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# Effect of Maitland mobilization versus deep cervical flexors muscles training on proprioception in adults with chronic mechanical neck pain: a randomized controlled trial

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**Abstract**

**Objective** To examine the effect of adding Maitland mobilization (MM) versus deep cervical flexors muscles training (DCFMT) to conventional physical therapy (CPT) on proprioception in adults with chronic mechanical neck pain (CMNP).

**Materials and methods** A randomized controlled study was carried out at the outpatient clinics of physical therapy at Cairo and Suez universities. Sixty participants (27 males, 33 females) with CMNP were randomized into 3 equivalent groups. Group I received MM plus CPT, group II received DCFMT in addition to CPT, and group III received CPT only. All individuals were given three sessions a week for 4 weeks. The primary outcomes were proprioception (CROM), and pain (VAS). The secondary outcomes were cranio-vertebral angle (CVA), and upper cervical angle (C0–C2). Outcomes were evaluated at baseline and following 4 weeks of treatment.

**Results** Following 4 weeks of treatment, the DCFMT group showed statistically significant improvement to the MM group as well as the CPT group in all outcome measures ($p > 0.05$). Also, the MM group was remarkably better than the CPT group in all measured outcomes ($p > 0.05$). The mean signed difference (M±SD) post-treatment within the group of VAS were 6.87 ± 1.26, 7.15 ± 1.38, and 7.20 ± 1.39 cm for MM, DCFMT, and CPT groups respectively. The (M±SD) of CVA were 42.61 ± 4.36, 42.24 ± 3.64, and 42.32 ± 4.81 degrees for MM, DCFMT, and CPT groups respectively. The (M±SD) of C0–C2 were 24.25 ± 2.98, 23.37 ± 1.94, and 24.95 ± 3.01 degrees for MM, DCFMT, and CPT groups respectively. The (M±SD) of flexion JPE to target were 3.62 ± 0.91, 2.86 ± 0.77, and 4.35 ± 0.91 degrees for MM, DCFMT, and CPT groups respectively. The (M±SD) of flexion JPE to neutral were 3.96 ± 0.78, 2.66 ± 1.03, and 5.23 ± 1.52 degrees for MM, DCFMT, and CPT groups respectively.

**Conclusion** Adding MM and DCFMT to CPT revealed significant enhancement, favoring DCFMT, on proprioception, pain, cranio-vertebral angle (CVA), upper cervical angle (C0–C2), and intensity than CPT alone in adults with CMNP.

**Trial registration** Pan African Clinical Trails Registry with a registration No. PACTR202211651838599 on the 3rd of November 2022.

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**Keywords** Maitland mobilization, Deep cervical flexors muscles training, Chronic mechanical neck pain, Cranio-vertebral angle, Upper cervical angle, Proprioception

## Introduction

Mechanical neck pain (MNP) usually has multiple causes and develops gradually. Worldwide, MNP is still among the most common and costly medical conditions people encounter. Affecting 70% of individuals at different stages, making it a widespread musculoskeletal problem. Therefore, many individuals seek physiotherapy for neck pain [1].

Muscle and joint proprioceptors, particularly those in the neck, are continually transmitting essential information on the body's spatial position and the relative placement of different bodily parts. Impaired proprioceptive input that extends from the cervical region may explain why individuals with non-specific chronic neck pain (NSCNP) have lower postural stability compared to healthy controls [2]. Significant functional impairment and compensatory postural mechanisms can result from pain and lack of proprioception. Alterations to cervical biomechanics brought on by changes in joint position sense (JPS) after NSCNP can have a negative impact on long-term results [3].

Deep cervical flexor muscles are thought to be the principal receptors in the cervical spine that sense position [4]. When individuals experience neck pain, their DCFM may become hypoactive. As a consequence, the cervical region joints may not be supported and controlled as well, and superficial muscles such as the sternocleidomastoid as well as anterior scalene may become hyperactive as a compensatory mechanism [1]. Alterations in proprioception can result from changes in the output from muscle spindles, which in turn impacts the afferent input, caused by dysfunction in the deep as well as superficial cervical muscles [4].

Due to the changes that occur on the vertebral level, enhancing the mechanics as well as alignment of the cervical vertebrae has an essential role in treating adults suffering from MNP [5]. The oscillatory movements of the mobilization produce mechanical effects, resulting in the re-establishment of normal frictional resistance between muscle bundles and the adjacent structures which helps to restore normal mobility [6]. Additionally, DCFM strength, as well as proprioception, are both incrementally improved by MM because it stimulates the articular receptors located in the capsuloligamentous structure [7].

There is currently no agreed-upon treatment guideline in the literature for adults categorized as having CMNP, despite ongoing studies into this condition [8]. Different treatment protocols were used for CMNP. Nevertheless, strong evidence is lacking to support the utilization of numerous of these treatment approaches for neck pain [9].

Several researchers studied the impact of DCFMT and MM on pain, proprioception, and CVA in adults having CMNP; however, the effect of these studies can't be generalized as they were limited to a small sample size and according to a within-group impact while there was no comparison with a control group [10–13]. Also, up to date, the literature lacks a comparison study between the MM and DCFMT and regarding pain, proprioception, and CVA, there is not sufficient evidence in the literature that either MM or DCFMT is better in adults with CMNP. In addition, their effects on upper cervical angle (C0–C2) have not been studied.

Therefore, the current study aimed to investigate the additive effect of MM versus DCFMT to conventional physical therapy on proprioception, pain, cranio-vertebral angle (CVA), and upper cervical angle (C0–C2) in adults with chronic mechanical neck pain (CMNP).

## Material and methods

### Design and setting

The current study was a randomized controlled study design. participants were selected from outpatient clinics of faculty of physical therapy at Cairo and Suez universities. The clinical practice of therapeutic programs and the physical evaluation of participants were carried out in the Faculty of Physical Therapy of Cairo University in the period from November 2022 to July 2023. The Ethical Committee for Human Research at the Physical Therapy Faculty approved the present study (reference number P.T. REC/012/003925). Every participant understood the purpose, and the benefits of the study, that they were able to withdraw at any time moment, and that their personal information would be kept secret. Prior to participating, a formal consent form was executed. The study was entered into the Pan African Clinical Trials Registry under the following number: PACTR202211651838599.

### Participants

All referred adults with CMNP were examined if they were eligible to take part in this study. Sixty adults were chosen according to the study inclusion criteria including those between the ages of 18 to 45 years old with cervical pain that should be persistent greater than 3 months in duration when diagnosed by a physician. adults were excluded from the study if they experienced Dizziness syndrome, post-traumatic whiplash, cervical pain caused by neural conditions, cervical neoplasm, pregnant women, adults who had speech and understanding problems, and a past history of neck surgery.

### Sample size and randomization

We made sure to calculate the sample size before we started the investigation so that we could prevent type II errors. We estimated the sample size using G*POWER statistical software (version 3.1.9.6, Dusseldorf, Germany) according to the following parameters: [post-hoc-MANOVA: Repeated measures, within-between interaction, 0.45 effect size, 20% beta error, as well as a two-sided 0.05 alpha error] to determine if there were at least 20 mm of clinically significant differences in pain intensity among the groups. The effect size was determined by using pilot research with 5 volunteers in each group and as a reserve for any dropout, the size was raised by 15% to 60 individuals from the original predicted sample size of 51 participants. Sixty adults were divided evenly into three groups at random. The author who created the randomization was not involved in the data collection process. To remove the potential for bias and reduce the variance between the groups, a computer-generated block randomization with block sizes between 6 and 9 was used during the study. Participants were randomized using sealed, numbered, sequential envelopes. Then the treating author began by opening the envelopes and then continued therapy in accordance with group classifications.

### Outcome measures

The assessor, who was blinded to the group allocation, assessed all outcome measures immediately before treatment began and immediately after a 4-week intervention.

- *Visual analog scale (VAS)* typically takes the form of a horizontal line that is 100 mm long; the left end of the line denotes "no pain" and the right end denotes "unbearable or severe pain". The patient indicates their current state of health by marking the point in the line which they feel best shows it. The VAS has good validity and test-retest reliability 0.95 [14].
- *Camera and Kinovea software*: one way to get distance and angle information from coordinates is via Kinovea, which is a free, valid, as well as reliable (both inter- and intra-rater raters) program. The camera is mounted on a stationary platform 1.5 m away from the patient. The subject's shoulder height served as the basis for adjusting the camera's height. The individuals had two markers implanted on their cervical regions: one at C7 and the other at the ear tragus for CVA and for (C0–C2) the markers implanted on their cervical regions: one at the base of the occiput *and* the other at the inferior base of C2. The patients were also told to keep their heads up and their bodies relaxed. After bringing up the picture in Kinovea, we calculated the angle between the horizontal line that went through C7 and a line that went from the tragus of the ear toward C7 for CVA, while for (C0–C2) angle was calculated between the foramen magnum plate and another line drawn at the inferior endplate of C2 [15, 16].
- *Cervical range of motion device (CROM)*: it was utilized to evaluate cervical proprioception. The CROM is attached to the wearer's head and contains three inclinometers, one for each plane of motion. The subject's shoulders are equipped with two magnets to enhance the accuracy of the compass meter, which measures rotation, along with two other gravity dial meters measuring flexion and extension. Reliability (ICC = 0.92–0.96) as well as criterion validity ($r$ = 0.89–0.99) were both demonstrated by the CROM device. The first test was the head-to-neutral head position (NHP) repositioning test. The adults were then instructed to turn the head, completely to their left and reposition back, (considered the starting point in a controlled fashion) without opening their eyes. When the participants reached the reference position, their relocation accuracy was measured in degrees with the CROM device. The second repositioning test was the head-to-target head position (THP) test. The investigator moved the participant's head slowly to the predetermined target position to 65% of the maximum range of motion. The speed of that motion was very slow. The head was maintained in the target position for 3 s, and the subject was asked to remember that position. The head was then brought to the neutral position, and the adults were asked to reposition actively by moving the head to the target position. When the participant reached the reference position, the participant's relocation accuracy was measured in degrees with a CROM device. Three trials were executed consecutively in each direction, and the average of the three trials was computed for the analysis [17].

### Intervention

The three groups of participants were all given a CPT.

- The Maitland group (I) was given MM Applying one of the following techniques: postero-anterior central vertebral pressure (PACVP), postero-anterior unilateral vertebral pressure (PAUVP), as well as transverse vertebral pressure (TVP). Technique choice was the treating author's own decision, according to examination findings. Grades 2 and 3 were used, where grade 2 is an oscillatory mobilization within the range but before the spine restriction range. Grade 3 is an oscillatory mobilization performed to the spine restriction range. Two or three oscillations were performed in a second for one to two minutes, with a 1-min interval between each pressure. The oscillations applied were PACVP and PAUVP. In PACVP, the participant lay prone while the treating author stood at the participant's head performing oscillatory mobilization directly by thumbs to the spinous process of the selected cervical segment. In postero-anterior unilateral vertebral pressure (PAUVP), the participant lay prone while the therapist stood at the patient's head performing oscillatory mobilization to the cervical articular (pilar) process for both sides by thumbs**,** and transversal vertebral pressure (TVP): the participant lied prone while the therapist stood at the participant's side to be treated while applying pressure with the thumbs on the side of the vertebrae's spinous process that requires treatment [18–22].

- The deep cervical flexors muscles training group (II) was given the DNFMT program. This program was composed of three exercises that re-training DCFM from three different positions: (a) crook lying position: inflatable air-filled pressure biofeedback sensor was placed over the suboccipital part on the back of the participant's neck with pressure 20 mmHg increased by 2 mmHg at every stage till 30 mmHg was reached in the final stage. Shifting the eye towards the flexion direction made the movement easier, 3 sets were performed (each set consisted of 10 repetitions and held for 10 s for with 5 s rest between each motion and 30 s among each set). (b) quadruped: the participant produced chin tuck and head retraction and lower cervical vertebrae until he felt tension across the posterior cervical musculature. The exercise was repeated three times with 30 s hold and 30 s rest in between. (c) standing: the participant leaned against the wall while maintaining the curvature of the waist and pelvic region and tucking the chin while maintaining a 5-mm thick notebook or book at the back of the head. The thickness of the book was changed according to the individual differences. There was a total of five sets of training, with a 1-min rest in each set [23–26].
- Control group (III) received the CPT program which included stretching exercises for the upper trapezius, levator scapulae as well as pectoralis muscles and Strengthening exercises for rhomboids, lower trapezius, and serratus anterior muscles [27, 28]. All details about CPT are presented in Supplementary 1.

### Statistical analysis

The data was tested for normality utilizing the Shapiro-Wilk test before analysis. The homogeneity of variances among groups was tested using Levene's test. There was homogeneity of variance, as well as the data, had normal distribution. In order to compare the groups based on the combined impact of all outcomes, a two-way mixed design MANOVA was employed. In order to prevent type I errors, we repeated the analyses with univariate ANOVAs for each outcome when the MANOVA was statistically significant. All statistical tests were set to have a significance level of $p < 0.05$. The statistical software for the social sciences (SPSS) version 25 for Windows was used for the statistical analysis (Fig. 1).

## Results

The baseline data as well as individual characteristics of groups A, B, and C were displayed in Table 1. When comparing the groups according to age, pain duration, or gender distribution, no statistically significant differences were found ($p > 0.05$). The results of the mixed MANOVA showed that the treatment and time variables interacted significantly (Wilk's $\Lambda = 0.059$, $F = 10.73$, $p = 0.001$, $\eta^2 = 0.75$). There was a significant main impact of time (Wilk's $\Lambda = 0.006$, $F = 550.75$, $p = 0.001$, $\eta^2 = 0.99$). There was a significant main impact of treatment (Wilk's $\Lambda = 0.245$, $F = 3.53$, $p = 0.001$, $\eta^2 = 0.51$).

### Between groups comparison

A significant decline was detected in the VAS of the DCFMT group when compared to that of the MM group ($p = 0.03$) and control group ($p = 0.001$); and a significant decrease in the VAS of the MM group when compared to that of the CPT group ($p = 0.009$).

A significant improvement was detected in CVA and a significant decline in C0–C2 of the DCFMT group when compared to that of the MM group ($p = 0.02$) and CPT group ($p = 0.001$); and a significant increase in CVA and a significant decrease in C0-C2 of MM group when compared to that of CPT group ($p = 0.02$).

A significant decline was detected in flexion, right and left bending in addition to right and left rotation JPE to target and PPE to neutral of the DCFMT group when compared to that of MM group ($p < 0.05$) and control group = 0.0001); and a significant decrease in flexion, right and left bending and right and left rotation JPE to target of MM group when compared to that of CPT group ($p < 0.05$). (Tables 2 and 3).

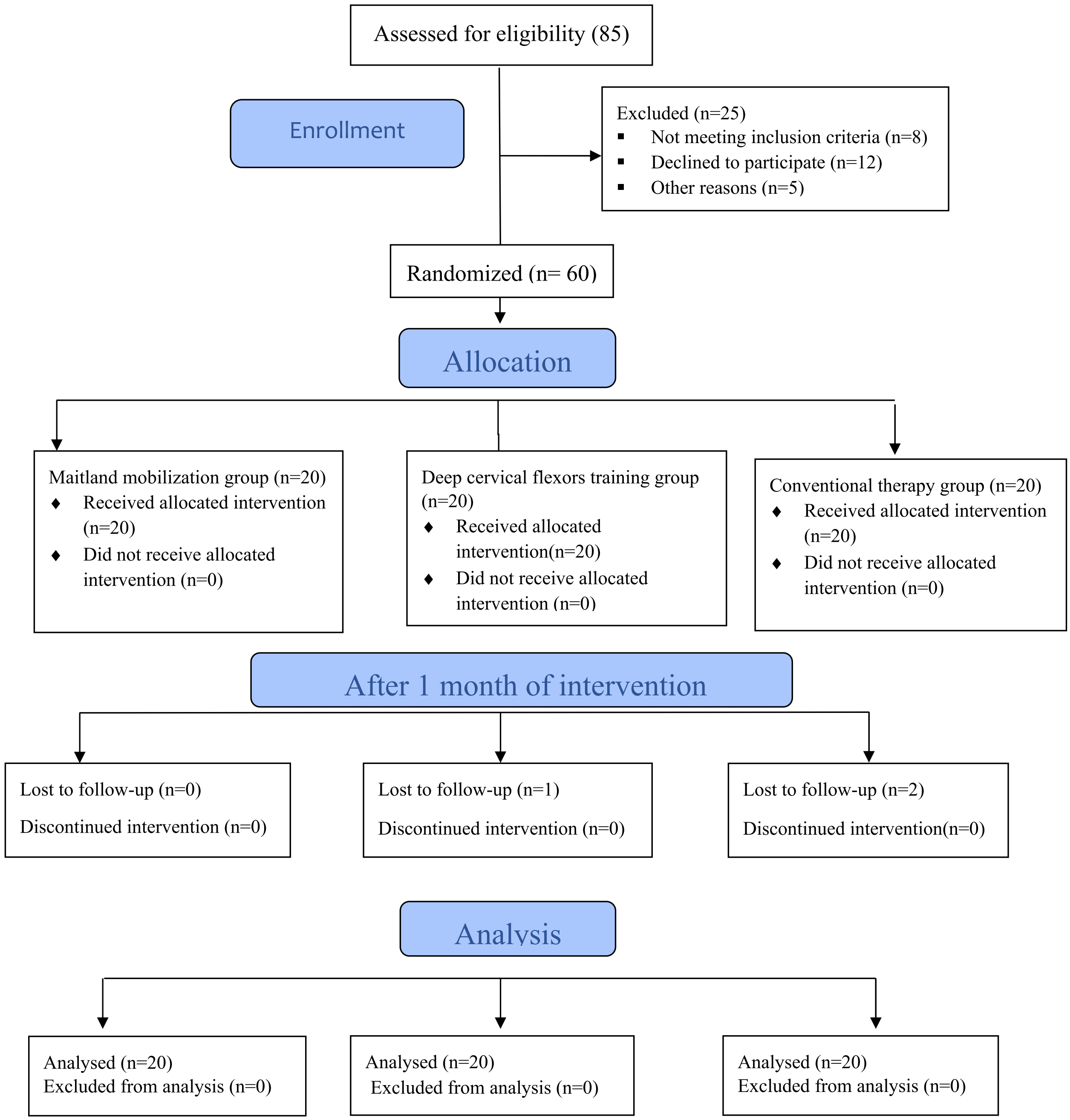


**Fig. 1** Participant flow chart

### Within group comparison

A significant decline was detected in VAS, C0–C2 angle, JPE to target, and JPE to neutral, and a significant improvement in CVA after treatment when compared to that before treatment in the MM group ($p > 0.001$), DCFMT group ($p < 0.001$), and CPT group ($p < 0.01$) (Table 4).

## Discussion

The current study aimed to test the effect of adding deep cervical flexors muscles training versus Maitland mobilization to conventional physical therapy programs on proprioception and pain intensity, craniovertebral angle (CVA), and upper cervical angle (C0–C2), in adults with chronic mechanical neck pain. The primary results of this study revealed that statistically significant differences

**Table 1** Demographic and baseline clinical characteristics of participants ($N = 60$)[a]

| | Group A ($n = 20$) | Group B ($n = 20$) | Group C ($n = 20$) |
|---|---|---|---|
| Age (years) | 24.25 ± 8.87 | 26 ± 9.64 | 25.35 ± 8.03 |
| Pain duration (month) | 14.25 ± 4.32 | 15.35 ± 5.52 | 15.45 ± 5.21 |
| Sex, *n* (%) | | | |
| Females | 11 (55%) | 9 (45%) | 13 (65%) |
| Males | 9 (45%) | 11 (55%) | 7 (35%) |
| VAS | 6.87 ± 1.26 | 7.15 ± 1.38 | 7.20 ± 1.39 |
| CVA (degrees) | 42.61 ± 4.36 | 42.24 ± 3.64 | 42.32 ± 4.81 |
| C0–C2 (degrees) | 24.25 ± 2.98 | 23.37 ± 1.94 | 24.95 ± 3.01 |
| JPE to target (degrees) | | | |
| Flexion | 7.54 ± 1.18 | 7.84 ± 1.15 | 8.16 ± 1.20 |
| Right bending | 6.87 ± 0.98 | 7.22 ± 0.83 | 7.37 ± 1.1 |
| Left bending | 7.28 ± 1.53 | 7.14 ± 1.38 | 7.02 ± 1.48 |
| Right rotation | 6.73 ± 0.85 | 7.18 ± 0.97 | 6.95 ± 1.16 |
| Left rotation | 6.76 ± 0.94 | 6.33 ± 1.15 | 6.84 ± 1.11 |
| JPE to neutral (degrees) | | | |
| Flexion | 7.06 ± 1.85 | 7.51 ± 1.93 | 7.73 ± 2.03 |
| Right bending | 5.57 ± 1.56 | 5.27 ± 1.38 | 5.32 ± 1.71 |
| Left bending | 6.08 ± 1.37 | 5.85 ± 1.21 | 5.97 ± 1.12 |
| Right rotation | 8.68 ± 1.48 | 9.09 ± 1.55 | 9.18 ± 1.62 |
| Left rotation | 7.87 ± 1.51 | 8.56 ± 1.77 | 8.70 ± 1.27 |

*Abbreviations*: *VAS* visual analog scale, *CVA* craniometrical angle, *C0–C2* upper cervical angle, *JPE* joint position error

[a] Data are mean ± SD

were detected between the three groups, favoring the DNFMT group, regarding CVA, upper cervical angle (C0–C2), pain intensity, JPE of flexion, right and left sides bending, in addition to right and left sides rotation outcome measures ($p < 0.05$). However, both DNFMT and MM had better improvements in all measured variables ($p < 0.05$) than the CPT group.

The results of the present study indicated enhancements in proprioception, as measured by CROM after the application of DNFMT in CMNP. Because DCFMs include a high concentration of muscle spindles, training DCFMs repeatedly by contracting them may enhance the function of these spindles, leading to enhanced cervical proprioception. Joints as well as other cervical components were subject to less stress following DCFMT improved neuromuscular control. A decrease in DCFM strength can cause excessive stress on joints, which in turn can disrupt the firing signals of cervical inputs and ultimately affect the amount of proprioceptive function [4].

The results of this study came in agreement with Mahto and Malla [10] compared the benefits of DCFMT utilizing pressure biofeedback with those of PNF exercises. The results of the study demonstrated that both approaches can be utilized separately to alleviate pain while correcting joint position errors, and there was no significant difference in the effects between the two groups. It should be noted that the study only included 20 participants, relied on a within-group effect, did not compare the adults to a control group and proprioception was measured by laser.

The results of this study showed enhancement in pain, as measured by VAS after the application of DCFMT in CMNP. One possible explanation for the alleviation of pain is the restoration of normal alignment and posture, which occurs when the DCFMs and the stabilizers on the back of the neck work together more effectively. This, in turn, reduces the probability of cervical injury. Activating DCFMs and reducing the activity of the sternocleidomastoid muscle led to a reduction in neck pain [29].

The results of this study were in accordance with Ashfaq and Riaz [30] stated that adults suffering from MNP showed better pain relief results with cranio-cervical flexion training by pressure biofeedback. It should be noted that the study only included 30 adults, relied on a within-group effect, and did not compare the participants to a control group.

The results of the present study indicated enhancement in CVA, as measured by Kinovea after the application of DCFMT in CMNP. Craniovertebral angle improvements can be attributed more specifically to the activation of DCFMs that alter the increased extension of the middle

**Table 2** Clinical characteristics of participants after 1 month of intervention ($N = 60$)[a]

| Outcome | Group A ($n = 20$) | Group B ($n = 20$) | Group C ($n = 20$) | *F* value | *p* value |
|---|---|---|---|---|---|
| VAS | 3.57 ± 1.07 | 2.8 ± 0.83 | 4.5 ± 0.94 | 15.930 | 0.001 |
| CVA (degrees) | 46.56 ± 4.08 | 49.83 ± 2.85 | 43.32 ± 4.47 | 14.217 | 0.001 |
| C0-C2 (degrees) | 21.55 ± 2.84 | 19.23 ± 2.18 | 23.89 ± 2.90 | 15.363 | 0.001 |
| JPE to target (degrees) | | | | | |
| Flexion | 3.62 ± 0.91 | 2.86 ± 0.77 | 4.35 ± 0.91 | 14.601 | 0.001 |
| Right bending | 3.02 ± 0.65 | 2.31 ± 0.92 | 3.72 ± 0.81 | 15.445 | 0.001 |
| Left bending | 3.05 ± 0.68 | 2.24 ± 0.81 | 3.93 ± 0.96 | 20.811 | 0.001 |
| Right rotation | 3.01 ± 0.58 | 2.27 ± 0.64 | 3.64 ± 0.88 | 18.445 | 0.001 |
| Left rotation | 2.80 ± 0.56 | 2.13 ± 0.66 | 3.33 ± 0.62 | 19.006 | 0.001 |
| JPE to neutral (degrees | | | | | |
| Flexion | 3.96 ± 0.78 | 2.66 ± 1.03 | 5.23 ± 1.52 | 24.642 | 0.001 |
| Right bending | 2.69 ± 0.89 | 1.95 ± 0.78 | 3.63 ± 0.95 | 17.921 | 0.001 |
| Left bending | 2.56 ± 0.64 | 1.89 ± 0.82 | 3.23 ± 0.85 | 14.867 | 0.001 |
| Right rotation | 3.52 ± 1.04 | 2.67 ± 0.91 | 5.59 ± 1.14 | 42.423 | 0.001 |
| Left rotation | 3.88 ± 0.87 | 3.01 ± 0.61 | 4.58 ± 0.82 | 20.916 | 0.001 |

*Abbreviations*: *VAS* visual analog scale, *CVA* craniometrical angle, *C0–C2* upper cervical angle, *JPE* joint position error, *p* probability value, $p < 0.05$ indicates statistical significance

[a] Data are mean ± SD

cervical spine owing to their muscular attachments. Training the craniocervical flexors has the potential to enhance forward head posture (FHP) in adults suffering from neck pain by eventually modifying the cervical vertebrae's lordosis [31].

This finding agreed with Malik et al. [11] studied the impacts of the suboccipital muscle inhibition technique as well as craniocervical flexion exercise for MNP. The results suggested that the Suboccipital muscle inhibition technique and craniocervical flexion exercises were equally efficient techniques for improving cranio-vertebral angle in adults with MNP. Nevertheless, the study had a small sample size (28 participants), they did not involve a control group for comparison, and the treatment was performed for 8 sessions only.

The findings of this study revealed improvements in upper cervical (C0–C2) angle, as measured by Kinovea after the application of deep cervical flexors training in CMNP. In DCFM activation as the subject retracts the chin a decrease occurs in the anterior head offset [C0–C7, the cervical sagittal vertical axis (SVA)], reducing C1–C2 hyperextension in addition to stretching the tightened sub-occipital muscles. The cervical sagittal vertical axis (SVA) reduction is consistent with the reduction of the hyperextension in the C2–C7 segments [32].

The results of this study were in line with Lin et al. [33] who correlated the presence of cervical flexors and cervical extensor muscle weakness to the malignment changes that happen to cervical segments affecting (C0–C2) angle. Therefore, that study emphasized the importance of maintaining the balance between cervical flexors and extensor muscle strength. However, that was a different study design (correlational design).

On the other hand, the current study findings showed dissimilarity with Shah and Shukla [34] revealing that there was no statistically significant difference among craniocervical flexion training as well as traditional physical therapy group in pain and cervical proprioception. However, the reasons for these conflicting results may include the small sample size (26 participants) and the proprioception measured by Sensamove software.

The current study revealed that MM improved proprioception, as measured by CROM in adults with CMNP. It was determined that stimulating the proprioceptors within the cervical muscles as well as joints was responsible for the enhancement in proprioception. The proprioception, vestibular, as well as visual systems' sensory discrepancy, is reduced as a result of this stimulation, which normalizes the abnormal afferent inputs [35].

The results of this study were supported by Sachdeva et al. [12] who compared the effectiveness of first rib MM as well as muscle energy technique on pain along with head position sense in adults with CMNP. Both groups improved significantly in favor of MET. However, that was limited to a small sample size (40 participants), there was no control group for comparison and MM was performed on the first rib.

The current study revealed that MM improved pain, as measured by VAS in adults with CMNP. Various biomechanical, neurophysiological, as well as psychological factors may contribute to the alleviation of pain. The use of MM reduces temporal summation and raises the threshold for pain caused by remote pressure. Supraspinal areas that process central pain are also less activated after MM [36].

The results of this study were supported by Al Shehri et al. [37] performed a comparative study of Mulligan (SNAGs) versus MM in neck pain. The result recommended that both SNAG and MM enhanced neck pain favoring MM. The most effective treatment for neck pain, according to the results, is a combination of traditional therapy and MM, not SNAGs alone. However, there was no control group comparison, therefore the findings depended on within-group effects.

**Table 3** Between groups effects after 1 month of intervention

| Outcome | Group A vs B MD (95% CI) | *p* value | Group A vs C MD (95% CI) | *p* value | Group B vs C MD (95% CI) | *p* value | Partial eta square |
|---|---|---|---|---|---|---|---|
| VAS | 0.77 (0.04, 1.50) | 0.03 | – 0.93 (– 1.65, – 0.19) | 0.009 | – 1.7 (– 2.42, – 0.97) | 0.001 | 0.359 |
| CVA (degrees) | – 3.27 (– 6.22, – 0.33) | 0.02 | 3.24 (0.30, 6.18) | 0.02 | 6.51 (3.57, 9.46) | 0.001 | 0.333 |
| C0-C2 (degrees) | 2.32 (0.29, 4.35) | 0.02 | – 2.34 (– 4.37, – 0.32) | 0.02 | – 4.66 (– 6.69, – 2.64) | 0.001 | 0.350 |
| JPE to target (degrees) | | | | | | | |
| Flexion | 0.76 (0.09, 1.41) | 0.02 | – 0.73 (– 1.39, – 0.07) | 0.02 | – 1.49 (– 2.14, – 0.82) | 0.001 | 0.339 |
| Right bending | 0.71 (0.1, 1.32) | 0.01 | – 0.7 (– 1.31, – 0.08) | 0.02 | – 1.41 (– 2.02, – 0.79) | 0.001 | 0.351 |
| Left bending | 0.81 (0.17, 1.43) | 0.009 | – 0.88 (– 1.51, – 0.25) | 0.004 | – 1.69 (– 2.31, – 1.05) | 0.001 | 0.422 |
| Right rotation | 0.74 (0.19, 1.28) | 0.005 | – 0.63 (– 1.18, – 0.08) | 0.01 | – 1.37 (– 1.92, – 0.82) | 0.001 | 0.393 |
| Left rotation | 0.67 (0.19, 1.13) | 0.003 | – 0.53 (– 1, – 0.06) | 0.02 | – 1.2 (– 1.67, – 0.73) | 0.001 | 0.400 |
| JPE to neutral (degrees) | | | | | | | |
| Flexion | 1.3 (0.42, 2.18) | 0.002 | – 1.27 (– 2.14, – 0.38) | 0.003 | – 2.57 (– 3.45, – 1.68) | 0.001 | 0.464 |
| Right bending | 0.74 (0.06, 1.41) | 0.02 | – 0.94 (– 1.61, – 0.26) | 0.004 | – 1.68 (– 2.34, – 0.1) | 0.001 | 0.386 |
| Left bending | 0.67 (0.07, 1.25) | 0.02 | – 0.67 (– 1.26, – 0.08) | 0.02 | – 1.34 (– 1.93, – 0.74) | 0.001 | 0.343 |
| Right rotation | 0.85 (0.07, 1.64) | 0.03 | – 2.07 (– 2.85, – 1.28) | 0.001 | – 2.92 (– 3.71, – 2.14) | 0.001 | 0.598 |
| Left rotation | 0.87 (0.28, 1.46) | 0.002 | – 0.7 (– 1.29, – 0.11) | 0.01 | – 1.57 (– 2.16, – 0.1) | 0.001 | 0.423 |

*Abbreviations*: *VAS* visual analog scale, *CVA* craniometrical angle, *C0–C2* upper cervical angle, *JPE* joint position error, *MD* mean difference, *CI* confidence interval; *p* probability value. $p < 0.05$ indicates statistical significance.

**Table 4** Within groups changes pre-1 month of intervention

| Outcome | Group A MD (95% CI) | *p* value | Group B MD (95% CI) | *p* value | Group C MD (95% CI) | *p* value |
|---|---|---|---|---|---|---|
| VAS | 3.3 (2.82, 3.78) | 0.001 | 4.35 (3.9, 4.8) | 0.001 | 2.7 (2.2, 3.2) | 0.001 |
| CVA (degrees) | – 3.95 (– 4.52, – 3.39) | 0.001 | – 7.59 (– 8.2, – 7) | 0.001 | – 1 (– 1.6, – 0.4) | 0.001 |
| C0–C2 (degrees) | 2.7 (2.24, 3.16) | 0.001 | 4.14 (3.7, 4.6) | 0.001 | 1.06 (0.6, 1.5) | 0.001 |
| JPE to target (degrees) | | | | | | |
| Flexion | 3.92 (3.43, 4.42) | 0.001 | 4.98 (4.5, 5.5) | 0.001 | 3.81 (3.3, 4.3) | 0.001 |
| Right bending | 3.85 (3.38, 4.33) | 0.001 | 4.91 (4.4, 5.4) | 0.001 | 3.65 (3.2, 4.1) | 0.001 |
| Left bending | 4.23 (3.63, 4.84) | 0.001 | 4.9 (4.3, 5.5) | 0.001 | 3.09 (2.5, 3.7) | 0.001 |
| Right rotation | 3.72 (3.28, 4.17) | 0.001 | 4.91 (4.5, 5.4) | 0.001 | 3.31 (2.9, 3.7) | 0.001 |
| Left rotation | 3.96 (3.49, 4.43) | 0.001 | 4.2 (3.7, 4.7) | 0.001 | 3.51 (3, 4) | 0.001 |
| JPE to neutral (degrees) | | | | | | |
| Flexion | 3.1 (2.29, 3.90) | 0.001 | 4.85 (4, 5.6) | 0.001 | 2.5 (1.7, 3.3) | 0.001 |
| Right bending | 2.88 (2.39, 3.38) | 0.001 | 3.32 (2.8, 3.8) | 0.001 | 1.69 (1.2, 2.2) | 0.001 |
| Left bending | 3.52 (3, 4.05) | 0.001 | 3.96 (3.4, 4.5) | 0.001 | 2.74 (2.2, 3.3) | 0.001 |
| Right rotation | 5.16 (4.38, 5.94) | 0.001 | 6.42 (5.7, 7.2) | 0.001 | 3.59 (2.8, 4.4) | 0.001 |
| Left rotation | 3.99 (3.42, 4.57) | 0.001 | 5.55 (5, 6.1) | 0.001 | 4.12 (3.5, 4.7) | 0.001 |

*Abbreviations*: *VAS* visual analog scale, *CVA* craniometrical angle, *C0–C2* upper cervical angle, *JPE* joint position error, *MD* mean difference, *CI* confidence interval, *p* probability value, $p < 0.05$ indicates statistical significance

The current study revealed that MM improved craniovertebral angle, as measured by Kinovea in adults with CMNP. Craniovertebral angle improvements can be attributed to explained by central as well as unilateral P-A pressure from C1-T3 producing longitudinally directed force vector and rotational force vector might respectively. The capsuloligamentous structure contains articular receptors that, when stimulated, cause DCFMs' motor activity along with the strength to gradually improve [7].

The results of this study were supported by Kim and Kim [13] studied the immediate effect of Maitland mobilization on particular spine levels in adults with MNP and FHP. The results showed improvement in cervical alignment (CVA) in adults with MNP (with FHP) in both groups with favor to mobilization at the cervicothoracic junction. However, that study was restricted to a limited sample size (22 participants) and the intervention was for single sessions only.

This study demonstrated that MM enhanced the upper cervical (C0–C2) angle, as measured by Kinovea in adults with CMNP. Joints of the pivotal (atlanto-axial) as well as very mobile saddle (occipito-cervical) types that form the upper cervical C0–C2 angle have a direct correlation between the reduction of sub-axial cervical vertebrae movement and an increase in occipital-cervical movement [38]. Mobilizing a joint involves manually stretching the capsuloligamentous tissue encircling it to its ideal length, which removes the inhibitory impact of the orthokinetic reflex upon the muscles around the joint. Perhaps this explains why motor activity and joint mechanics have improved [8].

This study's results corroborated those of Kawasaki et al. [39], who examined the relationship between the cervical vertebrae alignment shown on radiographs and the cranial angles captured in photographs. When the upper cervical spine is extended, the cranial rotation angle (CRA) as well as the CO–C2 angle are bigger, but when the spine is flexed, they decrease. Furthermore, objective comparisons are made through the evaluation of head and neck alignment to guarantee the efficacy of therapy. However, that was a different study design (correlational study design).

On the contrary, the study findings are in contradiction with Fredin and Lorås [40] conducted a systematic review that concluded that a combination of manual therapy and exercise didn't appear to be more beneficial than exercise alone in alleviating CMNP at rest, neck disability as well as quality of life. This contradiction might be because the manual therapy included in the review was not Maitland mobilization only, as heterogeneity of studies included spinal manipulative therapy (SMT), Mulligan and Maitland mobilization, massage as well as traction.

### Study limitations

The current study was constrained by a limited sample size; hence, the study results require evaluation in a larger sample. Also, a follow-up assessment was not conducted, and the treatment only lasted four weeks, which is a short period of time. As a result, additional studies should examine the long-term impact of the intervention and follow-up. Furthermore, because of the nature of the study, it was not possible to make the therapist, or the participant blinded.

### Clinical implementation

Deep cervical flexor muscle training and MM can be safely applied in adults with CMNP. Also, they may have additional positive effects on motivating the adults to participate in the rehabilitation process. Moreover, these therapies should be considered in the rehabilitation of CMNP adults due to their ease of execution and inexpensive cost in clinical practice.

### Clinical messages

- Deep cervical flexor muscle training has significant improvements to MM on proprioception, pain, craniovertebral angle (CVA), and upper cervical angle (C0–C2), intensity in adults with CMNP. Deep cervical flexor muscle training has significant improvements to MM on proprioception, pain, craniovertebral angle (CVA), and upper cervical angle (C0–C2), intensity in adults with CMNP.
- Either, MM or DCFMT is better than CPT on proprioception, pain, craniovertebral angle (CVA), and upper cervical angle (C0–C2), intensity in adults with CMNP.

### Abbreviations

| | |
|---|---|
| CMNP | Chronic mechanical neck pain |
| CNP | Chronic neck pain |
| CPT | Conventional physical therapy |
| CROM | Cervical range of motion |
| CVA | Craniovertebral angle |
| DCFM | Deep cervical flexors muscles |
| DNFM | Deep neck flexors muscles |
| DNFMT | Deep neck flexors muscles training |
| Fig | Figure |
| JPE | Joint position error |
| MM | Maitland mobilization |
| MNP | Mechanical neck pain |
| RCTs | Randomized control trials |
| SD | Standard deviation |
| VAS | Visual analog scale |

## Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s43161-024-00200-y.

Supplementary Material 1: Details of conventional physical therapy exercises treatment.

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### Authors' contributions

FS, NM, and BS contributed to the design of the study, acquisition, analysis, or interpretation of data for the article. FS NM, and BS revised it critically for important intellectual content. The authors read and approved the final manuscript.

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**Availability of data and materials**
The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

## Declarations

**Ethics approval and consent to participate**
Before beginning the study, ethical approval was given by the Ethical Committee of the Faculty of Physical Therapy, Cairo University, Cairo, Egypt. (NO: P. T. REC/012/003925) After all participants were given a full explanation of the study protocol, before taking part in the study, they were given an informed consent form to sign.

**Consent for publication**
Not applicable.

**Competing interests**
The authors declare that they have no competing interests.

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