SPORT TK-EuroAmerican Journal of Sport Sciences

https://revistas.um.es/sportk Online ISSN: 2340-8812

Received: **12/03/2022.** Accepted: **27/04/2022.** Published: **29-07-2022**

Comparison between upper thoracic spine mobilization and the Ergon technique in the treatment of mechanical neck pain

Hebatalla M. Said Zaghloul[1]*, Shahesta A. Osama Ghally[2], Mona M. Talaat Abdelkhalek[3], Marwa T. Mohamed[4], Lama Saad El-Din Mahmoud[5], Lamis A. Osama Ghaly[6]

[1] Department of Musculoskeletal Disorders and Its Surgery, Faculty of Physical Therapy, Benha University, Egypt.

[2] Department of Musculoskeletal Disorders and Its Surgery, Faculty of Physical Therapy, October 6 University, Egypt.

[3] Department of Burn and Surgery, Cairo University Hospitals, Cairo University, Egypt.

[4] Department of Basic Science, Faculty of Physical Therapy, Egyptian Chinese University, Egypt.

[5] Department of Neuromuscular Disorders and Its Surgery, Faculty of Physical Therapy, October 6 University, Egypt.

[6] Department of Internal Medicine Disorders and Its Surgery, Faculty of Physical Therapy, October 6 University, Egypt.

* Correspondence: Hebatalla M. Said Zaghloul; hobbymzaghloul@gmail.com

ABSTRACT

Upper thoracic spine mobilization and the Ergon technique are used to treat mechanical neck pain in order to speed recovery, promote tissue healing and improve range of motion. There have been a few studies discussing the Ergon IASTM and upper thoracic spine mobilization in patients with neck pain, but none compared the aforementioned techniques in the treatment of mechanical neck pain. This clinical trial was conducted on a sample of thirty participants (16 females and 14 males) with mechanical neck pain who were randomly divided into two groups: Upper Thoracic Spine Mobilization (n=15) and Ergon Technique (n=15). Twelve sessions were delivered to all participants over a four-week period, three days per week. Before and after treatment, pain severity was measured by Numeric Pain Rating Scale (NPRS), cervical spine's active range of motion was measured by using a Cervical Range of Motion (CROM) device, and cervical spine's disability index was measured by Neck Disability Index (NDI). The statistical analysis was carried out using the Statistical Package for Social Sciences (SPSS) version 25. Both groups showed improvement in neck pain, reduced functional disability and increased cervical range of motion after treatment. The upper thoracic spine mobilization group had significantly better results in terms of cervical left lateral flexion and left rotation ranges of motion, while the Ergon Technique group had significantly better results in terms of improvement of neck pain and reduction in functional disability. In conclusion, the upper thoracic spine mobilization was effective at increasing the range of motion of the cervical region, while the Ergon technique was effective at relieving pain and dysfunction in the cervical spine in patients with mechanical neck pain.

KEYWORDS

Upper Thoracic Spine Mobilization; Ergon Technique; Mechanical Neck Pain.

1. INTRODUCTION

Neck pain is a common source of pain in the general population. The prevalence is 10 to 15% and approximately 60 to 70% of adults are affected at some point in their lives (Côté et al., 1998). Many people in contemporary society suffer from neck pain. Neck pain can occur when the cervical extensors are activated, increasing the load on the erector spinae muscle to maintain the balance of the neck (Straker et al., 2008). Neck pain is mostly mechanical in nature and a specific pathoanatomical cause is frequently unidentifiable in clinical practice. It is defined as pain in the cervical spine, including the cervicothoracic junction, that is aggravated by the cervical motion, prolonged postures, and/or palpation of the cervical musculature (Martínez-Segura et al., 2012). Chronic pain in the cervical region is typically the result of repeated trauma or overuse, and this may lead to restriction of adjacent joints' movement, impairing the cervical spine's functional mobility (Cross et al., 2011).

The cervical and thoracic spines have a strong relationship. For example, movement of the cervical vertebrae is associated with the movement of the upper thoracic vertebrae, also, hypermobility of the upper thoracic vertebrae can cause pain in the cervical spine via compensation, whereas hypermobility of the upper thoracic can result in upper thoracic incompetence. Moreover, continuous load on the cervical spine alters the spinal curve, resulting in joint degeneration, a straight cervical spine and forward head posture (Fernández-de-Las-Peñas et al., 2006). As a result, the upper cervical spine will be extended and the lower cervical and upper thoracic spines will be flexed, with the head position deviating forward from the gravity line, resulting in a load applied to the neck and shoulder muscles that is 3.5 times that applied to a normal person (Salahzadeh et al., 2014). Thus, this biomechanical relationship between the lower cervical and upper thoracic vertebrae, in which a dysfunction in the former can lead to pain in the latter and a dysfunction in the latter can restrict the movement of the former, may provide a significant contribution to eliciting neck pain (Vicenzino et al., 1996).

Conservative management of mechanical neck pain frequently entails a combination of interventions, including education modalities, therapeutic exercises, non-thrust and thrust (mobilization) manipulation. According to previous research, manual therapy of the upper thoracic and cervical spines in patients suffering from neck pain and stiffness improved their symptoms (Dunning et al., 2016). A recent clinical practice guideline (CPG) published in 2017 by the American Physical Association's Orthopedic Section, summarized the effectiveness of those interventions and stated that manual therapy of the cervical and thoracic spine using a variety of mobilization and manipulation techniques was moderately effective in relieving symptoms in all patients, regardless of symptom duration (Blanpied et al., 2017).

In manual therapy, upper thoracic mobilization (joint mobilization) is frequently used. This method passively applies distraction and sliding techniques to the joint surfaces in order to maintain or regain joint mobility (Kaltenborn et al., 2011). Sandow (2011) demonstrated that thoracic mobilization induced cervical mobilization (rotation) which was beneficial in achieving successful outcomes both immediately after treatment as well as six months after discharge from the treatment institution. Other researchers also demonstrated that the application of joint mobilization to the upper thoracic has an additional beneficial effect on chest expansion, but its effect in improving pulmonary function was found to be non-significant (Jung & Moon, 2015).

Instrument-assisted soft tissue mobilization (IASTM) is another new procedure that is rapidly gaining popularity due to its efficacy and efficiency, enabling clinicians to treat patients with soft tissue dysfunction while remaining non-invasive (Baker et al., 2013). Through the use of specially designed instruments, IASTM mobilizes connective tissue and myofascial adhesions by a mechanism that involves remodeling connective tissue, resorbing excess fibrosis, recruiting fibroblasts and inducing collagen repair and regeneration (Strunk et al., 2014). Therefore, this study aims to investigate the effect of upper thoracic mobilization compared to the Ergon technique as one of the examples of IASTM on certain treatment outcomes in patients with mechanical neck pain.

2. METHODS

2.1. Study design and participants

This clinical trial was carried out on a sample of thirty patients (16 females and 14 males) with mechanical neck pain who were seen in an outpatient physical therapy department at Cairo

University. Their ages ranged from 20 to 40 years. Patients who had suffered from mechanical neck pain (pain between the posterior aspect of the cervical spine and the interscapular region) for a duration of 6 to 12 months were included in the study, while patients with a history of neck surgery, cervical fractures, tumors, neurological disorders or taking medications for psychiatric problems were excluded from the study. Each study subject was required to read and sign an informed consent form issued by the Cairo University Hospitals Institutional Review Boards. The patients were then simply randomly divided into two groups: group A received upper thoracic spine mobilization (n=15) and group B received the Ergon technique (n=15). All participants signed a written informed consent that was approved by the ethical committee for research studies, Cairo University (P.T.REC/012/003645).

2.2. Examination procedures

All participants underwent a demographic questionnaire and physical examination. After patient admission, a systematic evaluation was conducted in which the following specific outcome measures were recorded during the initial assessment: numeric pain rating scale (NPRS), cervical range of motion and neck disability index (NDI). At the initial examination, the integumentary system was equally, visually and palpably assessed for ecchymosis, edema, points of tenderness or induration. All inquiries about previous orthopedic injuries, corticosteroid injections, or skin allergies were answered negatively by the study participants.

The NPRS was used to assess pain severity (Figure 1), and provided an estimate of the patient's experience as it was previously found to be the most reliable and valid method for evaluating acute pain over time and also indicates when pain was relieved (Akgun et al., 2018; Ferreira-Valente et al., 2011). The cervical spine's active range of motion was determined using a CROM device (Deluxe Inclinometer; Performance Attainment Associates and Mednet Technologies Inc., Roseville, MN, USA). The CROM's highest intra-tester reliability (intra-class correlation coefficient (ICC) was found to be 0.86 to 0.95 in patients with neck pain (Fletcher & Bandy, 2008) and the CROM's minimal detectable change (MDC) varied between 5 and 10 degrees (Youdas et al., 1991). The NDI was used to determine the cervical spine's disability index as it has been shown to be a valid tool for evaluating patients with neck pain (Walton et al., 2011). According to a recent systematic review of the literature, the NDI had an MDC of 10% and an MCID (minimal clinically important difference) of 14% (Vernon & Mior, 1991).

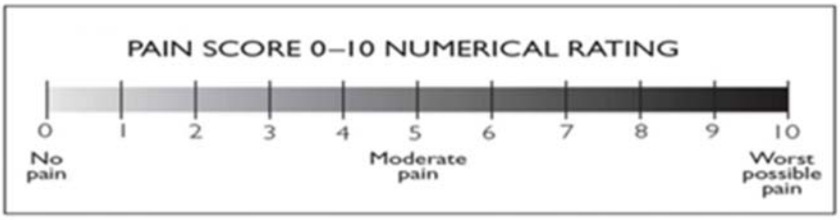

Figure 1. Numerical Pain Rating Scale (used with permission).

2.3. Intervention

Group A

This group received the upper thoracic spine mobilization three times a week for four weeks. The participants were in prone position and the therapist stood facing the neck joint where the mobilization would be applied to increase upper thoracic spine extension (T1-T2). The therapist's index and middle fingers were placed on the participant's vertebral process, which was located on the caudal side of the targeted segment. The therapist's other hand's lateral side was then placed on the index and middle finger of the first hand and the thoracic segmental mobilization was performed from ventral to caudal.

Group B

Group B received the Ergon IASTM technicue three times a week for four weeks. The Ergon IASTM technique entails the application of specialized IASTM semicircular or circular strokes (Razor, Global, Small Globes and Excav) to specific myofascial restriction points. Additionally, this technique includes specific strokes for separating myofascial structures. M2T-Blades (Figure 2a and 2b) were used, which were made entirely of Surgical Grade Stainless Steel (Made in Canada). They are the only products on the market that are double beveled (35° and 55°). One-way stroking (from inferior to superior) at a frequency of 80 strokes per minute was used for 5 minutes at the beginning of the treatment session and for another 5 minutes half an hour later. A force of approximately 500–750 g was applied for three minutes at the beginning of the treatment and for 90 seconds at the end of each session. After returning home, the patient was advised to use ice massage to alleviate any skin hyperemia. Study participants additionally received a ten-minute myofascial release treatment with the Ergon IASTM Technique in a direction parallel to the instrument-treated muscle fibers.

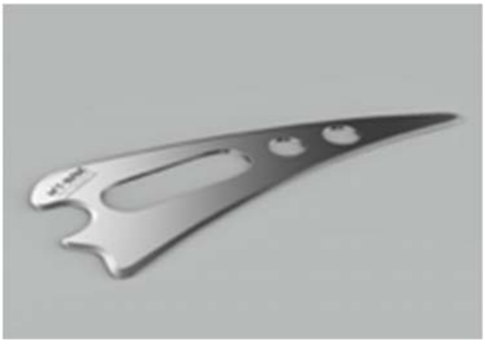

Figure 2(a)

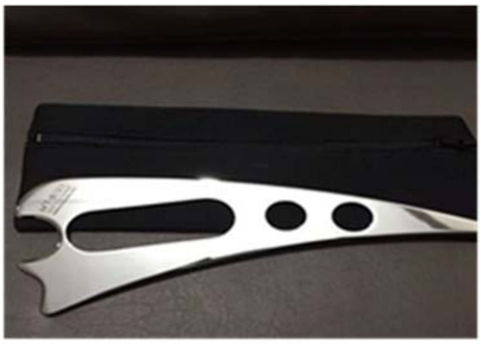

Figure 2(b)

2.4. Statistical Analysis

The statistical analysis was carried out using the Statistical Package for Social Sciences (SPSS) version 25. Descriptive statistics and t-test were conducted for comparison of subject characteristics between both groups and paired t-test was conducted to compare between pre and post-treatment mean values of the measured variables in each group. For all statistical tests, a p-value of <0.05 was considered statistically significant.

3. RESULTS

The following t-test results revealed that demographic data were comparable between the two treatment groups and that there were no statistically significant differences (p-value > 0.05) in age, weight, or height between the group members prior to treatment, as shown in Table (1).

Table 1. Comparison of subject characteristics between group A and B.

	Group A	Group B	P-value
Age (years) (Mean±SD)	22.92 ±1.92	22.00 ±2.41	0.886
Height (cm) (Mean±SD)	171.75 ±2.73	171.42 ±2.81	0.993
Weight (kg) (Mean±SD)	65.92 ±5.38	66.00 ±5.02	0.903

**NOTE: SD (Standard Deviation)*

The following table (Table 2) shows the results of the comparison of pre and post-treatment mean values of neck pain severity within and between-groups. The results tell us that neck pain severity significantly decreased post-treatment compared to pre-treatment in both groups (Table 2).

Table 2. Comparison of pre and post-treatment mean values of neck pain severity within and between-groups.

	Neck Pain Severity	
	Pre-treatment	**Post-treatment**
Group A (Mean±SD)	8.15 ±0.62	3.04 ±0.57 *
Group B (Mean±SD)	8.21 ±0.61	1.89 ±1.42 *
p-value between groups	0.0001**	

**Statistically significant (p<0.05)*
***Statistically significant (p<0.05) when pre–post intervention change (within-group comparison).*

Between-groups comparison showed that the mean difference in neck pain severity index was significantly improved (p-<0.0001) in group B compared to group A (Table 2). As regards the cervical range of motion, the data from Table 3 show that the mean differences of the ranges of motion for left lateral flexion and left rotation were the only ranges of motion that were significantly improved in group A compared to group B (p=0.033 and p=0.045, respectively).

Table 3. Comparison of pre and post-treatment mean values of cervical range of motion within- and between-groups.

Motion/Group	Pre-treatment	Post-treatment	Within group differences	Between group differences/p-value
Flexion/A	50.5±8.9	60.6±9	10.1±8.1	2.2±(-3.5)/0.426
Flexion/B	48.2±10	58.1±9.2	9.9±3.2	
Extension/A	59.7±9.3	70.0±9	10.3±8.5	3.9±(-0.99)/0.11
Extension/B	60.3±8.3	69±9.1	8.7±3.6	
Right lat flexion/A	37.58±5.9	44.31±2.6	6.73±5.4	1.4±(-2.45)/0.561
Right lat flexion/B	38.66±5.6	45.3±5.2	6.64±4.2	
Left lat flexion/A	37.31±6.6	44.5±4.7	7.19±4.9	3.3±4.2/0.033*
Left lat flexion/B	41.8±5.8	45.6±5.1	3.8±2.88	
Right rotation/A	63.6±11.9	77±6.2	13.4±10.2	4.7±(-0.69)/0.068
Right rotation/B	67.1±7.9	76.1±5.5	9.0±6.8	
Left rotation/A	63.5±12.9	77.9±10.1	14.4±11.2	5.8±(-0.1)/0.045*
Left rotation/B	69±7.9	77.9±5.1	8.9±6.0	

**NOTE: lat (lateral); all values are presented as mean±standard deviation; * (statistically significant differences between groups).*

As regards the neck disability index (NDI), the results from Table 4 demonstrate that the mean difference in NDI was significantly higher in group B compared to group A (p=0.006), indicating a greater improvement in the disability of the group receiving the Ergon Technique.

Table 4. Comparison of pre and post-treatment mean values of Neck Disability Index (NDI) within and between-groups.

NDI/Group	Pre-treatment	Post-treatment	Within group differences	Between group differences/p-value
Group A	7.8±4.2	5.2±3.6	2.6±2.5	3.1±1/0.006*
Group B	10±4	4.2±2	5.8±4.6	

4. DISCUSSION

In this study, we were able to demonstrate that neck pain significantly decreased in both groups (A and B) after four weeks of treatment, with the higher statistically significant improvement detected in group B (Ergon Technique group) ($p<0.05$). The change in group B was -76.98%. Also, after treatment, both active cervical extension and active flexion demonstrated statistically significant improvement in both groups ($p<0.05$), although there were no statistically significant differences between the groups ($p>0.05$). However, significant differences in left lateral flexion and left rotation were observed in favor of group A (the upper thoracic spin mobilization group), and finally, the NDI showed a statistically significant difference in favor of group B (the Ergon Technique group).

Soft tissue techniques represent a cutting-edge therapeutic approach to musculoskeletal disorders and rehabilitation. All of these procedures, which include massage, transverse friction, myofascial release techniques using hands or IASTM (Instrument assisted soft tissue mobilization) tools, treatment of myofascial trigger points, and spine mobilization, are associated with an improvement in the patients' functionality, most notably affecting peripheral joint ranges of motion (Hou et al., 2002; Lin et al., 2012; Nagrale et al., 2010). Although our study was able to demonstrate significant superior performance of the upper thoracic mobilization technique in improving left lateral flexion and rotation movements, other researchers demonstrated the same significant effect yet with more neck movements (flexion, extension and rotation) in only eight therapeutic sessions (Cagnie et al., 2013). This variability in the outcomes could be explained in terms of variations in the diagnostic criteria of improvement, the instruments used or the composition of the analytic cohort.

Another important finding of our study was that the application of the Ergon IASTM Technique was capable of inducing significant increases in myofascial flexibility in the neck region. These findings corroborate the findings of previous research that reported that the application of myofascial techniques could result in generalized body relaxation, decrease in myofascial tone reduced neck pain severity and improved neck disability (Carvalhais et al., 2013). Mobilization of the upper thoracic spine increased lateral flexion and rotation range of motion in the cervical region, which is consistent with previous research that demonstrated increased range of motion by improving joint hypomobility and thus adhesions between soft tissues when joint mobilization was applied to patients with mechanical neck pain (Masaracchio et al., 2013).

Nevertheless, our study had several limitations. First, the sample size of our study which included two comparison groups and three outcomes, was small (15 patients per group). Second, there was no control group, so we were unable to determine the effect of additional factors such as the natural history of the neck pain or any treatment-related side effects on the three outcomes of the study. Yet, several studies have proven that either the mobilization or the Ergon techniques were superior to placebo (Gross et al., 2010; Miller et al., 2010). Third, we conducted our interventions for 12 sessions, which might not be a sufficient period to elicit the full potential of the interventions to produce significant changes. Therefore, future studies are warranted to compare the upper thoracic mobilization and the Ergon techniques using a sufficient sample size, including a control group, and investigating a cut-off number of sessions to produce significant changes in patients with mechanical neck pain.

In conclusion, we found that upper thoracic mobilization was effective at increasing the range of motion of the cervical region, whereas the Ergon Technique was effective at relieving pain and dysfunction in the cervical spine in patients with mechanical neck pain. Additional research is necessary to determine the efficacy of upper thoracic spine mobilization and the Ergon Technique in treating mechanical neck pain over a longer period of time. Additional studies of this type are recommended to compare the effectiveness of both treatments and other physical therapy programs in preventing mechanical neck pain.

5. REFERENCES

1. Akgun, E., Kozaci, N., & Avci, M. (2018). Measurement of the Pain Levels of Patients with Extremity Traumas and Assessment of the Attitudes of Emergency Physicians to Pain Management. *Annals of Medical Research, 25*(4), 553-558.
2. Baker, R. T., Nasypany, A., Seegmiller, J. G., & Baker, J. G. (2013). Instrument-Assisted Soft Tissue Mobilization Treatment for Tissue Extensibility Dysfunction. *International Journal of Athletic Therapy & Training, 18*(5), 16–21.
3. Blanpied, P. R., Gross, A. R., Elliott, J. M., Devaney, L. L., Clewley, D., Walton, D. M., et al. (2017). Neck Pain: Revision 2017. *The Journal of Orthopaedic and Sports Physical Therapy, 47*(7), 1–83. https://doi.org/10.2519/jospt.2017.0302

4. Cagnie, B., Dewitte, V., Coppieters, I., Van Oosterwijck, J., Cools, A., & Danneels, L. (2013). Effect of ischemic compression on trigger points in the neck and shoulder muscles in office workers: a cohort study. *Journal of Manipulative and Physiological Therapy, 36*(8), 482–489. https://doi.org/10.1016/j.jmpt.2013.07.001
5. Carvalhais, V. O., Ocarino, J. M., Araújo, V. L., Souza, T. R., Silva, P. L. P., & Fonseca, S. T. (2013). Myofascial force transmission between the latissimus dorsi and gluteus maximus muscles: an in vivo experiment. *Journal of Biomechanics, 46*(5), 1003–1007. https://doi.org/10.1016/j.jbiomech.2012.11.044
6. Côté, P., Cassidy, J. D., & Carroll, L. (1998).The Saskatchewan Health and Back Pain Survey. The prevalence of neck pain and related disability in Saskatchewan adults. *Spine, 23*(15), 1689–1698. https://doi.org/10.1097/00007632-199808010-00015
7. Cross, K. M., Kuenze, C., Grindstaff, T. L., & Hertel, J. (2011). Thoracic spine thrust manipulation improves pain, range of motion, and self-reported function in patients with mechanical neck pain: a systematic review. *Journal of Orthopaedic & Sports Physical Therapy, 41*(9), 633–642. https://doi.org/10.2519/jospt.2011.3670
8. Dunning, J. R., Butts, R., Mourad, F., Young, I., Peñas, C. F., Hagins, M., et al. (2016). Upper cervical and upper thoracic manipulation versus mobilization and exercise in patients with cervicogenic headache: a multi-center randomized clinical trial. *BMC Musculoskelet Disord, 17*(64), 1-12. https://doi.org/10.1186/s12891-016-0912-3
9. Fernández-de-Las-Peñas, C., Cuadrado, M. L., & Pareja, J. A. (2006). Myofascial trigger points, neck mobility and forward head posture in unilateral migraine. *Cephalalgia: An International Journal of Headache, 26*(9), 1061–1070. https://doi.org/10.1111/j.1468-2982.2006.01162.x
10. Ferreira-Valente, M. A., Pais-Ribeiro, J. L., & Jensen, M. P. (2011). Validity of four pain intensity rating scales. *Pain, 152*(10), 2399–2404. https://doi.org/10.1016/j.pain.2011.07.005
11. Fletcher, J. P., & Bandy, W. D. (2008). Intrarater reliability of CROM measurement of cervical spine active range of motion in persons with and without neck pain. *Journal of Orthopaedic and Sports Physical Therapy, 38*(10), 640–645. https://doi.org/10.2519/jospt.2008.2680
12. Gross, A., Miller, J., D'Sylva, J., Burnie, S. J., Goldsmith, C. H., Graham, N., et al. (2010). Manipulation or mobilisation for neck pain: a Cochrane Review. *Manual Therapy, 15*(4), 315–333. https://doi.org/10.1016/j.math.2010.04.002

13. Hou, C-R., Tsai, L-C., Cheng, K-F., Chung, K-C., & Hong, C-Z. (2002). Immediate effects of various physical therapeutic modalities on cervical myofascial pain and trigger-point sensitivity. *Archives of Physical Medicine and Rehabilitation, 83*(10), 1406–1414. https://doi.org/10.1053/apmr.2002.34834
14. Jung, J-H., & Moon, D-C. (2015). The effect of thoracic region self-mobilization on chest expansion and pulmonary function. *Journal of Physical Therapy Science, 27*(9), 2779–2781. https://doi.org/10.1589/jpts.27.2779
15. Kaltenborn, F. M., Evjenth, O., Kaltenborn, T. B., Morgan, D., & Vollowitz, E. (2011). *Manual Mobilization of the Joints: Joint Examination and Basic Treatment: The Extremities.* Orthopedic Physical Therapy.
16. Lin, Y-C., Lai, C-H., Chang, W-H., Tu, L-W., Lin, J-C., & Chou, S-W. (2012). Immediate effects of ischemic compression on neck function in patients with cervicogenic cephalic syndrome. *Journal of Manipulative and Physiological Therapy, 35*(4), 301–307. https://doi.org/10.1016/j.jmpt.2012.04.009
17. Martínez-Segura, R., De-la-Llave-Rincón, A. I., Ortega-Santiago, R., Cleland, J A., & Fernández-de-Las-Peñas, C. (2012). Immediate changes in widespread pressure pain sensitivity, neck pain, and cervical range of motion after cervical or thoracic thrust manipulation in patients with bilateral chronic mechanical neck pain: a randomized clinical trial. *Journal of Orthopaedic & Sports Physical Therapy, 42*(9), 806–814. https://doi.org/10.2519/jospt.2012.4151
18. Masaracchio, M., Cleland, J. A., Hellman, M., & Hagins, M. (2013). Short-term combined effects of thoracic spine thrust manipulation and cervical spine nonthrust manipulation in individuals with mechanical neck pain: a randomized clinical trial. *Journal of Orthopaedic and Sports Physical Therapy, 43*(3), 118–127. https://doi.org/10.2519/jospt.2013.4221
19. Miller, J., Gross, A., D'Sylva, J., Burnie, S. J., Goldsmith, C. H., Graham, N., et al. (2010). Manual therapy and exercise for neck pain: a systematic review. Manual Therapy, 15(4), 334–354. https://doi.org/10.1016/j.math.2010.04.002
20. Nagrale, A. V., Glynn, P., Joshi, A., & Ramteke, G. (2010). The efficacy of an integrated neuromuscular inhibition technique on upper trapezius trigger points in subjects with non-specific neck pain: a randomized controlled trial. *The Journal of Manual and Manipulative Therapy, 18*(1), 37–43. https://doi.org/10.1179/106698110X12595770849605
21. Salahzadeh, Z., Maroufi, N., Ahmadi, A., Behtash, H., Razmjoo, A., Gohari, M., et al. (2014). Assessment of forward head posture in females: observational and photogrammetry methods.

Journal of Back and Musculoskelet Rehabilitation, 27(2), 131–139. https://doi.org/10.3233/BMR-130426

22. Sandow, E. (2011). Case studies in cervicothoracic spine function evaluation and treatment of two dancers with mechanical neck pain. *Journal of Dance Medicine & Science: Official Publication of the International Association for Dance Medicine & Science, 15*(1), 37–44.
23. Straker, L., Burgess-Limerick, R., Pollock, C., Coleman, J., Skoss, R., & Maslen, B. (2008). Children's posture and muscle activity at different computer display heights and during paper information technology use. *Human Factors, 50*(1), 49–61. https://doi.org/10.1518/001872008X250575
24. Strunk, R. G., Pfefer, M. T., & Dube, D. (2014). Multimodal chiropractic care of pain and disability for a patient diagnosed with benign joint hypermobility syndrome: a case report. *Journal of Chiropractic Medicine, 13*(1), 35–42. https://doi.org/10.1016/j.jcm.2014.01.009
25. Vernon, H., & Mior, S. (1991). The Neck Disability Index: a study of reliability and validity. *Journal of Manipulative and Physiological Therapy, 14*(7), 409–415.
26. Vicenzino, B., Collins, D., & Wright, A. (1996). The initial effects of a cervical spine manipulative physiotherapy treatment on the pain and dysfunction of lateral epicondylalgia. *Pain, 68*(1), 69–74. https://doi.org/10.1016/S0304-3959(96)03221-6
27. Walton, D. M., Macdermid, J. C., Nielson, W., Teasell, R. W., Chiasson, M., & Brown, L. (2011). Reliability, standard error, and minimum detectable change of clinical pressure pain threshold testing in people with and without acute neck pain. *Journal of Orthopaedic and Sports Physical Therapy, 41*(9), 644–650. https://doi.org/10.2519/jospt.2011.3666
28. Youdas, J. W., Carey, J. R., & Garrett, T. R. (1991). Reliability of measurements of cervical spine range of motion--comparison of three methods. *Physical Therapy, 71*(2), 98–104.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

FUNDING

This research received no external funding.

COPYRIGHT