



Influence of Cervical Spine Manipulation on Neck Joint Position Sense error in patients with chronic neck pain.

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ABSTRACT

Introduction: Cervical joint dysfunction may interfere with the sensorimotor afferent response, interfering with neck neck Joint Position Sense error (JPS). **Objective:** The aim of this study was to evaluate the influence of Cervical Spine Manipulation (CSM) on neck JPS error in patients with chronic neck pain. **Method:** 21 patients with chronic neck pain were divided into 2 groups: Spinal Manipulation Group (MG) or Sham Group (SG) who received 4 sessions of CSM and Sham CSM respectively. JPS was assessed in three different time frames: 1) pre-intervention; 2) Right after the first intervention (post-intervention 1); and 3) After a chronic intervention (post-intervention 2). The outcome measured in this study was the head reposition accuracy test with the Revel's Test. **Results:** The JPS showed no significant differences between pre- and post-intervention 1 and 2 for any of the assessed groups. **Conclusion:** We conclude that, for this sample, neither the CSM nor the Sham CSM statistically changed the JPS error for neither groups. We believe that the changes in JPS after CSM were concealed because the ability of other sensory system information to compensate for inadequacies in any other component. Therefore, more studies have to be done with a stronger methodological rigor, clinical prediction rule for spinal manipulation, bigger sample and a blind assessment.

Keywords: Kinesthesia. Chiropractic Manipulation. Neck Pain.

INTRODUCTION

Proprioception is a term invented by Charles Sherrington to indicate the perception of the body's own position due to the receptors in the muscles, joints and skin.^(1,2) Furthermore, this body's own perception capacity can be impaired by muscle fatigue, which would be a cause for worsening of motor responses.⁽³⁾ Additionally, Joint Position Sense, is the ability to reposition a joint actively, and authors consider to be one of the parameters of proprioception.⁽²⁾ Thus, altered proprioception, postural control and so JPS, increase the possibility of musculoskeletal injuries.⁽⁴⁾ In addition, the perception of the head in space demands not only of the vestibular, visual and cerebellar systems, but also of mechanoreceptors from cervical spine, muscles and skin,⁽⁵⁾ and they can reorganize the hierarchy of sensory information to maintain the JPS in a variety of environmental conditions.⁽⁶⁾

Cervical and lumbar joint dysfunction is one of the major causes of musculoskeletal pain.⁽⁷⁾ They are described in the literature, and recent neurophysiological studies have shown that spinal articular facets have both mechanoreceptors and nociceptors and those facets' inflammation lead to a decrease of the threshold of nerve endings.⁽⁷⁾ Moreover, neurophysiologic studies have shown that the neck is

composed by a great density of muscle spindles.⁽⁸⁾ Due to the high density of muscle spindles and the fact that the neck plays an important role in the sensorimotor integration responsible by the neck JPS,^(9,10) is not incorrect to affirm that the cervical joint dysfunction, be it traumatic or not, interferes with the sensorimotor afferent response, unsettling neck JPS, postural control and oculomotor control.⁽¹⁰⁻¹³⁾ Therefore, restrictions on the neck movements can affect the quality of the neck JPS.^(7,14-17) Moreover chronic neck pain has a great socioeconomic impact in the health system, being one of the most common problems treated by chiropractors, also, there is a high likelihood of the individual presenting it during some stage of his life.⁽¹⁸⁻²²⁾

Several studies have been published affirming that joint dysfunction, also called by chiropractors as vertebral subluxation complex, represents an area of altered afferent responses to the central nervous system (CNS), which will lead to an altered somatosensory and motor control response.^(7,23,24) Thus, chronic neck pain, has been proposed as an important correlation factor with disturbance in cervical proprioceptive information.^(12,25)

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To quantify the neck JPS, the Head Repositioning Accuracy Test (HRA) was used, which would be the ability of repositioning the head in an initial position after an active movement of the head. This test was used in several studies ^(5,12,15,17,26) and was validated by Roren in 2009.⁽²⁷⁾

This test was first proposed by Revel, Andre and Minguet ⁽⁵⁾ and is a test that has good reliability and validity.^(26,27) They assessed the absolute error of two tests (HRA and three-dimensional ultrasound motion analysis) for the evaluation of neck kinesthesia and found no significant differences between the tests.⁽²⁷⁾

Due to abnormal proprioceptive afferent response of sensorimotor control and the cervical disability generated by the various structures of the neck, which increase the likelihood of injury and degenerative joint disease, this study aimed to evaluate the influence of CSM and a Sham CSM in the neck JPS in patients with chronic neck pain.

METHOD

Ethical aspects

The study was carried out in the Chiropractic Clinical School of the Feevale University, at Novo Hamburgo, Brazil. Also, this project followed the resolutions of the National Health Council Nº 466, December 12, 2012, which provides guidelines and standards involving human subjects and was approved by the university’s research ethics committee of Feevale University (nº555.015). Furthermore, all participants were informed about the procedures, benefits and risks before being given and signing the written informed consent form.

Participants

Participants were selected in Feevale university’s chiropractic and physiotherapy school clinics and also within the community, which were are indicated by professionals of chiropractic or physiotherapists. This study was conducted with a non-probabilistic sample, attended by 33 subjects. Of these, 6 patients were excluded by the exclusion criteria (see Table 1) and 6 were excluded for not completing the trial period of 4 interventions. Thus, totaling 21 patients, 3 males and 18 females, who were divided into two groups: MG, consisting of 14 patients with chronic neck pain, aged between 20-59 years, with a mean age of 30.2 (SD=11.0) years, which received the CSM; and the SG, composed of 7 patients with chronic neck pain, aged between 20-59 years, mean age of 38.9 (SD=17.0) years, which received the Sham CSM.

Outcome Measures

Data collection was performed in previously scheduled appointments with patients interested in participating in the project and was divided into three steps: Step 1, consisted of the voluntary acceptance of the participant in the study, assessment to verify the inclusion and exclusion criteria of the

Table 1. Eligibility Criteria

Inclusion	Chronic Neck Pain
	Both genders
	Age between 18 and 59 years
	NDI≥10%
	Did not receive a cervical spine manipulation in a period of three months before the research
	Signed the Informed consent
Exclusion	Vertebrobasilar insufficiency
	Aneurism
	Bone Cancer
	Bone infection
	Recent fractures
	Vertebral luxation
	Any neurological or vestibular diseases
	High vertebral instability
	Spine surgery
	Whiplash
	Treatments for neck disorders or proprioceptive deficit

study and interview. Step 2 was to assess cervical kinesthesia (pre-intervention), the group allocation, and the intervention of the group, which was in 4 interventions, and cervical kinesthesia reassessment, performed immediately after it (post-intervention 1). Step 3, was on the last intervention, which was evaluated the neck JPS immediately after the last intervention (post-intervention 2). The interventions were provided with a mean interval of 28.5 days for the MG and 30.6 days for the SG, also, all evaluations and interventions were conducted during the 7 months period by the same trained examiner.

Assessment of neck JPS

To assess the neck JPS the Head Repositioning Accuracy test (HRA) was used, which was originally proposed by Revel, Andre and Minguet ⁽⁵⁾ and has been widely used in scientific researches.^(3,26,28,29) The HRA measures the ability of the neuromusculoskeletal system to reposition the head in a neutral position after active movements in different planes of motion. A deficit in this ability is mainly attributed to an afferent disturbed response of the neck mechanoreceptors. The kinesthetic alteration is measured by the difference between the initial position and the position after the active movement of the individual.^(7,12)

Participants sat in a chair with low back support with their hands on their thighs, using only light cloths and without the use of accessories (scarf, earrings or hair accessories). The legs were placed in a comfortable angle of 90° and with the feet to the ground or to a support if they were too short.



The eyes were blindfolded with the use of a sleep mask and the participant was instructed to remain with closed eyes during the procedure. An elastic band with a fixed laser pointer (Figure 1 A) was attached to the head, which was adjusted according to the dimensions of the head of each individual. The position of the laser on the elastic band was calibrated by the investigator at an angle of 90°, parallel to the ground with the use of an inclinometer, toward the center of a portable coordinate system at a distance of 100 cm. This coordinate system has total radius of 20 cm, with a circle for each of the radius (Figure 1 B). It was fixed to a wall in front of the patient (Figure 1 C) and in perfect alignment by using a plumb line.

Each participant was instructed to memorize the initial neutral position of each movement and repeat it after a submaximal active movement performed by the participant. The investigator wrote the initial and the final position for each movement which was always done in all planes of movement, always following the same order: extension, flexion, right rotation, left rotation, right and left lateral flexion, previously explained to avoid confusing the patients. To obtain a standard for both researcher and subject, a command process was used for each move in the following order:

- "Stay with your neck in a comfortable position" (5 seconds).
- "Perform a: extension and flexion of the head; right and left rotation; lateral flexion to the right and left" (2 seconds for each movement).
- "Return to the start position" (2 seconds for each movement).
- After, the researcher wrote at the coordinate system, for each movement, the initial and final position (2 seconds).

It was used 3 repetitions for every movement, between planes of motion was given a rest period of 2 seconds and between 3 planes of movement the patient was instructed to take the sleep mask off for 20 seconds, to avoid creating a sense of disorientation. The procedure for moving the head and hold it for 2 seconds was used to reduce errors caused by sudden movements of the head. The coordinate system (Figure 1 C) was preserved for each assessment and was used a new one for each patient. The measurement was taken with the distance between the initial and final position of the laser projected in the coordinate system (measured in centimeters). So the higher the average distance (greater the error), the greater the neck JPS interference, and the lower the average distance less change in JPS the patient had.

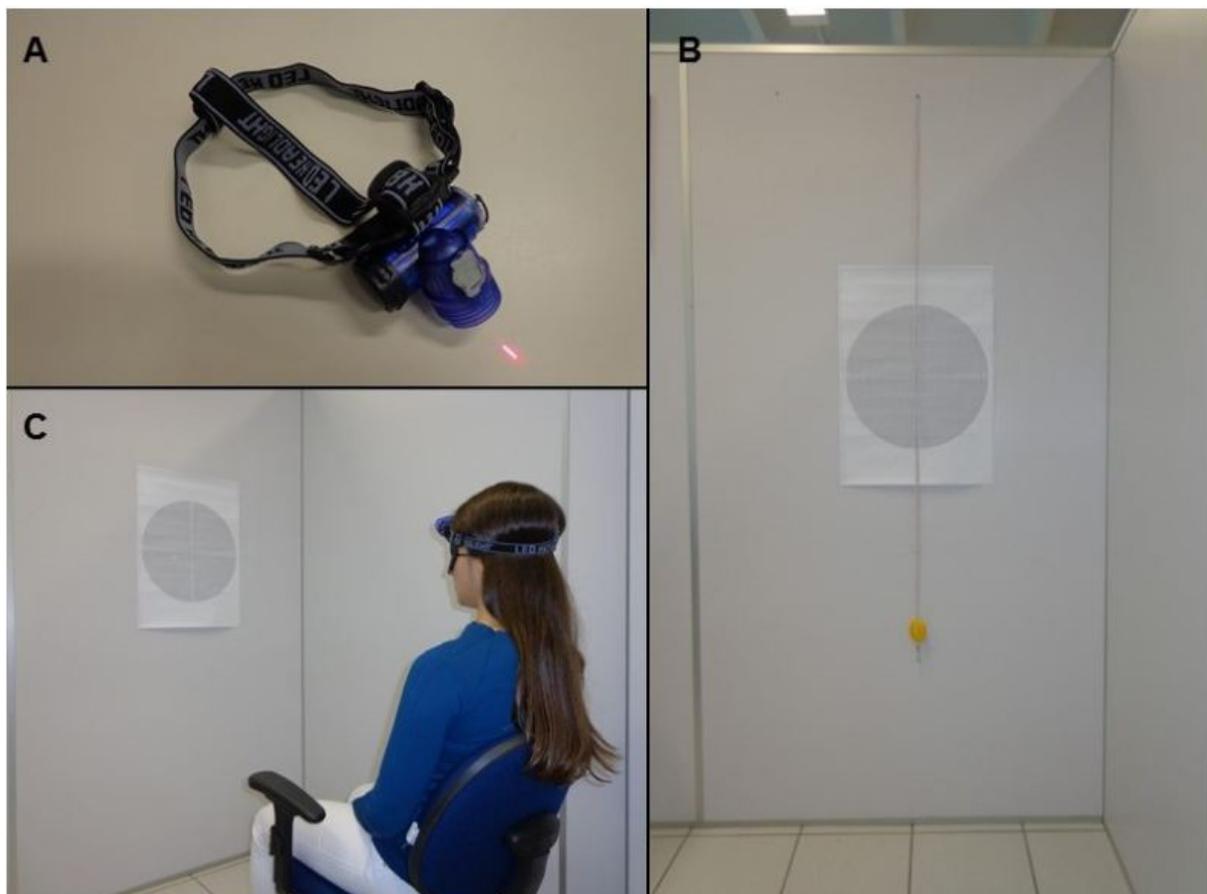


Figure 1. Head Repositioning Accuracy Test. A. Headband with a laser fixed. B. Patient Position. C. Coordinate system.

Intervention

All of the patients went through the same clinical evaluation, with imaging and laboratorial analysis when required. Physical examination with specific orthopedic tests, to confirm the inclusion and exclusion criteria according to each patient was performed.

To analyze the cervical spine articular dysfunction both groups underwent a clinical examination including static and dynamic palpation to identify cervical joint dysfunctions which were defined as either an abnormal palpable motion and/or a local tender joint palpable spot, as these criteria are shown to be acceptable and reliable in the literature for the analysis of the cervical spine.^(24,30)

After the evaluation of one or more joint dysfunctions, the intervention at the MG was a CSM with high-velocity, low-amplitude thrust to the spine held in lateral flexion, with slight rotation and slight extension, with the patient in a seated position (see Figure 2).^(18,31,32) This type of CSM is a standard procedure commonly used by chiropractors.⁽¹⁸⁾

For the SG, it was used a validated Sham CSM simulating the sensory experience of a high-velocity, low-amplitude

manipulation procedure with the 4 components of the procedure: touch the region with dysfunction, head positioning, movement and sound with the help of the headpiece table-drop (see Figure 3).^(33,34) This procedure proved to be valid immediately after and until 48 hours after the intervention to blind the SG and should be applied in experimental studies to determine whether the treatment results are attributed to the intervention or to a non-specific placebo effect.⁽³⁵⁾ The figure 4 shows the flowchart of study design.

Statistical analysis

The statistical analysis was done with the SPSS-22.0 software. Descriptive and Inferential statistics were used. Descriptive statistics consisted of mean, standard deviation, minimum and maximum. To assess data normality, the Shapiro-Wilk test was employed. Inferential statistics consisted



Figure 2. Cervical Spine Manipulation.

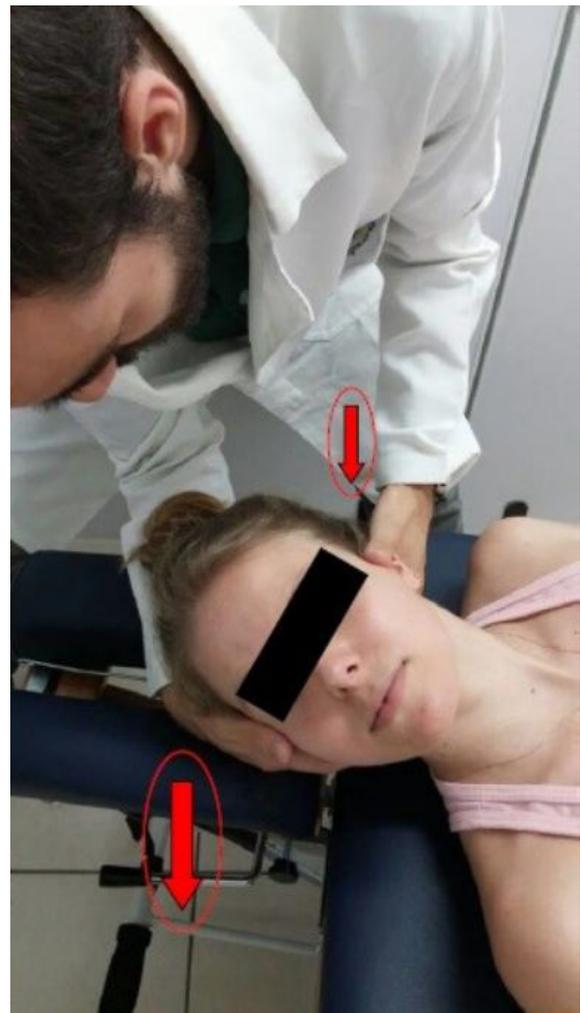


Figure 3. Sham Manipulative Procedure for the Cervical Spine. Small arrow: Chiropractor's hand on the paraspinal area in the restricted vertebra. Big arrow: Chiropractor's forearm as a support for patient head and giving a thrust against the drop headpiece.



of an Analysis of Variance (ANOVA) for the HRA for pre- and post-intervention 1 and 2.

RESULTS

An initial contact was made with 26 patients and 5 was excluded for did not meet the inclusion criteria (NDI<10% or vestibular disease) and 21 was included in the study. The allocation ratio was 2:1, 14 for the IG and 7 for SG and all of those completed all the trial (Figure 2).

There were no statistically significant differences inter group for age and height in the pre-treatment assessment ($p < 0.05$), confirming adequate subject similarity. As for weight statistically significant differences were found ($p = 0.048$) between the groups (Table 2).

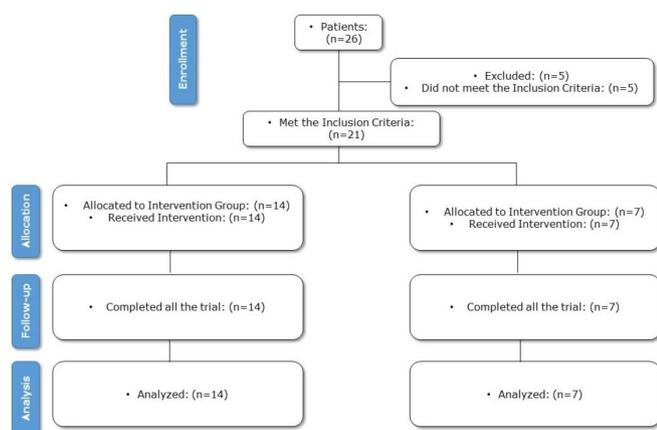


Figure 4. Flowchart of study design

Table 2. Descriptive Analysis

Sample Data	Manipulation Group	Sham Group
Age (years)	30.21(11.03)	38.86(17.05)
Height (meters)	1.63(0.57)	1.63(0.85)
Weight (kg)	65.25(9.83) *	78(18.1) *
Gender (Female/Male)	12 F e 2 M	6 F e 1 M

*Statistically significant differences ($p < 0.05$)
Student T-Test for independent samples

Table 3 – Data for Head Repositioning Accuracy Test (mean (SD)).

	Manipulation Group (n=14)			Sham Group (n=7)		
	Pre-Intervention	Post-Intervention 1	Post-Intervention 2	Pre-Intervention	Post-Intervention 1	Post-Intervention 2
Extension	9.91 (7.92)	18.55 (9.99)	7.30 (6.20)	14.03 (6.67)	12.40 (4.83)	10.47 (7.60)
Flexion	10.21 (5.43)	10.67 (4.35)	7.74 (5.37)	11.73 (6.88)	13.32 (7.28)	10.33 (5.52)
Right Rotation	9.81 (8.06)	12.30 (6.23)	9.03 (5.66)	12.61 (3.90)	10.95 (4.35)	15.84 (7.77)
Left Rotation	10.51 (8.70)	9.66 (4.73)	10.99 (6.17)	10.41 (3.94)	10.66 (5.14)	12.67 (5.33)
Right Lateral Flexion**	7.73 (3.90)	11.15 (7.46)	8.35 (5.30)	9.78 (4.48)	13.31 (6.39)	12.10 (4.41)
Left Lateral Flexion	8.84 (7.18)	11.71 (7.63)	5.80 (4.80)	9.50 (3.87)	6.55 (1.77)	10.46 (6.0)

*Statistically significant differences ($p < 0.05$)

** One patient did not perform this movement(n=13)

SD: Standard Deviation; Repeated measures ANOVA

Assessment of Kinesthesia

For the neck kinesthetic evaluation by the HRA, no significant differences ($p > 0.05$) between pre- and post-intervention 1 and 2 were found using the CSM or a Sham CSM in neither of the movements: flexion/extension, right/left rotation or inclination of the neck (Table 3).

DISCUSSION

Women are more likely to experience an episode of neck pain than men, also more likely to report symptoms of persistent neck pain and less likely to have a complete resolution of the symptoms of cervical pain and disability.⁽³⁶⁾ This information is confirmed with the findings of this study that evaluated 18 women and 3 men only (Table 2).

As for age, there is a greater likelihood of symptoms of neck pain in young patients, less than 46 years of age.^(20,36) The same information was found in this study, which had a mean age of 34.5 years (Table 2). Factors such as body weight and height in previous studies did not presented themselves as important cervical pain incidence predictors.⁽²⁰⁾

Regarding neck kinesthesia, it was described that it usually has the most significant changes in middle-aged patients (45-65 years old) independently of a history of neck pain. This might be related to muscle spindle deficit in middle-aged patients, which affects the neck JPS error,⁽²⁸⁾ factor that was not relevant to this work which presented a mean age of 34.5 years (Table 2). As for weight, height and sex, they were not described by Teng et al.⁽²⁸⁾ as factors that affect the neck JPS.⁽²⁸⁾ Additionally, Teng et al., Wibault et al.^(28,29) says that age as well as gender, body weight, height, body mass index and physical activity were not significantly correlated with the HRA in any of rotational movements.^(28,29)

To our knowledge, only the study of Rogers⁽¹⁵⁾ intended to evaluate the effects of cervical and thoracic manipulation on the neck kinesthesia in patients with chronic neck pain, as a controlled but not randomized study.⁽¹⁵⁾ And the present study was the first to evaluate the effects of CSM in the cervical kinesthesia, compared to a Sham CSM. Therefore the results



of this study can be discussed with the study Rogers⁽¹⁵⁾ and the studies of Palmgren et al.^(12,17)

There is a parameter, a level of normality, determined in other studies of what would be the error rate of the HRA, in patients with chronic neck pain.^(5,27) This level was measured in degrees, by Roren et al.⁽²⁷⁾, with the same instrument previously proposed by Revel et al.⁽⁵⁾ in a study with patients with chronic neck pain at a distance of 90 cm, with unilateral rotation of the neck and has established a mean of 6.3° (2.4°) for unhealthy patients and 3.6° (0.8°) for healthy patients.^(5,27) For the purposes of this study, this parameter was converted from degrees to centimeters using a simple trigonometry system. Therefore, the average error of the HRA test in patients with chronic neck pain, measured at a 90 cm distance is 9.96 (3.83) cm. In addition, Heikkilä & Wenngren,⁽¹⁶⁾ and Wibault et al.⁽²⁹⁾ didn't find statistically significant correlation between the HRA with pain or NDI, this is an important factor due to the presence of different levels of pain during the experiment.^(16,29)

In Palmgren et al.⁽¹²⁾ study the scope of practice of chiropractic care (CSM, soft tissue mobilizations, segmental stabilization exercises) was evaluated in regard to pain relief and neck JPS error, and not only the CSM, and it was found a cervical kinesthetic improvement after the chiropractic care.⁽¹²⁾ Differently, the study of Palmgren et al.⁽¹⁷⁾ found no statistically significant differences in the neck JPS error with CSM in healthy patients.⁽¹⁷⁾ And according to Rogers⁽¹⁵⁾ cervical and thoracic spine manipulation can have a positive effect on the neck JPS in patients with chronic neck pain.⁽¹⁵⁾ In contrast to the results of this study that didn't show statistically significant differences in the neck kinesthesia after a post-treatment with CSM or a Sham CSM, in any of the groups analyzed or compared (Table 3). Nevertheless, several other studies have proven the effectiveness of chiropractic care and spinal manipulation, in the activation of mechanoreceptors and proprioceptive improvement.^(12,15,23,24,37) A possible explanation for the failure to improve neck JPS after a CSM procedure compared with a Sham CSM in patients with chronic neck pain, may be associated with an adaptive reweighting of other sensory modalities' information, like vestibular or cerebellar, which adapted for the inadequacy in the neck sensorimotor that is present in patients with neck dysfunction.^(6,24,30) Other reasonable explanation is that the changes in JPS error with the CSM in other studies^(12,15) may be due to the placebo effect, since this was the first study to control that variable and no differences was found neither in acute or chronic CSM.

A systematic review concluded that it is more advantageous to classify the patient based on predictors of success in patients with non-specific neck pain.⁽³⁸⁾ Thus, it is recommended to analyze predictors of success for manipulative treatment, so we can predict which patients will benefit with greater clinical outcome with the cervical spinal manipulation. Among these predictors some of them are bilateral involvement, no

radiculopathy and cervical extension less than 45°.^(39,40) So, this way we can evaluate the outcomes of CSM, in an isolated and focused way in the joint dysfunction itself.

CONCLUSIONS

For the outcomes of the neck JPS there weren't found statistically significant intragroup or intergroup (Manipulation Group and Sham group) differences, but there was a slight trend of improvement in pre-intervention assessment for post-intervention 2, especially for the extension, flexion, right and left rotations movements. However, this may be concealed due the ability of the neck JPS to reweight the hierarchy of sensory information to compensate for inadequacies in any one component.

It is therefore of extreme importance that new studies be made with a high methodological rigor, utilizing clinical prediction rule for cervical spinal manipulation, and also a greater number of patients, with less variability, due to the trend to improve. Still, it is emphasized in this study that the size and variability of the sample, the interval between each treatment session and the use of only one chiropractic technique may have influenced our results.

AUTHOR'S CONTRIBUTION

IFM developed the project, the methodological and experimental parts and wrote the manuscript. DF was part of the review process of the project and took part on the correction and adjustment of the manuscript. EFM oriented the study as a reviewer for the methodological and experimental parts, and also contributed to the development of the manuscript.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

STATEMENT ON ETHICS

The study was carried out in the Chiropractic Clinical School of the Feevale University, at Novo Hamburgo, Brasil. Also, this project followed the resolutions of the National Health Council Nº 466, December 12, 2012, which provides guidelines and standards involving human subjects and it was approved by the university's research ethics committee of the Feevale University (nº555.015). All participants were informed about the procedures, benefits and risks before signing a written informed consent form.

AUTHOR DETAILS

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