PNF and Movement, 2022; 20(3): 371-381
https://doi.org/10.21598/JKPNFA.2022.20.3.371

Print ISSN: 2508-6227
Online ISSN: 2508-6472

Original Article

Open Access

Immediate Effects of Cervical and Thoracic Mobilization on Cervical Range of Motion in the Sagittal Plane and Pain in Patients with Forward Head Posture

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Received: October 21, 2022 / Revised: November 13, 2022 / Accepted: November 24, 2022

| Abstract |

Purpose: Forward head posture (FHP) is known to cause pain, limit range of motion, and reduce quality of life. Joint mobilization is commonly used to correct FHP. However, no study has compared cervical, thoracic, and combined cervical and thoracic joint mobilization for FHP. The aim of this study was to investigate and compare the effects of each mobilization technique on range of motion in the sagittal plane and pain in patients with FHP.

Methods: Forty-five patients were recruited and randomly divided into three groups: the mobilization group (CM; n = 15), the cervical and thoracic mobilization group (CTM; n = 15), and the thoracic mobilization group (TM; n = 15). Each intervention was performed in sets of three and repeated six times. Range of motion and pain were assessed pre- and post-intervention. The cervical range of motion was evaluated using a goniometer, and pain was evaluated using a visual analogue scale and pain thresholds of the suboccipital and upper trapezius muscles.

Results: All groups showed an increase in range of motion post-intervention, but the increase in the CTM group was significantly greater than in the CM and TM groups ($p < 0.05$). Pain measured using the visual analogue scale decreased in all groups, but the decreases in the CM and CTM groups were significantly greater than in the TM group ($p < 0.05$). The pain thresholds of the suboccipital and upper trapezius muscles increased in all groups, but the increase in the CTM group was significantly greater than in the CM and TM groups ($p < 0.05$).

Conclusion: Overall, our findings suggest that CTM may be more effective than CM or TM for improving cervical range of motion in the sagittal plane and pain in patients with FHP.

Key Words: Manual Therapy, Neck Pain, Range of Motion

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Ⅰ. Introduction

In the forward head posture (FHP), the cervical spine is positioned forward from normal alignment. It is considered a poor head posture and is frequently observed in patients with head and neck problems (Good et al., 2001). FHP increases the load on cervical muscles and joints and, is at major cause of musculoskeletal disorders (Szeto et al., 2002). FHP could induce non-specific cervical and radiating pain by causing soft tissue damage and limiting range of motion of the joints (D. H. Kim et al., 2018). Continuous, computer-related work can affect the upper cervical curvature, thereby leading to FHP and an associated deterioration in proprioception (Park & Yoo, 2014). In addition, abnormal changes in the head and neck joints because of FHP (Harrison et al., 2003) cause excessive kyphosis of the upper thoracic spine (Szeto et al., 2002). Lau et al. (H. M. Lau et al., 2011) reported a notably close association between excessive kyphosis of the thoracic spine and cervical pain-related disabilities in patients with cervical spine dysfunction when compared with in healthy controls. Therefore, thoracic spine mobility plays a critical role in these patients, and the cervical and thoracic spines are intimately related and ergonomically connected (Jull et al., 2008; K. T. Lau et al., 2010).

Electrotherapy, spinal traction, and joint mobilization are conservative treatments for the recovery of cervical spine functionality (Chiu et al., 2005; Gross et al., 2004). Joint mobilization comprises the manual application of traction and gliding motions to the articular surface as a means of maintaining or restoring the normal range of joint mobility (Choi et al., 2017). Mulligan (Mulligan, 2006) suggested the use of sustained natural apophyseal glides (SNAGs) as a form of joint mobilization is used for the treatment of spinal pain. The SNAGs were described one of mobilization with movement techniques, and to apply passive glide simultaneously while performing active movement (Moutzouri et al., 2008). The SNAGs may enhance treatment effects by eliminating pain originating from the lesion (Konstantinou et al., 2002).

Joint mobilization for FHP commonly involves the cervical spine (Lee et al., 2013). However, thoracic kyphosis is associated with reduced physical function, poor postural control, and reduced quality of life (Balzini et al., 2003; Sinaki et al., 2005; Takahashi et al., 2005). Manual therapy of the thoracic spine improves the range of motion within the cervical curvature of patients with FHP (H. M. Lau et al., 2011). In rehabilitation medicine, association between thoracic kyphosis and cervical spine dysfunction has been a primary focus owing to extensive clinical evidence supporting the effectivity of manual therapy and thoracic spine mobilization in these patients (Cleland et al., 2007; Krauss et al., 2008; H. M. Lau et al., 2011). FHP generally worsen the curvatures of the lower cervical and upper thoracic spines and increases extension of the atlas, occiput, and upper cervical spine. Therefore, the upper thoracic and cervical spines should be treated concurrently (G. Kim et al., 2011). This study aimed to identify the most effective method among CM, CTM, and TM performed using the Mulligan technique. Patient benefit was measured with respect to range of motion in sagittal plane and pain in the cervical spine.

Ⅱ. Method

1. Participants

The participants were randomly allocated to groups in the order of enrollment using a random number table. Patients diagnosed with FHP were recruited as participants using an advertisement placed on the hospital noticeboard. The study purpose, methods, and procedures were explained to each participant. Participants was voluntary, and consent was obtained from the participants after they were informed of possible treatment discontinuation before completion of the study. The study design was approved by the institutional review board of Sahmyook University (2-1040781-AB-N-01-2016065HR).

Participants with FHP, whose tragus was positioned anteriorly to the acromion, were enrolled. The inclusion criteria were as follows: no consumption of medication or alcohol for 24 h before the session, having an adequate understanding of the study purpose and contents, having a craniovertebral angle (CVA) between 31° and 51° (Quek et al., 2013), and having complaints of neck pain. The exclusion criteria were as follows: diagnosis of a musculoskeletal disorders in the cervical or thoracic spine, such as rheumatic arthritis or acute disease (Wilson, 2001), history of cervical or thoracic spinal surgery, and presence of cognitive impairment or neurological symptoms.

2. Experimental procedure

A total of 45 patients with FHP were enrolled in this study. A physical therapist with more than three years of clinical experience assessed the ranges of motion of flexion and extension of the cervical spine, and pressure pain threshold (PPT) in the suboccipital and upper trapezius muscles before and after application of the manual therapy. All participants were randomly allocated to the CM, CTM, and TM groups (n = 15 in each group) in the order of enrollment. Participants in the CM and TM groups were subjected to three sets of SNAGs in the cervical and thoracic areas, respectively. Each set was performed six times. Participants in the CTM group were subjected to three sets of SNAGS, with each set performed six times in both the cervical and thoracic areas.

3. Outcome measurements

To measure the range of motion, we used a previously described method (Cipriano, 1985). A goniometer was used to measure the active ranges of motion of neck flexion and extension because CVA used to diagnose patients with FHP is evaluated in the sagittal plane (Quek et al., 2013). The patient was seated on a stool, with the axis of the goniometer aligned with the external auditory canal. Measurements were taken with the stationary arm positioned parallel to the floor and the movable arm positioned parallel to the base of the nose (Youdas et al., 1991). The active ranges of motion of flexion and extension were measured three times each, and the means of the three values were used in the analysis.

Pain was assessed using the visual analog scale (VAS) and PPT. VAS was used to assess the pre- and post-intervention levels of pain. The participants self-ranked their levels of pain on a 10-cm line (Dixon & Bird, 1981). The scoring ranged from 0 to 10, where “0” indicated no pain and “10” indicated unbearable pain. PPT was defined as the minimum applied pressure required to induce a pain response in a muscle (Fischer, 1986). PPT was measured using a digital algometer (Commander ™ Algometer, J Tech, USA), which allows for quantification of susceptibility to pressure and the precise identification of the origin of pain. In this study, PPTs of the suboccipital and upper trapezius muscles were measured. The inferior nuchal line served as the application point on suboccipital muscle. For the upper trapezius muscle, the device was applied between C5 and C7 (Travell et al., 1995). The pressure at which the participant produced a pain-related vocalization was recorded.

4. Intervention

1) Cervical mobilization

The participants were instructed to sit comfortably on a chair at eh end of the treatment table, with their feet touching the ground and their head and cervical spine in a neutral position. SNAGs were applied with the therapist standing behind the patient. The therapist placed their left and right thumbs on the respective sides of the spinous process on the cervical spine and applied the SNAG in a horizontal direction. For continuous gliding, participants were guided to perform neck flexion and extension movements (Fig. 1A, B, C).

2) Thoracic mobilization

Participants were instructed to sit on a chair at the end of the treatment table, with their feet touching the ground and both hands placed behind the neck to protract the scapula. SNAGs were applied with the therapist standing to one side of the patient. The therapist placed one hand on the participant's chest and one leg behind the participant to support the lumbosacral spine. Traction for the upper spinal segments was provided when the therapist extended the knee of the leg opposite to the one placed behind the participant. For joint mobilization, the therapist placed the palm of the hand not on the participant's chest on the spinous process of the thoracic spine. While the participant was performing thoracic flexion and extension movements, the therapist used the palm of the hand placed on the spinous process to glide the facet joints of the thoracic spine in the cranial direction, while placing the other hand on the chest above the level of joint mobilization for support (Fig. 1D, E, F).

5. Data analysis

SPSS statistics for windows version 18.0 (SPSS Inc.,

Fig. 1. Sustained natural apophyseal glides (SNAG) techniques. (A) start position in cervical mobilization, (B) end position of flexion in cervical mobilization, (C) end position of extension in cervical mobilization (D) start position in thoracic mobilization, (E) end position of flexion in thoracic mobilization, and (F) end position of extension in thoracic mobilization.

Chicago, ILL, USA) was used for all data processing and statistical analyses. All data were tested for normality and demographic characteristics were analyzed using descriptive statistics. Within-group differences in pain and ranges of motion pre- and post-intervention were analyzed using paired t-tests. Between-group differences in post-interventional changes were analyzed using a one-way analysis of variance (ANOVA). The Scheffe test was performed for post hoc analysis. The level of significance was set at 0.05.

Ⅲ. Results

1. General characteristics of the participants

There were no significant between-group differences in participant's demographic data, including sex, age, height, and weight ($p>0.05$) (Table 1).

2. Changes in cervical range of motion

Post-intervention improvements in the range of motion of flexion were significant in all three groups, namely 7.83%, 28.72%, and 12.21% in the CM, CTM, and TM groups, respectively ($p<0.05$ for all when compared with pre-intervention values). Similarly, post-intervention improvements in range of motion of extension were significant in all groups, namely 5.23%, 14.41%, and 9.04% in the CM, CTM, and TM groups, respectively ($p<0.05$ for all when compared with pre-intervention values). While post-intervention improvements were significant in all three groups, the improvement in the CTM group was significantly greater when compared with in the other two groups ($p<0.05$) (Table 2).

3. Changes in pain

Post-intervention VAS scores decreased significantly in all groups, namely 47.82%, 36.04%, and 30.83% in the CM, CTM, and TM groups, respectively ($p<0.05$ for all when compared with pre-intervention values). The decrease in VAS scores was significantly greater in the CM and CTM groups than in the TM group ($p<0.05$).

Post-intervention increase in PPT of the suboccipital muscle was significant in all three groups, namely 6.55%,

Table 1. General characteristics of the participants (n=45)

Variables	CM group (n=15)	CTM group (n=15)	TM group (n=15)	χ^2/F(p)
Sex (male / female)	5 / 10	7 / 8	6 / 9	0.26 (0.77)
Age (years)	32.20±5.54	38.07±7.08	36.00±6.89	3.10 (0.06)
Weight (kg)	62.00±13.27	61.60±10.03	64.33±15.19	0.76 (0.48)
Height (cm)	164.73±7.06	167.13±8.50	168.13±7.72	0.76 (0.48)
ROM				
Flexion (°)	43.40±6.27	37.60±4.08	43.07±3.53	0.52 (0.59)
Extension (°)	52.33±6.75	50.93±2.34	52.27±4.06	0.70 (0.49)
VAS (pts)	4.60±1.24	4.80±0.67	4.80±0.98	0.20 (0.81)
PPT (kg/cm^2)				
SO	38.73±19.11	38.07±10.91	31.27±14.22	1.27 (0.29)
UT	19.73±3.55	21.47±2.69	22.00±5.26	0.52 (0.59)

CM: cervical mobilization, CTM: combined cervical and thoracic mobilization, TM: thoracic mobilization, ROM: range of motion, VAS: visual analogue scale, PPT: pressure pain threshold, SO: suboccipital, UT: upper trapezius.
Values are presented as mean ± SD.

Table 2. Changes in cervical range of motion among the CM, CTM, and TM groups (n=45)

Variables	CM group (n=15)		CTM group (n=15)		TM group (n=15)		F (p)
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test	
Flexion (°)	43.40±6.27	46.80±4.05*	37.60±4.08	48.40±2.50*†	43.07±3.53	48.33±2.52*	22.71 (<0.01)
Extension (°)	52.33±6.75	55.07±5.87*	50.93±2.34	58.27±2.28*†	52.27±4.06	57.00±3.68*	10.31 (<0.01)

CM: cervical mobilization, CTM: combined cervical and thoracic mobilization, TM: thoracic mobilization.
Values are presented as mean ± SD.
* presents a significant difference between the pre-test and the post-test (p<0.05).
† presents a significant difference compared to other groups (p<0.05).

15.05%, and 8.73% in the CM, CTM, and TM groups, respectively (p<0.05 for all when compared with pre-intervention values). Similarly, all groups showed a significant increase in PPT of the upper trapezius muscle after intervention, namely 6.79%, 30.74%, and 14.22% in the CM, CTM, and TM groups, respectively (P<0.05 for all when compared with pre-intervention values). The improvement in the CTM group was significantly greater than in the other two groups (p<0.05) (Table 3).

Ⅳ. Discussion

This study demonstrated that CTM was efficient technique to improve cervical range of motion in sagittal plane and pain compared to CM or TM. According to the Mulligan technique (Mulligan, 2006), the use of SNAGs during joint mobilization facilitates gliding of the spinal facet joints while patients actively perform the symptomatic movement; the application must restore pain-free joint mobility (Wilson, 2001). Among the joint mobilization methods incorporating the Mulligan technique, those that are effective while permitting active movements during manipulative therapy are mainly used in the treatment of pain caused by motion (Andrews et al., 2018; Seo et al., 2020). The application of SNAGs immediately reduces vertigo, cervical pain, and disability caused by cervical spine dysfunction (Ali et al., 2014;

Table 3. Changes in pain among the CM, CTM, and TM groups (n=45)

Variables	CM group (n=15)		CTM group (n=15)		TM group (n=15)		F (p)
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test	
VAS (pts)	4.60±1.24	2.40±0.91*‡	4.80±0.67	3.07±0.88*‡	4.80±0.98	3.80±0.77*	13.49 (<0.01)
PPT (kg/cm^2)							
SO	38.73±19.11	41.27±20.14*	38.07±10.91	43.80±13.68*†	31.27±14.22	34.00±15.91*	6.62 (<0.01)
UT	19.73±3.55	21.07±3.65*	21.47±2.69	28.07±3.73*†	22.00±5.26	25.13±5.59*	7.74 (<0.01)

CM: cervical mobilization, CTM: combined cervical and thoracic mobilization, TM: thoracic mobilization, VAS: visual analogue scale, PPT: pressure pain threshold, SO: suboccipital, UT: upper trapezius.
Values are presented as mean ± SD.
* presents a significant difference between the pre-test and the post-test (p<0.05).
‡ presents a significant difference compared to TM group (p<0.05).
† presents a significant difference compared to other groups (p<0.05)

Reid et al., 2014). Therefore, this study compared and verified the effects of three intervention methods of CM, CTM, and TM on reducing pain and increasing the range of motion. According to our finding, CTM may be more effective than CM and TM.

The cervical spine undergoes several types of motion performed at varying degrees during daily activities, and structural disorders can easily occur (Friedrich et al., 2007). Appropriate assessments and treatments of the cervical spine are critical for functional improvement. In our study, the effects of treatment on cervical ranges of motion of flexion and extension in the CTM group were significantly larger than in the CM and TM groups ($p<0.05$); differences between the CM and TM groups were nonsignificant ($p>0.05$). González-Iglesias et al. (González-Iglesias et al., 2009) previously demonstrated that thrust manipulation of the thoracic spine significantly increase range of motion in patients with neck pain. This result indicated an improvement in spinal joint flexibility resulting from joint mobilization alleviating muscle stiffness or structural shortening of the ligaments (Buran Çirak et al., 2021). Therefore, CM can directly affect the range of movement of the cervical spine (Gong, 2015), and since the force applied during TM also affected the increase in the range of movement of the cervical region (Engell et al., 2019), it is believed that the CTM group showed the largest increase in the range of movement.

Pain is difficult to quantify because it is experienced subjectively and emotionally, and comparing pain response among individuals is challenging (Von Korff et al., 2000). The measurement of pain is important for the collection of data relating to pain intensity, characteristics, and duration; these data influence the diagnosis and choice of treatment (Reiner et al., 2013). In this study, CTM and CM treatment significantly alleviated participant's pain as measured using the VAS scale. When compared with the effect TM, the improvements following CM and CTM were significantly greater ($p<0.05$). However, CM and CTM are applied directly to the cervical spine, which may have emotionally influenced the reported pain level. In a study by Fernández-De-Las-Peñas et al., C7–T1 manipulation significantly increased measured PPT when performed on healthy individuals. Interestingly, the increase was greater on the dominant than on the non-dominant side (Fernández-de-Las-Peñas et al., 2008). In our study, the changes in PPTs of the suboccipital and upper trapezius muscles were significantly larger in the CTM group than in the CM and TM groups ($p<0.05$). The trigger point in the upper trapezius muscle is closely associated with poor posture, such as FHP. Head extension is required to keep the eyes forward in these individuals, which induces hypertension of the suboccipital muscle (Travell et al., 1995). Increases in the PPTs of the upper trapezius and suboccipital muscles may produce functional improvements in patients with FHP. In the previous study, the trapezius PPT was negatively correlated with FHP (Yao et al., 2021). In this study, since the range of motion was significant improved after CMT in the sagittal plane, the correction of FHP might be likely to have improved most significantly. Therefore, the PPT of upper trapezius and suboccipital mussels would have been the highest in the CTM group.

Although various interventions have been applied for FHP patients, manual therapy is still considered first, and the results of this study demonstrated that CTM applied with SNAGs can show more significant improvement in cervical joint range and pain in FHP patients than CM or TM. The SNAGs are mobilization-with-movement treatment techniques on the premise that the pain is related to biomechanical changes such as joint restriction or stiffness (Wilson, 2001). This technique can help the gliding in the articular surface and increase range of motion through muscle activities. Joint mobilization can also affect the reduction of pain by stimulating the inhibitory pathways in the spinal cord (Alkhawajah & Alshami, 2019). Skyba et al. (2003) reported that joint mobilization reduced hyperalgesia by activation of serotonergic and noradrenergic receptors (Skyba et al., 2003). Therefore, the SNAGs can reduce pain and increase range of motion immediately (Mulligan, 2006).

This study has several limitations. First, the convenience sampling was used to recruitment, thereby limiting generalization of the results. Second, the factors that could affect intervention, such as motor control, strength, and sensory deficit, were not considered in the inclusion criteria. Finally, the subjects were randomly assigned, and there was no statistically significant difference in the age of all groups, but the CM group was lower in age than other groups. Further investigations are needed to determine the effects of long-term interventional approaches and the influence of treatment during.

Ⅴ. Conclusion

This study investigated and compared the immediate effects of CM, CTM, and TM on cervical pain and range of motion in individuals with FHP. The improvements in pain and range of motion were significantly higher immediately after CTM than after CM or TM. Therefore, CTM may be a more effective intervention approach in patients with FHP than CM or TM alone.

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