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Does the Addition of Upper Thoracic Manipulation to Proprioceptive Training Improve Cervicocephalic Joint Position Sense and Forward Head Posture in Asymptomatic College Students?

Background: This study evaluated the effectiveness of upper thoracic manipulation (UTM) and proprioceptive training versus proprioceptive training alone on forward head posture (FHP) and cervicocephalic joint position sense (CJPS) in asymptomatic university students during a short interval of time.
Objectives: To evaluate whether the suggested combination would provide greater benefit, and be superior to proprioceptive training alone in improving proprioceptive acuity and head posture.
Design: A single-blind randomized controlled trial.
Methods: Thirty-three university student volunteers with asymptomatic FHP were recruited. Subjects were randomly assigned to a manipulation group (n=16) receiving UTM combined with proprioceptive training or a proprioception group (n=17) receiving proprioceptive training only. The intervention period lasted 5 weeks in total, and consisted of one 15 to 20-minute session per week. FHP and CJPS were assessed before and after the intervention.
Results: A significant pre- to post-intervention decrease in FHP and joint position error was identified in both groups ($P<.05$). Subjects in the manipulation group demonstrated greater improvements in CJPS and head posture compared to the proprioception group ($P<.05$).
Conclusion: These findings support employing either intervention for treating asymptomatic students with FHP. However, the addition of UTM to proprioceptive training was more effective than proprioceptive training alone in reducing joint position errors and improving head posture.

Keywords: *Forward head posture; Cervicocephalic joint position sense; Thoracic manipulation; Proprioceptive training*

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INTRODUCTION

In our contemporary world, the extended use of computers and mobile phones is leading people to face the ache of mischievous postures. Accordingly, epidemiological studies have shown a high prevalence of spinal postural deviations emerging in the last few years, especially among college students. The most common postural deformity in the cervical region is forward head posture (FHP); defined as the forward translation of the head in the sagittal plane.[1,2]

Over the years, numerous reports documented the close relationship between FHP and diverse types of chronic musculoskeletal pain. Eventually, the deviation from the ideal and efficient alignment induces changes in the biomechanical load around the cervical spine leading to neuromuscular imbalances.[3] Thus, the latter will generate a vicious cycle of musculoskeletal dysfunction and chronic pain symptoms including: neck pain, cervicogenic headaches, temporomandibular joint disorders, and shoulder pain.[3-6]

According to Silva et al.[7] FHP is age-associated.

Hence, greater levels of disability will emerge with aging, the sensorimotor function in the cervical spine becomes impaired and FHP becomes more severe. Therefore, young individuals with asymptomatic FHP will ultimately suffer from one or many of the disorders mentioned previously if not treated.[8,9]

Moreover, various recent studies reported that subjects with FHP exhibit deficits in proprioception and more specifically in cervicocephalic joint position sense (CJPS).[10]

FHP induces changes in the lengths of the cervical muscles, including shortening of the cervical extensors and weakness of the cervical flexors. This muscle imbalance would negatively impact the activity of the muscle spindles, the receptors responsible for position sense and the maintenance of an optimal body alignment.[11] Accordingly, sustained stretching of the weak deep neck flexors alters the sensitivity of their spindles and reflects thixotropic effects. Hence, these receptors become relatively less sensitive.[12] Clinically, this garbled proprioceptive reporting affects the mechanoreceptive afferent integration and tuning in the central nervous system. Consequently, the motor output and joint function are both modified resulting in local and global dysfunctions.[11] This modification leads to the loss of kinesthetic acuity of neck motions and inadequate spatial representation of the head provoking further postural alterations.[11] Also, it affects postural stability as well as head and eye movement control causing functional impairment in daily activities.[13]

Correspondingly, it is confirmed that there's a correlation between the degree of FHP and CJPS; showing that as FHP becomes more severe, joint position sense becomes worse and muscles adopt a position of somatic dysfunction.[14]

Furthermore, subjects with FHP exhibit an increased thoracic kyphosis accompanied by an intensified postural stress applied on the lower cervical vertebrae till the 4th thoracic vertebrae. In fact, the mobility of the cervical spine is associated with the mobility of the high thoracic spine. Any dysfunction in the thoracic spine can serve as an underlying contributor to the development of neck disorders and poor postural patterns such as FHP. That is to say, the upper thoracic segments (T1–T4) also require a treatment.[15] Lately, many studies found an improvement in CJPS and FHP in asymptomatic adults through direct cervical manipulation.[16,17] However, there's an encountered concern in using this technique, because it is a dangerous intervention.[18] Interestingly, an emerging evidence suggests employing upper thoracic manipulation (UTM) to treat cervical dysfunctions. Ernst[18] stated that the risk of adverse events in UTM is much less frequent than those associated with cervical manipulation. In addition, many studies concluded that thrust UTM would be more effective than mobilization in the reduction of cervical pain and disability.[19]

Evidence suggests that UTM is an effective intervention for relieving neck pain and enhancing its range of motion. Nevertheless, previous studies didn't direct this intervention towards impaired cervical proprioception and poor cervical posture. Thus, the effects of UTM on CJPS and FHP remain uncertain.[20,21] Moreover, proprioceptive training is a conservative treatment widely used by physical therapists and there are studies that have reported considerable effects on improving impaired CJPS, pain, and function in patients with neck pain. However, few explored the role of proprioceptive training on postural enhancement and FHP.[22,23]

To our knowledge, there are no studies inquiring into the effectiveness of a combined UTM and proprioceptive training intervention in comparison to a proprioceptive training alone on FHP and CJPS in asymptomatic students. Thereon, not only a study on their effectiveness would be of value, but also of a great significance, since it's designed to help healthy young adults improve their posture and proprioceptive function. Ultimately, preventing the development of chronic neck pain and recurrent musculoskeletal dysfunctions.

On that account, the target of this trial is to investigate the short-term effects of proprioceptive training with and without additional UTM on FHP and CJPS in asymptomatic college students. More specifically, we will test whether the addition of UTM has a superior effect to proprioceptive training alone in treating FHP and proprioceptive disturbances or not.

SUBJECTS AND METHODS

Study groups and design

The current research is a single-blind randomized controlled trial, conducted from May 2020 to July 2020. Data collection and the interventions took place at the Lebanese University physical therapy center.

A total of thirty-three university students with FHP were recruited for this study. The inclusion criteria were: asymptomatic college students (18–25 years old college students with no neck pain), mild-severe FHP with >2.5 cm of anterior weight bearing, and pain-free full active range of motion in the cervical spine.

The exclusion criteria were: acute/chronic neck pain, history of traumatic neck injury, congenital spinal deformity, vestibular pathology, temporomandibular joint pathology, previous physiotherapy treatment for the neck in the past 12 months, and neuromuscular disorders.

After baseline testing, subjects were randomly assigned to a manipulation group (n=16) receiving UTM combined with proprioceptive training or a proprioception group (n=17), receiving proprioceptive training only.

All subjects were informed of the purpose and procedures of this study and provided their written informed consent prior to participation. This experimentation adhered to the ethical principles of the Declaration of Helsinki.

Testing procedures

An experienced physiotherapist examined the participants provisionally eligible for the trial. A series of measures were performed at baseline and immediately after the treatment. The testing procedures involved assessing FHP and CJPS.

Forward head posture measurement

FHP was measured using the Plumb line posture test; a method sensitive enough to assess FHP and to detect improvement in response to training.[24] Subjects were instructed to stand in a self-selected upright posture, in front of a posture analysis grid, then the auricular lobule and the acromion process were palpated and marked with adhesive skin markers. To prevent postural changes due to the vision, the subjects were required to fix their sight on a point in front of them. While standing still, they were photographed in the lateral view.[25] Data of photography were analyzed using Photoshop, the inter-rater and intra-rater evaluations of photogrammetry findings in the standing sagittal posture of the cervical spine were found to be reliable.[26]

The plumb line was used as a reference of alignment for the body. Having a good posture enables the auditory lobule to be in vertical alignment with the midline of the shoulder. If the individuals' auditory lobule was positioned anterior to the plumb line through the shoulder joint, this means he/she has FHP. In this sense, the distance from the line passing through the acromion to another line passing through the auditory lobule was measured to define the severity of FHP and marked the progress after starting the training program. If the distance ranged between 2.5-5 cm, it was defined as moderate FHP, and if the distance was more than 5 cm, it was defined as severe FHP.[27]

Assessment of cervicocephalic proprioceptive function

CJPS was evaluated using the head repositioning accuracy (HRA) test. This test has fair to excellent reliability and validity and is sensitive enough to detect improvements in response to training. It allows testing one's ability to relocate the head back to center after maximal or submaximal rotation in the transverse or sagittal planes.[28,29]

Subjects were seated at a distance of 90 cm from a white plain wall. A laser pointer secured to a headpiece was firmly placed on the head. The participants were asked to find what they had perceived as a straight neutral head position (NHP). Targets were then placed on the wall in front of them at eye level and were adjusted to the participants' NHP, so that the current position of the laser pointer's light beam projected on the center (zero position). After a few seconds of concentration on this reference/starting position, subjects were instructed to close their eyes and memorize it. Then, subjects performed neck flexion in the comfortable end range of motion at their own preferred speed and held this position for 5 seconds. Afterwards, they attempted to relocate their head back to NHP as accurately as possible. The stopping point of the laser beam on the target was the return position, marked with a dot and labeled according to the repetition number. No feedbacks were given during the procedure. Three trials were carried out for the movement of flexion, followed by three for an extension movement, while taking a rest for 3 seconds between measurements.[30,31] The normal relocation is within 7 cm from the starting point, and the abnormal error is considered more than 7 cm from the starting point.[32]

Treatment procedures

Randomization

Following the baseline examination, all eligible subjects were randomly assigned to one of two study groups, manipulation group or proprioception group by simple randomization in a 1:1 ratio. Patients were blinded to their allocation. An independent researcher, not involved in the recruitment and treatment of the patients performed the allocation using a computerized system for generating random numbers.

Details of the group assignment were concealed on cards inside a sequentially-numbered series of sealed, opaque envelopes. A second therapist, blinded to the baseline examination findings, opened the envelopes and proceeded with the treatment according to the group assignment.

Study interventions

The intervention period lasted for 5 consecutive weeks, and consisted of one 15 to 20-minute session per week. The manipulation group received upper thoracic manipulation combined with proprioceptive training and the proprioception group received proprioceptive training only. Patients in each group received personal instructions and supervision by an experienced physiotherapist, and were asked not to receive any other form of specific intervention on their neck. However, any usual medication was not withheld from any participant.

Proprioceptive training

Patients trained cervical proprioception using a regimen similar to the one described by Jull et al.[33,34]

It includes craniocervical flexion training, eye follow, gaze stability and eye-head coordination exercises.

Craniocervical flexion exercises target the deep neck flexor muscles activation and holding capacity. They involve training the interaction of deep and superficial cervical flexors in movement patterning and functional tasks, training the co-contraction of the deep cervical flexors and extensors, training to actively correct and hold a neutral cervical spine, and training craniocervical extensors and rotators with the cervical spine in a neutral position.

Oculomotor control exercises include eye follow exercises, where the participants follow with their eyes a target moving horizontally and vertically while keeping their head stationary with a neutral cervical spine. Gaze stability exercises comprise fixing the gaze on a particular target in which the participants perform active movements of the cervical spine (flexion, extension and rotation). These exercises would be further progressed by increasing the speed, range of movements and/or changing the visual target. Lastly, eye-head coordination exercises, where the participants move their eyes and head in the same direction to focus on a target, progression includes moving the eyes first to the target then the head, and moving the eyes and head in opposite directions.

Upper thoracic manipulation

The patient is supine with the operator standing at the side, crossing his arms over the chest, holding the opposite shoulder, with the arm opposite to the operator being superior. The therapist uses his manipulating hand to stabilize the inferior vertebra of the target spinal segment, the spinous processes placed in the palm of the hand with the thumb along their side. The supporting hand is used to fix the subject's elbows, then the operator's body pushes through the patient's arms in an anterior-to-posterior direction while the subject exhaled. The target segments were T1 to T4. In all sessions, the same technique was executed once after finishing the proprioceptive exercises, if there was no cavitation, only a second trial would be performed.[35]

Data analysis

HRA test data processing

For the HRA test, the projection on the abscissa and ordinate axes were measured (X, Y). While using each coordinate, the subject's global error of repositioning (R) was then calculated trigonometrically in centimeters using the following equation:

For every subject, the global error of repositioning (R) was calculated six times before and after treatment, because three repetitions of HRA to reference zero were undertaken for both head flexion and extension movements. Then, the mean and standard deviation values (in cm) for the three trials of each movement in the experimental and control groups were calculated.[32]

FHP photogrammetric measurement

FHP was evaluated by analyzing digital images based on the participant's head and neck position compared to the plumb line. The distance from the line passing through the acromion to the line passing through the auditory lobule was measured using Photoshop to assess the severity of FHP before and after treatment.[26]

Statistical analysis

For the plumb line posture test, the independent t-test was used with a level of significance α=.05, to assess the difference in the severity of FHP before and after treatment, between and within the two groups.

For the HRA test, the paired t-test was used to analyze the changes in the error values of the CJPS in cervical flexion and extension before and after treatment within each group, and the independent t-test to compare results between the two groups (α=.05).

RESULTS

Study population

A total of 40 participants underwent randomization and 33 subjects (82.5%) completed the study, 7 discontinued the intervention due to personal reasons. The participants' baseline clinical characteristics are detailed in Table 1, differences in sex, age, height and weight were not statistically significant in both groups ($P>.05$). Thus, the two groups were considered to be homogeneous.

Plumb line posture test

The comparison of the pre- and post-treatment results in both groups revealed a statistically significant decrease in the FHP severity ($P<.05$). But the comparison of the results between groups revealed that the manipulation group showed a greater reduction in FHP than the proprioception group after treatment ($P<.05$). A summary of the statistical values is shown in Table 2.

HRA test

Comparing the results within groups revealed in both cases a statistically significant improvement in proprioception after treatment ($P<.05$). However, comparing the results between the groups revealed that the manipulation group showed significantly smaller repositioning error values of the CJPS in cervical flexion and extension than the proprioception group ($P<.05$). A summary of the statistical values is shown in Table 3.

Table 1. General characteristics of the subjects

General characteristics	Proprioception group	Manipulation group
Female/male	11 / 6	9 / 7
Age (years)	20.65 ± .96	19.06 ± .94
Weight (kg)	66.17 ± 12.14	66.43 ± 12.34
Height (cm)	167.59 ± 7.96	168.19 ± 8.31

Values are expressed as Mean±SD

Table 2. Comparison of the severity of FHP before and after treatment within and between groups (Unit: cm)

General characteristics	Before treatment	After treatment
Proprioception group	4.75 ± 3.3	1.9 ± .7†**
Manipulation group	5.59 ± 4.2	1.7 ± .8†‡**

Values are expressed as the Mean±SD
An asterisk (**) indicates a significant difference ($P<.05$), †Within group comparison, ‡Between group comparison

Table 3. Comparison of cervical joint position errors before and after treatment within each group (Unit: cm)

	Movement	Pre-treatment	Post-treatment
Proprioception group	Flexion	10.05 ± .27	5.42 ± .73**
	Extension	10.23 ± 1.29	5.74 ± 1.16**
Manipulation group	Flexion	10.74 ± 1.87	4.86 ± .45**
	Extension	9.76 ± .97	4.17 ± .48**

Values are expressed as the Mean±SD. An asterisk (**) indicates a significant difference ($P<.05$)

DISCUSSION

The purpose of this study was to investigate the effect of proprioceptive training combined with UTM versus proprioceptive training alone on FHP and CJPS in asymptomatic college students, during a short interval of time. The study was performed over five weeks with one session per week. The plumb line posture test and the HRA test were used to compare changes before and after the treatment's results between and within the two groups.

In this regard, the results revealed that the proprioception group receiving proprioceptive training alone, exhibited great improvements in head posture with major declines in cervical lordosis. This group also displayed significant reductions in joint position errors (in both flexion and extension movements), indicating an enhanced proprioception.

The following results might be explained by the fact that FHP is associated with weakness and poor endurance of the rectus capitis anterior, longus capitis, and longus colli muscles also termed as deep neck flexors (DNF). Therefore, improving their strength will counteract the cervical lordosis increment produced by the weight of the head and cervical hyperextension in order to maintain proper posture (cervical lordosis) and equilibrium.[36,37]

Also, CJPS is influenced particularly by skeletal muscle sensory receptors called muscle spindles, which in turn are affected by the muscles' condition. Thus, training the weakened/inhibited DNF musculature activates its densely concentrated muscle spindles, increases their sensitivity and level of discharge. According to many previous studies, an enhanced muscle spindle function translates into an improved proprioception. Subsequently, the DNF muscles via a feedback loop would be able to execute fine forces to adjust the poor head posture and to ameliorate the individual's awareness of his neck position in space.[38,39]

Moreover, alteration in the deep and superficial muscles activity might also be responsible for the exhibited changes in proprioception. The increase in DNF activity could decrease the overstimulated sternocleidomastoid and scalene muscles activity by reciprocal inhibition. Hence, the cervical intersegmental kinematics will be altered. This leads to an improvement in proprioceptive acuity for the cervical movements.[40,41]

Another reason might be the incorporation of eye-head coordination exercises. The latter retrains the deep suboccipital muscles, which are also richly endowed with proprioceptors. Thereupon, it activates the reflexes linking the sensorimotor system of the neck with the oculomotor and vestibular systems. Eventually, this results in an enhanced CJPS.[42,23]

As a matter of fact, the manipulation group receiving both UTM and proprioceptive training also demonstrated significant improvements in FHP and CJPS. These improvements were greater than those of the proprioception group which received proprioceptive training alone.

The observed results are consistent with previous studies. According to Miller et al.[43] using manipulation with exercise prompts more notable improvements than exercise alone. Since the motion of the upper thoracic spine is coupled with the end movement of the cervical spine, the treatment should be addressed to both.[44,45] Generally, the greater improvements in the experimental group were derived from the effect of the high velocity low amplitude spinal manipulation. This passive mobilization might mechanically stimulate the proprioceptive receptors. More specifically, the ones which are located in the deep paraspinal muscles, joint capsules and ligaments. This ameliorates their responses in the central nervous system, and helps the recovery of proprioception.[46-48]

Therefore, the outcome implies that there's an overlap between the physiological mechanisms of each training strategy.

Both proprioceptive exercises and thoracic vertebrae mobilization aim at activating specific craniocervical musculature. They have a central common feature which might be an improved quality of cervical afferent input and sensorimotor integration into the central nervous system. In this case, it is due to reprograming and retraining of the joint receptors and muscle spindles. Consequently, altered firing of cervical afferents promotes motor control. This contributes to the normalization of joint stresses, which in turn reflects changes in the proprioceptive function and in the head posture.[49]

Moreover, the rapid amelioration in both groups in a short interval of time might be attributed to the short-term neuromuscular adaptations of the DNF muscles. They refer to an enhanced motor unit recruitment and synchronization, an increased firing frequency, and an intermuscular coordination.[50]

This study has few limitations. Firstly, due to the small number of study subjects, it was difficult to generalize the findings. Secondly, the intervention period was relatively short and could not examine the sustainability and durability of its effect. Lastly, this trial did not report any measured values of the muscles condition in terms of length and activity.

Therefore, it is thought that further research is necessary to elucidate the effects of proprioceptive training and UTM on FHP and CJPS. We recommend employing a larger sample of participants, a lengthier intervention period, and an investigation of the long-term outcomes (6 months to 1-year follow-up). Additionally, we suggest using an electromyogram conjointly with the HRA test to assess proprioception, as well as combining the photogrammetric measurement with electronic sensors to measure angles between body segments in the assessment of FHP.

Finally, considering that manipulation with no segmental specificity to the area in dysfunction has distant effects. Further research could explore the effects of sacral, lumbar, and lower thoracic spine manipulation on FHP and CJPS.

CONCLUSION

Based on the present results, it could be concluded that although UTM and proprioceptive training are both effective for FHP and CJPS recovery, yet greater benefit is gained from their combination. Suggesting that it's the more efficient short term intervention for asymptomatic students.

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