ 5-Piece Hand Kit Sensory Evaluators, North Coast Medical Inc.; Gilroy, California, USA) [24], since reduction or loss of fingertip tactile sensitivity negatively affects grip force control [25,26]. The monofilaments were applied three times bilaterally to the tips of the index fingers and thumbs. Detecting the filament's touch in two of the three trials was considered the sensorial threshold and the average scores of all sites were used for analysis [27]. For this evaluation, the following monofilaments were used: 2.83, 3.61, 4.31, 4.56, and 6.65, where 2.83–3.61 correspond to a normal sensory threshold for hand function use and 6.65 to an abnormally high-threshold hindering the ability to recognize objects [28].

In order to characterize the sample, the individuals responded to the Neck Disability Index (NDI) and the Disabilities of Arm, Shoulder and Hand questionnaire (Quick DASH). The NDI questionnaire score ranged from 0, no activity limitations, to 50, complete activity limitation. The Quick DASH questionnaire score ranged from 0, no disability, to 100, greatest disability. If the subject reported bilateral cervical pain, then, the most affected side, i.e. the side with greater pain sensation, was considered for EMG electrode placement and for grip force control data derived from the lifting task.

Instrumentation

Pressure pain threshold

The PPT, defined as the minimum pressure (force) necessary to cause pain [29], was measured using a digital pressure algometer (JTECH Commander, Salt Lake City, UT, USA) with a 1-cm wide tip. A digital readout of the pressure applied to the subject's skin was shown in Newton (N) and the peak pressure was registered automatically (see details below).

EMG

We evaluated the EMG activity of the muscles via electromyography (EMG System of Brazil®, model 811C, SP, Brazil) with an analog output, gain of 2000, band-pass filter from 23 to 500 Hz, Common Mode Rejection Ratio (CMRR) greater than 80 dB, and differential amplifier. All signals reached a computer via a digital/analog acquisition system (model PCI 6259, National Instruments, USA) with a frequency of 1000 Hz and resolution of 16 bits, acquired in a LabView environment (SignalExpress® 2010, Version 4.0.0 for Windows®, National Instruments, USA). Disposable surface electrodes (3 M®, 223BRQ, Sumaré, SP, Brazil) were placed on the skin of individuals with an inter-electrode distance of 20 mm, after cleansing with 70% alcohol and, when necessary, the area was shaved. In order to evaluate the EMG activity in the ipsilateral upper extremity of the neck pain, surface electrodes were fixed over the following muscles: lower trapezius (LT), upper trapezius (UT), anterior deltoid (AD), biceps brachii (BB), triceps brachii (TB), wrist extensors (WE), wrist flexors (WF), and adductor pollicis (AP). A reference electrode was fixed over the spinous process of the seventh cervical vertebra. All the procedures described above were performed by the same experimenter and followed Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles (SENIAM) standards [30].

The experimental cup

A cylindrical, plastic object (6 cm in diameter, 13 cm in height, and 305 g in weight) was used to evaluate thumb-index pinch force control (Figure 2). The object, designed in the shape of a cup, was equipped with a piezoelectric force sensor (model 208CO3, PCB Piezotronics Inc.; Depew, New York, USA) installed at its center. Two aluminum pads (2.5 cm wide and 3.8 cm long) connected to the force sensor with two metallic projections were used as grasping surfaces. A triaxial piezoelectric accelerometer (model 333B32, PCB Piezotronics Inc.; Depew, New York, USA) was affixed to the cup to register acceleration in the x-, y-, and z-planes. Accelerometer and force sensor data were powered with two signal conditioners (ICP R Sensor Signal Conditioner, model Y482A22, and Line-Powered ICP R Signal Conditioner, model 484B06, PCB Piezotronics Inc.; Depew, New York, USA). The force and accelerometer signals were sampled at 100 Hz with a 16-bit analog-digital converter (National Instruments; Austin, Texas, USA) and stored for further analysis. Data collection were performed in LabView Signal Express (Version 2.5.1 for Windows, National Instruments; Austin, Texas, USA).

Experimental procedure

The PPT was evaluated bilaterally by first marking the specific points on the skin with a demographic pencil. These points were marked on the middle third of the upper trapezius (UT) muscle and the medial third of the

Figure 2. (A) Gripping and lifting task. (B) High-velocity, low-amplitude cervical manipulation.

middle deltoid (MD) muscle, and over the lateral epicondyle (LE) as described elsewhere [29,31]. The patients were in supine position with their arms at their sides. The evaluator applied gradual force perpendicularly through the algometer to the skin's surface. The subjects were instructed to indicate the moment when the pressure sensation became painful by saying the word 'pain'. Hence, the experimenter stopped to apply pressure and the maximum force applied to that point was automatically registered by the algometer. Three measurements were made with 30-s intervals. This evaluation was performed before and 15 min after the intervention. This 15-min lag between the manipulation and the PPT post-test corresponded approximately the time it takes for the subjects to complete the grip force control task (see below).

The grip force control data from the gripping and lifting task were evaluated in the ipsilateral upper extremity of the most affected side. Prior to the beginning of the object-lifting task, alcohol swabs were used to clean the subjects' fingertips and the metallic surfaces of the object. The participants sat on an adjustable chair in front of a table, with their trunk straight and their feet resting on the floor. The elbow of the evaluated side was flexed at approximately 30°, with the forearm pronated and the wrist in neutral position while resting on the table. Subjects were required to handle the test object by opposing their thumb and index finger while placed centrally on the grasping surfaces, which had been marked previously. The task consisted of lifting the test object vertically from the table; holding it at a point of 20 cm above the table; and then, after 5 s, returning the object to its initial position. Subjects were instructed to perform

the lifting task as naturally as possible, starting with the experimenter's verbal command 'go' and returning the object to its starting position with the command 'return'. The participants performed five familiarization trials before the beginning of data collection which included six repetitions of grasping and lifting the test object.

After performing the task, the individuals were allocated through block randomization to either the experimental group (manipulation) or the control group (sham manipulation). The randomization arrangement was generated via a web-based program at Randomization.com [32]. A physical therapist with 10 years of experience in orthopedic manipulative physical therapy performed the procedure according to the group in which the subject was allocated. The subjects in the experimental group received high-velocity, low-amplitude (HVLA) cervical manipulation technique, also denominated as thrust or grade V manipulation [16]. With the subject in supine and the cervical spine in a neutral position, the therapist's index finger of one hand was placed on the level of the fifth cervical vertebra (C5), while the other hand contacted the subject's chin of the opposite side. The physical therapist performed a lateral bending of the cervical spine along with axial-rotation of it to the contralateral side up to the end of the available movement. From this point, the physical therapist applied further cervical rotation subtly within a small range of movement using both hands. It was expected, then, to hear a small 'crack' with the manipulation, which is due to cavitation phenomenon [33]. If this did not occur, the physical therapist performed the procedure once more. If there was still no success on the second attempt, the patient was excluded from the study. The direction of

cervical rotation was selected according to the painlessness and of opposite motion rules [34,35], i.e. the cervical rotation movement could not cause painful symptoms. For the control group, the physical therapist simulated a HVLA manipulation technique by positioning his hands on the subjects' cervical/head as previously described for the manipulation group; however, only the cervical rotation was performed without applying any tissue tension at the end of movement, which did not result in cavitation.

An evaluator blinded to the randomization and the procedures performed the data collection pre- and post-intervention. Prior to removing the electrodes, the experimenter performed the PPT evaluation again at the above-mentioned regions.

Data processing

Descriptive measurements were calculated (means and standard deviations) for the relevant subject characteristics: gender, age, and dominance. The NDI, Quick DASH scores, and the mean PPT values of the pre- and post-intervention as well finger sensitivity measures pre-intervention were entered in Microsoft Excel (2007) and stored for statistical analysis.

EMG

To calculate the integral of EMG ($\int$ EMG), first the raw data were filtered with second-order Butterworth band-pass filter (30–400 Hz) [36]. Then, the EMG data were aligned by the moment of the object lift-off (see details below) and the six trials of EMG activity pre-and post-intervention was averaged separately for each participant. The $\int$ EMGs during the object lifting task was demarcated within specific time intervals (from x_0 to x_1) based on the acceleration signals. They were: (1) pre-lifting interval (preL), including the time interval of 300 ms just before the object's lifting (first, subtle increase in the vertical acceleration). This included the time interval where the patients reached, contacted the object with their fingertips, and developed the force to lift it; (2) the post-lifting interval phase (postL) encompassing the time between the object's lift-off to the end of movement at which the acceleration returned to approximately zero. The pre- and post-lifting intervals represent the feedforward and feedback control of the movement to accomplish the object's lifting task, respectively. These two $\int$ EMG intervals (preL and postL), were corrected by their respective EMG activity at the baseline, which was integrated ($\int$ EMG base) at the beginning of data collection with the participants in resting position. The integration intervals (from y_0 to y_1) of the $\int$ EMG base have identical time intervals of their respective pre- and post-lifting $\int$ EMGs according to the equation:

$$\int \text{EMG} = \int_{x_1}^{x_0} \text{EMG} - \int_{y_1}^{y_0} \text{EMG}_{\text{base}}$$

The $\int$ EMG is the integral of the EMG within the time intervals for pre- and post-lifting minus their respective $\int$ EMG baseline activity.

In order to compare $\int$ EMG between groups, they were normalized as follows: for each participant, the maximal absolute value of a given $\int$ EMG for a given muscle across the two-time intervals (pre- and post-lifting) and conditions (pre- and post- manipulation) was determined. All other values of this particular participant and muscle (two time intervals and two conditions = 4) were divided by this maximal value [37,38]. The range values of $\int$ EMG intervals were therefore limited from –1 to 1. Negative and positive values were associated with inhibition and activation of muscle activity, respectively.

Grip force control

From the collected force and accelerometer, the following variables is identified and measured: (1) GFLO in Newton (N), which is the thumb-index pinch force applied at the instant the object leaves the surface of the table and represents planned grip force control [12]; the moment of object lift-off was indicated by the acceleration signal; (2) load force peak (LFP), defined as the maximum load force achieved during object lifting, calculated as $\text{LF} = m \times (\text{AccZ} + g)$, where load force peak (LF), in N, was calculated by multiplication of the object's mass (m), in kg, by the sum of the recorded vertical acceleration (AccZ) and gravity (g) [39–41]. Loading components acting in the direction of the applied grip force (X-axis) and sagittally (Y-axis) to it were not included in the calculation since the tasks consisted of vertical liftings; (3) Grip Force Peak (GFP; N), defined as the maximum thumb-index pinch force achieved during object lifting, indicating grip force control which depend on previous sensorial feedback during the dynamic phase (lifting) [11]. All data processing were performed by an experimenter blinded to the randomization and intervention. All signals are processed in Matlab (version 7.10 R2010b, The MathWorks®, USA).

Statistical analysis

Independent t -tests were used to compare the groups regarding, age, NDI, Quick DASH, scores, and fingers sensitivity measures from the initial clinical evaluation as shown in (Table 1).

Analyses of covariance (ANCOVA) [42], controlling for the baseline result, was performed to evaluate the effect of cervical manipulation on PPT, EMG integrals ($\int$ EMG) in both intervals (pre- and post-lifting) and the grip force control variables (GFLO, LFP, and GFP). The pre-test and post-test means were used as co-variables and dependent variables, respectively. The group was used as fixed factor. To account for the relatively large number of comparisons due to the number of co-primary dependent variables, we lowered the significance level to $p < 0.01$ for the PPT and EMG integral statistical tests.

Table 1. Clinical features at pre-test.

Groups	Manipulation		Sham	
Clinical features	SD		SD	
Age (years)	28	±3.80	27	±5.74
Gender (n)	2 Male	13 Female	1 Male	14 Female
Laterality (n)	1 Left	14 Right	2 Left	13 Right
Task Side	10 D	5 ND	11 D	4 ND
SWMT (threshold)	3.01	±0.28	3.14	±0.33
Pain duration (months)	35	±51.62	26	±19.45
Quick Dash (score)	32.43	±61.58	25.01	±14.24
NDI (score)	11.93	±4.30	11.73	±3.55

Notes: SD: Standard Deviation; QuickDASH: Disabilities of Arm, Shoulder e Hand questionnaire; NDI: Neck Disability Index; SWMT: Semmes-Weinstein Mono-filament Test; Task Side: refers to Dominant (D) and Non-Dominant (ND) hand used in the grip task; number (n).

This significance level was chosen based on the overall experimental error rate of approximately 10% for the PPT variables (6) and 15% for the EMG integrals variables (eight pre- and eight post-lifting). In other words, the chance of at least one of the tests within each pool of dependent variables being false-positive (Type-I error) was 10 and 15% or less, respectively. For the grip force control variables (3), the significance level was set at $p = 0.05$. The statistical analysis was performed in SPSS 20.0.

Results

No patient was excluded from the study due to lack of cavitation phenomenon caused by the cervical spine manipulation or because of intolerance to the maneuver. Two patients were excluded (one from each group) from this study due to technical difficulties with the EMG signals (refer to the flow chart, Figure 1). The independent *t*-test showed no significant intergroup differences for age ($t = -1.01$, $p = 0.32$), NDI ($t = -0.13$, $p = 0.89$), Quick DASH ($t = -0.45$, $p = 0.65$) scores, and fingers sensitivity ($t = 1.13$, $p = 0.26$), which demonstrates that the two groups were homogenous (Table 1).

No statistically significant differences were found in PPT between the control and experimental groups: left UT ($F = 0.21$, $p = 0.64$); right MD ($F = 0.03$, $p = 0.95$); left MD ($F = 3.98$, $p = 0.05$); right LE ($F = 3.45$, $p = 0.07$) and left LE ($F = 0.05$, $p = 0.81$) (Figure 3). The right UT approached significance ($F = 7.46$, $p = 0.01$).

ANCOVA did not detect a statistically significant difference between groups in the $\int$ EMG at pre-lifting interval: UT ($F = 0.45$, $p = 0.50$); LT ($F = 0.84$, $p = 0.36$); AD ($F = 0.71$, $p = 0.40$); BB ($F = 0.40$, $p = 0.53$); TB ($F = 1.02$, $p = 0.32$); WF ($F = 0.05$, $p = 0.82$); WE ($F = 0.09$, $p = 0.76$); AP ($F = 0.18$, $p = 0.77$) and at the post-lifting interval: UT ($F = 5.19$, $p = 0.03$); LT ($F = 0.04$, $p = 0.83$); AD ($F = 0.71$, $p = 0.40$); BB ($F = 0.15$, $p = 0.70$); TB ($F = 0.66$, $p = 0.42$); WF ($F = 0.08$, $p = 0.77$); WE ($F = 0.57$, $p = 0.45$); AP ($F = 0.09$, $p = 0.76$) (Figure 4).

No statistically significant inter-group difference was identified in the grip force control variables: GFLO ($F = 4.02$, $p = 0.05$); GFP ($F = 1.04$, $p = 0.31$) (Figure 5).

Discussion

The task paradigm used in this study was intended to replicate a common upper extremity functional task during the daily activities. This would allow us to identify potential motor control-related changes due to the effect of cervical manipulation in people with cervical pain. The findings of our study refute the hypothesis that a single session of cervical manipulation will affect the pain threshold, EMG activity and motor control of the upper extremity after the maneuver.

The PPT approached significance in the right UT point only during the post-lifting activity; however, no apparent change could be noted between pre- and post-manipulation for the experimental group (Figure 3 – left-upper panel). Increased pain threshold would indicate an immediate hypoalgesic effect as the result of the intervention. Our results differ from those by Ruiz-Saez, Fernandez-de-las-Penas [43], who found an increase in the PPT in the upper trapezius region after cervical manipulation as well as from other studies that found effects of the manipulation in distal sites from the maneuver [31,44]. In these studies, the cervical manipulation increased PPT in shoulder and epicondyle regions as well. The discrepancy between this and our study may be related to the type of population involved in the study. In our study, we selected individuals with chronic cervical pain and without signs of radiculopathy whereas in the above-mentioned studies the authors recruited asymptomatic individuals [31] and patients with lateral epicondylalgia [44]. Therefore, the effects of cervical manipulation on pain may depend on the pathophysiological characteristics of the cervical pain, especially, the location of the nociceptive inputs may influence the effects of manipulative therapy.

We found no changes in the EMG activity either pre- or post-lifting task for the group that received the manipulation. Previous studies have shown conflicting results in terms of EMG activity after cervical manipulation. For instance, Camargo and his colleagues showed increased EMG amplitude in the deltoid muscle after C5/C6 cervical manipulation [45]. This change was observed only during long-lasting (30 s) isometric contractions. For short isometric and isotonic contractions, no changes were observed in the deltoid muscle. In our study, the activity

Figure 3. Means and standard deviations of the pressure pain threshold (PPT, N). There were no significant differences between the Sham and Manipulation groups: right upper trapezius (UT) point. Left upper trapezius (UT), the right and left middle deltoid (MD), and the right and left lateral epicondyle (LE) points were not significantly different between groups.

of the upper extremity muscles was measured during a common daily task which provoked isotonic contraction and did not require great demand for muscle activity. Thus, it is possible that for tasks that involve greater amount of muscle contraction (activity) some effects of cervical manipulation can emerge for people that suffer from cervical pain. This may be a good topic for future studies since these patients complain about cervical pain during task that requires greater muscular effort.

In the present study, cervical manipulation did not show significant effects on the variables involved in grip force control. These results support those of previous studies, which did not demonstrate modification in

motor function in patients with cervical pain after cervical mobilization [46]. Previous studies have demonstrated that patients with cervical and upper extremity pain applied high levels of grip force compared to asymptomatic individuals while lifting an instrumented object [13]. These authors observed that individuals with neck pain applied a mean maximum force of 20 N during the lifting phase (GFP), whereas the values for the asymptomatic group oscillated at approximately 17 N. In the present study, the mean GFP was between approximately 10 and 12 N for both the control and experimental groups. These values are similar to those found for healthy individuals in previous studies using similar experimental

Figure 4. The means and standard errors of the EMG integrals during the post-lifting interval. There was a tendency of decreased activity for proximal muscles (LT and UT) and increased activity for distal muscles (WF and AP) after the intervention. However, no significant differences were found between the groups for any of the muscles: Upper trapezius (UT), lower trapezius (LT), anterior deltoid (AD), biceps brachii (BB), triceps brachii (TB), wrist extensors (WE), wrist flexors (WF), and adductor pollicis (AP).

methods [47]. In addition, it is known that the reduction or loss of fingertip tactile sensitivity negatively affects grip force control [25,26] and, at the same time, the sample of patients included in this study exhibited their fingertip sensitivity levels close to normality (Table 1). Therefore, the potential alterations in grip force control is more likely to be found in patients who, in addition to neck pain, also experience upper extremity impairment such as pain or paresthesia (radiculopathy). The effects of cervical manipulation in patients with these characteristics should be investigated in future studies. Alternatively, subjects with neck pain may require longer time for a complete recovery in terms of changes

in grip force control. Higher grip forces can be a sign of a learned behavior [48,49] in patients with neck pain, which may require a longer time to return to normative after the recovery. For instance, subjects with history of neck pain, but free of symptoms for more than a year did not present with deficits in grip force control as compared to those with neck pain or healthy controls [13]. Nevertheless, we only investigated the short-term effects of cervical manipulation in subjects with frequent episodes of neck pain. Therefore, future studies should investigate the long-term effects of cervical manipulation and whether other alternative treatments are needed to trigger changes in grip force control measures.

Figure 5. There were no significant differences in the grip force control variables between groups (Sham and Manipulation) pre- and post-intervention, during grasping and lifting the object. Means and standard deviations are shown. Grip force at lift-off (GFLO).

Conclusion

The results of the present study indicate that one single session of cervical manipulation in subjects with cervical pain might not immediately change the PPT, muscle activity of upper extremity and grip force control. Thus, the effect of this technique on PPT and upper extremity motor control continue in debate, which encourage more comprehensive studies addressing the effects of cervical manipulation for patients with neck pain. Future studies may address the long-term effect of manipulation, additional and combined treatments as well as other outcome measurements such as pain on the cervical vertebrae and range of movement. In addition, they may separate group of patients with neck pain based on specific causes, symptoms and physiopathological phase. Finally, from our perspective and in face of all these experimental challenges, the results of the present study combined with the findings of the previous studies does not invalidate the use of cervical manipulation for patients with neck pain in clinical sites.

Disclosure statement

The authors report no declarations of interest.

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