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Efficacy of Mulligan on electromyography activation of cervical muscles in mechanical neck pain: randomised experimental trial

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Abstract

Introduction. The aim of this trial is to determine the efficacy of the Mulligan mobilisation technique on electromyography activation of cervical muscles, pain, and function in chronic mechanical neck pain.

Methods. Ninety subjects of both sexes (44 females and 46 males) who were diagnosed with chronic mechanical neck pain by a physician and referred to the clinic of physiotherapy participated in this randomised controlled trial. The subjects were randomly allocated to two groups: group A, which is the experimental group, received the Mulligan technique combined with conventional therapy, and group B, which is the control group, received conventional therapy only. The two groups were given the treatment three times a week for four weeks. In this trial, muscle activity, pain and function were measured using electromyography, the visual analogue scale and the Arabic neck disability index, respectively, and measured before and after the 12 sessions of the treatment.

Results. MANOVA was used to detect the effect of treatment and time on all measured variables, which revealed a statistically significant effect ($p < 0.05$) in treatment and time in both groups.

Conclusions. Mulligan has a positive effect on muscle activity, pain and function in subjects with mechanical neck pain in excess of conventional therapy alone.

Key words: cervical muscles, mechanical neck pain, Mulligan method, electromyography

Introduction

Neck pain (NP) is one of the most common musculoskeletal problems prevalent among people worldwide, enforcing an economic burden on both society and people who are in pain [1]. The prevalence of NP is around 40%, varying from 17% to 75% of the adult population [2]. Even with such a broad prevalence of NP and its apparent impact on people, rehabilitation is still a daily challenge [3]. There are different variables, such as emotional disorder, trauma, and postural deformity, which play a crucial role in the growth of mechanical neck pain (MNP) [4]. Even though the pathology of MNP is not well known, it is assumed to be related to a wide range of spinal structures, which include muscles, disks, zygapophyseal joints, ligaments, and nervous tissue [5].

Variation in the behaviour of cervical muscles and alternation in muscle function have been reported in patients with MNP when compared with healthy persons in several studies using electromyography (EMG) [6, 7]. Altered coordination of their function influences the mechanical loading of cervical structures, leading to pain provocation [7]. Also, the muscles become a site of pain when they become weak or fatigued [8]. A contrasting opinion has also been reported that the onset of neck pain may lead to altered muscle activity [9]. Whatever the direction of cause and effect, such muscle activity is vital in the treatment of MNP. Some researchers have suggested that the amplitude of the myoelectric signal may provide some insight into the pain-spasm pain theory of musculoskeletal dysfunction [10].

Grase et al. [11] reported that the subjects with MNP had an increase in the root mean square (RMS) of the upper trapezius (UT), cervical erector spinae (CES), sternal head of sternocleidomastoid (SCM), and anterior scalene (AS) muscles than subjects with non-MNP. It was also reported that pain and disability increased in subjects with MNP compared with those who did not have MNP [11]. In the same line, Kumar and Prasad [6] investigated the EMG signals from all cervical muscles during movement in all directions in both healthy and patients with neck pain and reported that the patients with neck pain showed differences in muscle activity at 20%,60% and 100% of maximal voluntary isometric contraction.

There are many ways of treating MNP, such as manual therapy modalities; massage, manipulation and traction; electrotherapy modalities in the form of transcutaneous electrical nerve stimulation, high-voltage, ultrasound, LASER and magnetic stimulation. Also, medical therapy and exercises in the form of craniocervical flexion, neck stabilisation, proprioception, stretching and strengthening exercise [12, 13]. However, no final multi-model program has been developed for MNP. Therefore, many trials are needed to investigate the role of different treatment protocols [14]. Mobilisation therapy (Mulligan sustained natural apophyseal glides (SNAGs)) therapy has been reported to show better results in the treatment of MNP in terms of correcting the alignment of the zygapophyseal joints, reducing pain, and improving neck function [14–18]. In addition, Ali et al. [19] reported the role of The Mulligan technique in patients with non-specific neck pain on pain, function, range of motion, flexion, and extension and erector spinae muscle activity by electromyography and found a significant effect on time in all variables. However, there has been no clinical trial that studied the efficacy of Mulligan SNAGs on specific muscle activity using electromyography during functional position, hence this trial was conducted.

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Subjects and methods

Study design

The pre–post single-masking randomised experimental trial was conducted according to the Declaration of Helsinki (1964) and the guidelines of the Consolidated Standards of Reporting Trials (CONSORT) [20]. The sample (100 subjects) was randomly selected from an accessible sample in the outpatient clinic at the Faculty of Physical Therapy. Ten subjects were excluded because they had received treatment in the past three months (Figure 1). In total, 90 subjects (44 females and 46 males) signed the consent form that was accepted by the College of Physiotherapy and were randomly allocated to two equal groups. Subjects in group A received Mulligan SNAGs plus conventional therapy three times a week for four weeks, while those in group B received conventional therapy alone three times a week for four weeks.

Sample-size framework

The sample-size value was identified using G*Power (Franz Faul, Uni Kiel, Germany) (version 3.1.9.2). For *t*-test, the type I error rate was at 5% ($\alpha = 0.05$) and the primary outcome effect size (pain level) was 0.67, which was attained from a pilot study of 10 subjects, and the power was at 0.8. For this trial, the most appropriate total sample size was of 72 subjects; 36 subjects in each group.

Subjects

The subjects from both sexes were enrolled in this trial if they had experienced pain in the posterior or posterior lateral aspect of the neck in the last three months, and their ages ranged from 18 to 30 years [21]. The subjects were excluded if they had any spinal surgery, trauma, infection, or treatment in the past three months, radiating pain in an upper limb, fibromyalgia, or any visual disorder [21]. The trial was conducted in the Electromyography Laboratory at the College of Physiotherapy from the end of June 2020 to the end of January 2021.

Program of intervention

Subjects in groups A and B received conventional therapy (three times per week for four weeks) in the form of application of a hot pack for 15–20 minutes at the back of the neck [30], Then they performed isometric strengthening exercises for all cervical muscles by applying resistance on the side of the head for side bending, the forehead for flexion, and the occiput for extension [31]. The resistance was continued for 10 seconds and repeated for 10–15 times [31], then they performed a stretching exercise for the flexor, extensor, side flexor, and rotators for 30 seconds and repeated these three times in every session [32]. Finally, they performed an active range of motion exercise for the neck and shoulders, a chin tuck and a scapula retraction exercise [33].

SNAGs for group A

Before applying the SNAGs, each subject was assessed to determine the comparable sign in the form of limited range or pain.

1. Limited flexion or extension: The subject was seated on a chair in an upright position, and the researcher stood behind the subject. The medial border of the distal phalanx of the right thumb was positioned at the spinous processes, and the back of the left thumb reinforced the right thumb.

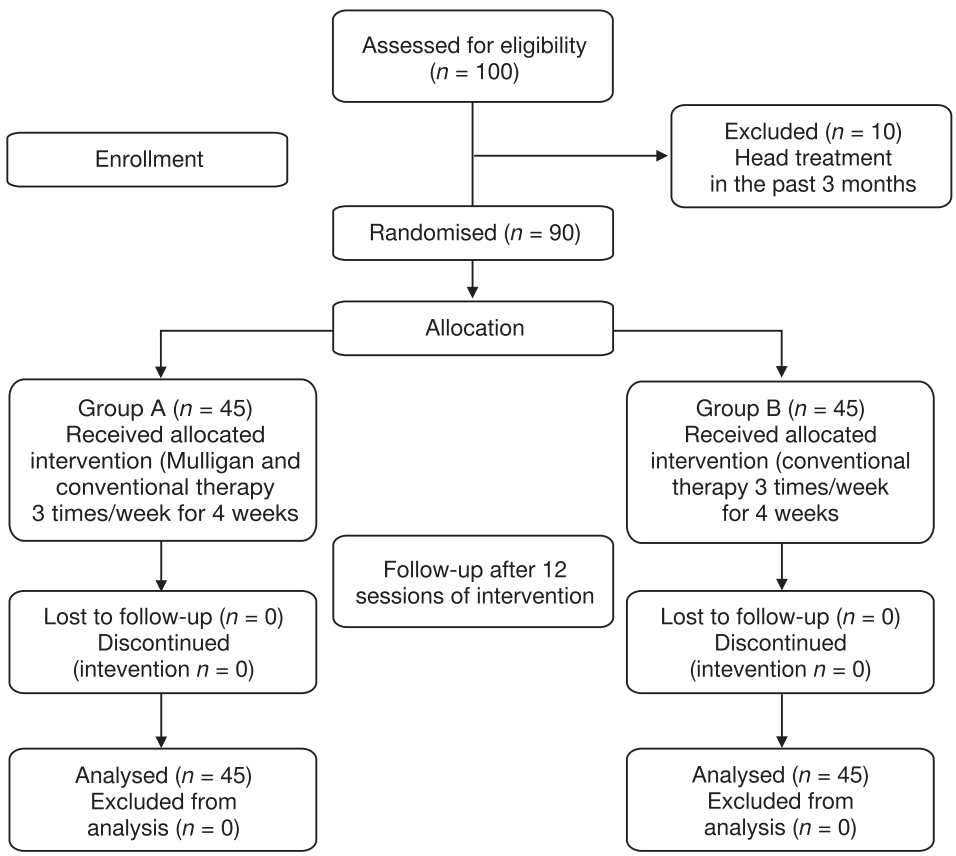

Figure 1. CONSORT flow chart

The mobilization was applied centrally from the direction of the facet joint toward the eyeball. While maintaining the glide, the subject was instructed to perform active flexion or extension and at the end of the range apply over pressure, and then return to the starting position. Then determine which range had a limitation or pain [14].

2. Limited rotation or side bending: The subject was seated on a chair in an upright position, and the researcher stood behind the subject. The medial border of the distal phalanx of the right thumb was positioned at the posterior part of the facet and the back of the left thumb reinforced the right thumb. The glide was applied laterally from the direction of the facet joint toward the eyeball. While maintaining the glide, the subject was instructed to perform active side bending or rotation towards the painful side and apply over the pressure at the end of the range and then to return to the starting position. Then determine which range had a limitation or pain. SNAGs were applied as three sets; each set contained 10 repetitions in every session [14].

Outcome measures

Outcome assessments were carried out before the start of the first session and after the end of the last (12th) session.

Muscle activation (primary outcome)

Neurosoft's electromyogram device (Neuro-EMG-Micro, Neurosoft, Ivanovo, Russia) assessed myoelectric activity in the form of root mean square. This procedure squares each signal value to create an average and then calculates the square root. The RMS value depends on the area, number, and rate of firing of the potential motor unit action. The RMS value of the EMG signal is considered the most reliable parameter and a good estimator of the degree of muscle activation [25]. The EMG signals of systemic bias were eliminated and the full wave was rectified before filtering. The resulting linear envelope signals were then normalised to maximal voluntary isometric contractions (MVICs).

Preparation of subjects

1. The skin over each muscle and around the wrist joint of the subject was carefully cleaned with alcohol [26]. The device contains two different electrode types: two recording electrodes at each muscle and one ground electrode at the wrist joint. The recording electrodes were placed 2 cm laterally from the centre of the line drawn between the spinous process of the C7 and the posterior lateral acromion and fixed by self-adhesive tape [26] (Figure 2). For the CES muscle, the recording electrodes were placed at the C2 level just at the edge of the trapezius muscle [27] (Figure 3).

For the sternal head the of SCM muscle, the recording electrode was fixed at the sternal head [28] (Figure 4). Finally, in the (anterior scalene) AS muscle, the recording electrode was fixed posterior to the clavicular head of the SCM muscle [27] (Figure 5).

Assessment of MVIC

Normalisation was applied by performing maximum voluntary isometric contraction. For UT, the arm was abducted at 90° from a sitting position and resistance was applied proximal to the elbow joint [26] and for CES, in a prone lying position, the subject was asked to raise their head 20 mm while the physiotherapist held it isometrically [27].

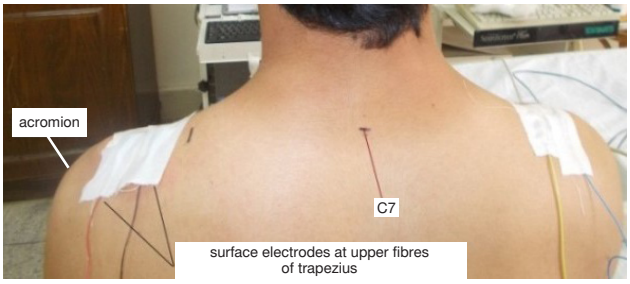

Figure 2. Recording electrode of UT

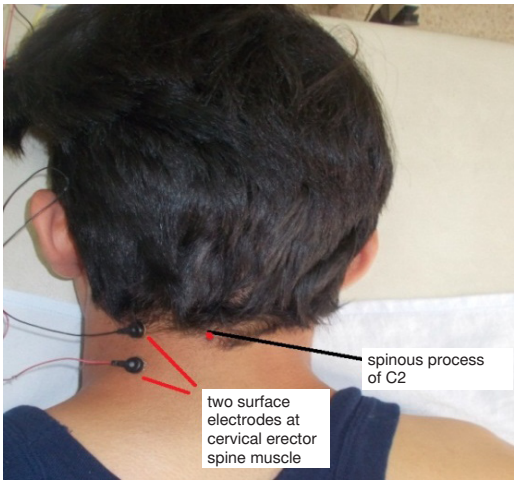

Figure 3. Recording electrodes for CES

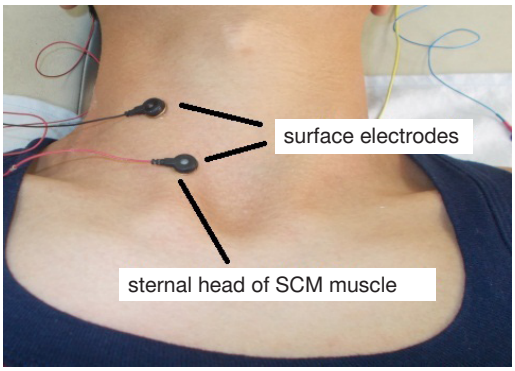

Figure 4. Recording electrode for SCM

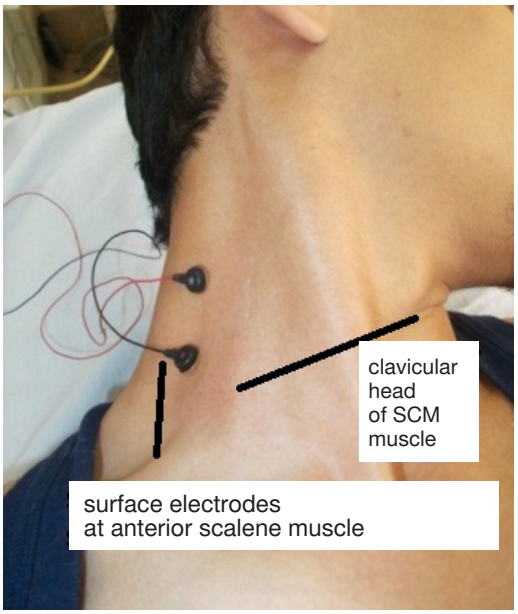

Figure 5. Recording electrode for AS

For both the SCM and AS muscles, the subject was asked to raise his/her head from a supine lying position while the physiotherapist held it isometrically [27, 28].

Isometric contraction was applied three times, with each contraction maintained for 7 seconds and with a 30-second rest between contractions.

Assessment of muscle activity

After the evaluation of the MVIC, patients were told to write for 15 minutes while sitting. This task was selected because it is the most common everyday task for participants and requires a semi-static load that aggravates their symptoms [25]. During assessment, the position of the head, neck, shoulder and spine were standardised to avoid having an impact on the movements of the examined muscles. The patients were advised to sit naturally on a flat, horizontal wooden chair with a backrest. The chair height was calibrated to guarantee that the participant's thighs were horizontal, parallel to the surface and their feet were placed shoulder width apart and well balanced. Normalised values were calculated as follows: Normalised RMS % = EMG amplitude during activity/(average of EMG_{MAX} for the three trials) × 100 [29].

Pain intensity (primary outcome)

The assessment was carried out using visual analogue scale VAS, which is a valid and reliable tool for measuring pain. It consists of a 10 cm line, where one end represents no pain and the other end represents the worst pain. Each subject was requested to add a dot on the line that defines their pain level [22].

Disability (secondary outcome)

The Arabic version of the Neck Disability Index (ANDI) was used to assess the functional ability of the neck. It is a valid and reliable tool consisting of 10 items with six choices each (0–5) [23, 24]. Each subject was requested to choose the best choice for his/her case. The numbers were collected and the level of disability calculated. There is no disability for scores from 0 to 4; 5–14 is mild; 15–24 is moderate; 25–34 is severe, and finally, more than 34 represents complete disability [23].

Randomisation and blinding

Dependent variables were assessed at baseline and after four weeks by an assessor blinded to the treatment allocation. Subjects were randomly selected to undergo Mulligan and conventional therapy (experimental group) or conventional therapy only (control group). The concealed distribution was carried out using a computer-generated randomised table of numbers developed by a researcher who did not participate in either selecting or handling subjects before the start of data collection. Individually, sequentially numbered index cards were folded and inserted into sealed, opaque envelopes containing the randomly selected intervention group. Blinded to the baseline test results, a second therapist opened the envelope and started the therapy according to the group assignment. The intervention was given to all patients on the day of the initial examination.

Statistical analysis

The dataset was evaluated using the Shapiro-Wilk test to evaluate its normality. All the data (age, weight, height, body mass index (BMI), RMS, VAS and ANDI) were normally distributed. Therefore, the parametric *t*-test was used to detect the differences between physical characteristics (age, weight, height, and BMI) of the subjects of both groups, the chi-squared (χ^2) test was used for sex distribution, and MANOVA was used to detect the differences between time and treatments for all variables between the subjects of both groups. SPSS version 23 (IBM Corp, New York, United States) was used to investigate the results of this trial and the α value was considered to be 0.05.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Ethical Review Committee of the College of Physiotherapy (approval No.:P.T.REC/012/002643). This trial was documented in the Pan African Clinical Trials Registry (PACTR 202005715810295).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

Physical characteristics of subjects

An unpaired *t*-test was used to determine the differences between the two groups in terms of age, weight, height, and BMI, and no statistically significant difference was found between groups. In the χ^2 test too, no statistically significant difference was found between males and females of both groups (Table 1).

Table 1. Physical characteristics of subjects

	Group A (mean ± *SD*)	Group B (mean ± *SD*)	*t*-value	*p*-value
Age (years)	26.6 ± 2.5	26.9 ± 3.05	–0.06	0.94[a]
Weight (kg)	65.4 ± 11.2	65.6 ± 9.7	–0.07	0.94[a]
Height (cm)	163.8 ± 6.3	163.5 ± 8.1	0.12	0.90[a]
BMI (kg/m^2)	24.3 ± 3.9	24.5 ± 3.4	–0.19	0.85[a]
Sex (male/female)	24 /21	22 /23	χ^2 = 1.77	0.67[a]

BMI – body mass index
[a] – no significant difference between groups

Results of VAS, ANDI, and RMS amplitude

MANOVA was conducted to determine the effect of the treatment on all variables in general, and it was found that there were significant effects of the treatment (p = 0.0001, f = 34.83) and time (p = 0.0001, f = 67.43). Moreover, for the interaction between time and treatment, there was a significant interaction (p = 0.0001 and f = 9.72).

Multiple pairwise comparisons within groups reported a significant difference between 'pre' and 'post' in both groups (p < 0.05) except in LT/AS in the control group, favouring the Mulligan group. The between-groups analysis reported no significant difference pre-treatment, but there was significant difference post-treatment. Partial Eta Square was used to detect the size of the difference between both groups post-treatment, which was found to be medium and large post-treatment (η^2 > 0.06) (Table 2).

Table 2. Between groups analysis

	Mulligan group (mean ± *SD*)	Conventional group (mean ± *SD*)	*p*-value between groups	η^2
RT/UT				
Pre-treatment	14 ± 1.2	14.8 ± 1.6	0.82	
Post-treatment	8.62 ± 1.28	13.1 ± 2.15	0.0001[a]	0.62
p-value (within-group)	0.0001[a]	0.002[a]		
Mean difference	5.42	1.73		
LT/UT				
Pre-treatment	14.9 ± 1.6	15.1 ± 1.4	0.74[b]	
Post-treatment	8.89 ± 1.5	12.7 ± 2.3	0.0001[a]	0.5
p-value (within-group)	0.0001[a]	0.0001[a]		
Mean difference	6.08	2.42		
RT/CES				
Pre-treatment	14.4 ± 1.3	14.64 ± 1.5	0.6[b]	
Post-treatment	8.7 ± 1.9	11.8 ± 2.1	0.0001[a]	0.37
p-value (within-group)	0.0001[a]	0.0001[a]		
Mean difference	5.65	2.84		
LT/CES				
Pre-treatment	14.9 ± 1.3	15.1 ± 1	0.51[b]	
Post-treatment	8.66 ± 1.17	11.8 ± 1.9	0.0001[a]	0.5
p-value (within-group)	0.0001[a]	0.0001[a]		
Mean difference	6.3	3.35		
RT/SCM				
Pre-treatment	15.42 ± 1.7	15.59 ± 1.8	0.76[b]	
Post-treatment	8.64 ± 1.52	12.59 ± 2.21	0.0001[a]	0.53
p-value (within-group)	0.0001[a]	0.0001[a]		
Mean difference	6.78	2.99		
LT/SCM				
Pre-treatment	15.99 ± 2.2	15.47 ± 1.5	0.38[b]	
Post-treatment	9.02 ± 1.1	12.4 ± 2.4	0.0001[a]	0.49
p-value (within-group)	0.0001[a]	0.001[a]		
Mean difference	6.97	3.06		
RT/AS				
Pre-treatment	14.32 ± 1.4	14.62 ± 1.6	0.54[b]	
Post-treatment	9.2 ± 1.66	12.07 ± 2.62	0.006[a]	0.31
p-value (within-group)	0.0001[a]	0.01[a]		
Mean difference	5.12	2.54		
LT/AS				
Pre-treatment	14.1 ± 1.73	13.76 ± 2	0.48[b]	
Post-treatment	8.93 ± 1.12	13.5 ± 2.36	0.0001[a]	0.61
p-value (within-group)	0.0001[a]	0.97[b]		
Mean difference	5.15	0.16		
VAS				
Pre-treatment	6.75 ± 1.9	6.9 ± 1.37	0.77[b]	
Post-treatment	1.6 ± 0.25	5.7 ± 1.08	0.0001[a]	0.81
p-value (within-group)	0.0001[a]	0.007[a]		
Mean difference	5.15	1.2		
ANDI				
Pre-treatment	25.15 ± 2.71	25.6 ± 1.69	0.53[b]	
Post-treatment	9.55 ± 1.53	16 ± 2.1	0.0001[a]	0.76
p-value (within-group)	0.0001[a]	0.001[a]		
Mean difference	15.6	9.6		

RT – right, LT – left, UT – upper trapezius, CES – cervical erector spinae, SCM – sternocleidomastoid, AS – anterior scalene, VAS – Visual Analogue Scale, ANDI – Arabic neck disability index, η^2 – partial eta square, [b] – significance difference, [a] – no significant difference

Discussion

The aim of this trial is to clarify the effect of the Mulligan mobilisation technique on electromyography activation of cervical muscles in a functional position, pain, and function in chronic mechanical neck pain. The outcome of this trial after four weeks of intervention indicated decreases in the RMS in the experimental and control groups of the right UT by 5.42 and 1.73 and the left UT by 6.08 and 2.42, respectively, the right CES by 5.65 and 2.84 and the left CES by 6.3 and 3.35, respectively, the right SCM by 6.78 and 2.99 and the left by 6.97 and 3.06, respectively, and the right decreased by 5.12 and 2.54 and the left by 5.15 and 0.16, respectively. The pain level decreased by 5.15 and 1.2 in both groups, respectively, and finally the disability decreased by 15.6 and 9.6 in both groups, respectively, and found more benefits in the Mulligan group. The advantages in the Mulligan SNAGs group may be attributed first to the effects of hypoalgesia produced from SNAGs by acting on gate control and the descending inhibitory pain pathway, and second to the biomechanical role of SNAGs in the correction of any positional fault at the facet joints [34, 35].

Mulligan SNAGs act by stimulating large-diameter mechanoreceptor fibres (A beta), which stimulate inhibitory interneurons and close the pain gate at the spinal level [34–36]. Spinal mobilisation also stimulates the periaqueductal grey matter in the midbrain, which in turn leads to the release of serotonin in subcortical nuclei and the spinal cord, inhibiting the incoming sensory activity [36]. Moreover, the gliding technique that is applied to spinous processes of cervical vertebrae leads to an increase in the blood supply to the joints and removes the waste product, which in turn results in a decrease in pain and improvement in the functions of the neck [37].

In this trial, Mulligan SNAGs played a major role in inhibiting muscle activity, which may be due to the correction of the abnormal position at the facet joints [38]. The accessory glide between the two surfaces of the facet joints leads to its surfaces separating and permits the caught meniscus to return to its normal position [38]. Correcting the faulty posture at the facet joints may lead to a change in the abnormal alignment of muscles and restore the normal muscle length [38].

The results of this trial indicated the role of conventional treatment in improving pain, functional ability, and muscle activity of the neck. The application of a hot pack reduces pain by increasing the threshold level and stimulating the large sensory fibres that close the pain gate at the spinal level. It also increases the extensibility of the muscle fibre and inhibits muscle spindle, which leads to relaxation of muscle [39]. Isometric strengthening and stretching exercises play a major role in relaxing the muscle by autogenic inhibition during strengthening exercises and increasing the flexibility of the muscle during stretching exercises [40]. The chin tuck and scapula retraction exercise (postural correction exercise), both and postural exercises, may have two main benefits. First, they can regularly decrease the adverse loads on the cervical joints caused by poor cervical and scapula postures. Second, in their supporting role, they train the deep postural stabilising the muscles of the spine. A change in postural patterns will occur if these exercises are carried out repeatedly during the day [41].

The outcomes of this trial were in line with the study by Duymaz and Yagci [16], who reported the role of MMT in the treatment of subjects with MNP. In that study, 40 subjects diagnosed with MNP were randomly allocated to two groups. One group received MMT combined with exercise treatment and the control group received exercise only. The outcome variables were pain measured using VAS, muscle strength using pressure biofeedback and a hand-held dynamometer, range of motion using a goniometer, and functions of the neck using the neck disability index. The results revealed that MMT played a definite role in reducing pain and improving muscle strength, range of motion, and functions of the neck [16]. In a similar study exploring the efficacy of the immediate- and short-term effect of the MMT concept after one month in subjects with MNP, Zemdanis [17] found improvement in pain and functions of the neck after nine sessions of treatment and after one month of follow-up in the MMT group. The control group saw no improvement at follow-up [17].

Tank et al. [14] examined the role of MMT and the muscle energy technique in 40 subjects with MNP. The subjects were randomly allocated to two groups. Subjects in one group received MMT plus traditional therapy and those in the other group received the muscle energy technique plus traditional therapy. The outcomes of this trial were assessed in terms of pain, functional ability and range of motion, and improvement was found in both groups with more benefits in the group that received the treatment using MMT [14]. In a study by Aggarwal and Verma [18], the efficacy of MMT was evaluated on 38 nursing professionals diagnosed with MNP. They randomly selected and allocated the nursing professionals to two groups using the lottery method. One group received self-SNAGs along with the traditional therapy, while the other group received only the traditional therapy. The results revealed improvement in pain, function, and range of motion of the neck with more advantages in the group that received the treatment with SNAGs technique [18].

Limitations

The limitations of this trial are that it does not have a control group that received no treatment and there was no follow-up.

Conclusions

The outcome results of this trial reported improvement in muscle activity, pain and function in both groups, with more benefits in the group that received Mulligan SNAGs.

Recommendations

Based on this trial, it is recommended that Mulligan SNAGs be applied as a basic part of the treatment program for MNP. For future research, it is proposed that a trial may be performed to investigate the long-term effects of Mulligan SNAGs in subjects with MNP.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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