Original Research Article

Effectiveness of Mulligan Spinal Mobilization with Arm Movement (SMWAM) Technique along with Neurodynamics in Cervical Radiculopathy Patients - An Experimental Study

Arul Pragassame S[1*], Karthikeyan S A[2], Sarumathi M[3]

[1]Assistant Professor, Department of P.M & R, RMMC & H, Annamalai University, Tamil Nadu, India.
[2]Principal, Government College of Physiotherapy, Periyamilaguparai, Trichy, India
[3]Department of P.M &R, RMMC & H, Annamalai University, Tamil Nadu, India
[*]Corresponding author email: **arulphysio77@gmail.com**

International Archives of Integrated Medicine, Vol. 8, Issue 1, January, 2021.
Available online at http://iaimjournal.com/
ISSN: 2394-0026 (P) **ISSN: 2394-0034 (O)**
Received on: 17-07-2020 **Accepted on:** 11-12-2020
Source of support: Nil **Conflict of interest:** None declared.
How to cite this article: Arul Pragassame S, Karthikeyan S A, Sarumathi M. Effectiveness of Mulligan Spinal Mobilization with Arm Movement (SMWAM) Technique along with Neurodynamics in Cervical Radiculopathy Patients - An Experimental Study. IAIM, 2021; 8(1): 11-22.

Abstract

Background: Cervical radiculopathy (CR) is one of the most common health related complaints. It occurs at an incidence rate of about 85 per 100,000 people. It is a disorder of spinal nerve root, pain and symptomatology that can spread far from the spine and radiate to the arm, neck, chest, upper back and/or shoulder. Mulligan manual therapy consists of functional painless techniques that are included in patients with spinal pain that show immediate symptoms relief. Mulligan spinal mobilization with arm movement (SMWAM) technique with neurodynamics has a positive effect in patients with CR. Studies focusing on these areas are very minimal, so the aim of the study is to find out the effectiveness of Mulligan SMWAM technique with neurodynamics in cervical radiculopathy patients.
Material and methods: In the study, 40 patients were chosen on the basis of selection criteria. The initial evaluation of pain intensity was measured using numerical pain rating scale (NPRS), cervical range of motion (ROM) was measured using inch tape, and functional disability was scored using the Northwick park neck pain questionnaire (NPQ). Patents were randomly assigned to two groups (Group A & Group B). Group A (Experimental) (N=20) patients were treated with mulligan

SMWAM technique along with neurodynamics, intermittent cervical traction (ICT), interferential therapy (IFT) and neck exercises. Group B (Control) (N=20) patients were treated with ICT, IFT and neck exercises. Pre and post evaluation measures were compared and statistically analyzed.

Results: The experimental group showed significant improvements in NPRS (t = 25.754, P = 0.001), cervical ROM extension (t = 4.26, P = 0.001), right rotation (t = 4.16, P = 0.001), left rotation (t =4.09, P = 0.001), and the Northwick Park Neck Pain Questionnaire (NPQ) (t = 13.08, P = 0,001) compared to the control group.

Conclusion: The study concludes that mulligan SMWAM technique, along with neurodynamics and conventional therapy, is effective in reducing pain, improving cervical ROM and functional disability in patients with cervical radiculopathy. However, patients who received mulligan SMWAM technique with neurodynamics showed better improvement in pain reduction, cervical ROM and functional disability than in the control group.

Key words

Mulligan Spinal Mobilization with Arm Movement (SMWAM), Neurodynamics, Cervical Radiculopathy, Interferential Therapy, Intermittent Cervical Traction, Northwick Park Neck Pain Questionnaire (NPQ).

Introduction

Cervical radiculopathy is one of the most common health related complaints. CR is a condition caused by the acute disk herniations, cervical spondylosis, foraminal narrowing, all leading to compression and irritation of the exiting cervical nerve root [1].

The average annual incidence rate of cervical radiculopathy is 83 per 1000 for the entire population [2], normally in younger patients aged 30-40 years' while the prevalence of males increased during the fifth and sixth decades of life, it was slightly higher than that of females [3].

The most commonly involved nerve roots are the cervical C_6 and C_7, which are typically caused by C_5-C_6 or C_6-C_7 disc herniation or spondylosis [2]. Patients usually have symptoms of pain numbness, tingling and weakness in the upper extremity, often leading to significant functional limitations and disability [4].

Conventional therapy for CR includes short–term use of a soft cervical collar, traction, medications, mobilization and physical therapy modalities, cervical traction as a treatment choice for patients with CR. Spinal muscles are considered to be the most important of the proposed mechanisms by which traction could be effective [2].

Mulligan Manual Therapy can be used to help treat a variety of injuries and pain including neck pain, back pain and upper and lower extremity injuries. Designed to reduce pain and improve the patient's range of motion the Mulligan technique involves Natural Apophyseal Glides (NAGS), Sustained Natural Apophyseal Glides (SNAGS) and Mobilization with Movement (MWM) for the treatment of musculoskeletal injuries.

When applying manual therapy techniques, a physiotherapist will identify one or more comparable signs that may include loss of joint movement, pain associated with movement or pain associated with specific functional activities. Then a passive accessory joint mobilization is applied, either parallel or perpendicular to the joint plane and the accessory glide is to be pain free. Using various combinations of parallel or perpendicular glides, the therapist will try to find the correct treatment plane and grade of movement. When done, the comparable sign should be significantly

improved by either an increase in the range of motion or absence of pain. If this is not achieved, the therapist has not found the correct contact point, treatment plane, grade or direction of mobilization [3].

The new concept of mulligan for spinal origin symptoms radiating to the periphery included spinal mobilization with arm movement (SMWAM) with neural mobilization. In this technique, sustained transverse glide is maintained at the spinous process of the affected vertebral level towards the unaffected side while actively performing the limited peripheral joint movements. Mobilization must be pain free and sustained throughout the ROM. The improvement in cervical lesion resulting in pain and other signs reduced. This technique is based on the knowledge that when the scapula, cervical vertebrae, and upper thorax cause simultaneous spine movement. This technique can be easily performed, and one of its advantages is that, if the basic principles are followed faithfully, the treatment can be done safely and effectively [5, 6].

Neural mobilization is a set of techniques designed to restore the plasticity of the nervous system and helps restore the ability of the neural tissue to stretch and tension and stimulates the reconstruction of normal physiological functions of the nerve cells [7]. This technique can be reducing intrinsic pressure on the neural tissue, it restores dynamic balance between relative movements of nerve tissue surrounding mechanical interference. It is evident that in neck pain when a patient undergoes nerve tension stretching, there is significant improvement in range of motion [8].

Mulligan SMWAM technique with neurodynamics has a positive effect in patients with CR. Studies focusing on these areas are very minimal, so the aim of the study is to find out the effectiveness of Mulligan SMWAM technique with neurodynamics in cervical radiculopathy patients.

Materials and methods

The present study was an experimental study conducted at the Outpatient Department of Physical Medicine and Rehabilitation, RMMCH, Annamalai University, Tamil Nadu, India, during January, February and March 2020. During the specified time period, the sample size was selected using a convenient sampling method.

The inclusion criteria for the study were

- 40 patients diagnosed with CR
- Age group between 25-60 years
- Unilateral radiating pain through the course of median nerve
- Subject having positive upper limb tension test (ULTT 1)
- Both male and female
- Subjects who can understand the instructions and are willing to participate in the study.

The main exclusion criteria were

- History of trauma, dislocation and subluxation of upper extremity
- Rheumatoid Arthritis
- Malignancy
- Cervical instability/Spondylolisthesis
- VBI (Vertebral-Basillar Insufficiency)
- Referred pain in patients with cardiac ischemia
- Cervical surgeries and systemic causes like diabetic neuropathy.

Study Procedure

Based on the selection criteria, the subjects were chosen. The purpose of the study was explained to the patients and an informed consent was given in their known language. Demographic data were collected. The initial evaluation of pain intensity was measured using numerical pain rating scale (NPRS), cervical range of motion (ROM) was measured using inch tape, and functional disability was scored using the Northwick park neck pain questionnaire (NPQ). Patents were randomly assigned to two groups (Group A & Group B). Group A (Experimental) (N=20) patients were treated with mulligan

SMWAM technique along with neurodynamics, intermittent cervical traction (ICT), interferential therapy (IFT) and neck exercises. Group B (Control) (N=20) patients were treated with ICT, IFT and neck exercises. The above evaluation was carried out on the patient first visit before the beginning of treatment and again on the final day of treatment at the end of the 2nd week. Pre and post evaluation measures were compared and statistically analyzed.

Outcome measures

Numerical Pain Rating scale (NPRS)

The NPRS was used to measure the pain intensity of the subject. Subject was sitting on the chair, and he / she was asked to mark the severity of resting pain in the range of 0 to 10, 0 as no pain and 10 as severe pain in the 10 cm line [9].

Cervical Range of Motion (ROM)

Cervical Extension:

The mean cervical extension ROM measured with a tape measure ranges from 18.5 to 22.4 cm. A tape measure can be used to measure the distance between the tip of the chin and the sternal notch. Be sure that the subjects mouth remains closed during measurement. The examiner's measure at the end of the ROM [3, 10].

Cervical Rotation (Rt/Lt):

The mean cervical rotation ROM to the right/left measured with a tape measure ranges from 11.0 to 13.2 cm. Measure the distance between the tip of the chin and the acromial process. Measurement of investigator at the end of the ROM [3, 10].

The Northwick Park Neck Pain Questionnaire (NPQ):

The NPQ measures the neck pain and the consequent patient disabilities. The questionnaire is divided in nine five-part sections. Namely: 1) neck pain intensity, 2) neck pain and sleeping, 3) pins and needles or numbness in the arms at night, 4) duration of symptoms, 5) carrying, 6) reading and watching television, 7) working and/or housework, 8) social activities and 9) driving. At the end there's a tenth question which aims to compare the current state to the state when the questionnaire was last completed [11, 12].

Treatment procedure:

Treatment was administered 3 days a week for 2 weeks. The frequency was one session a day, three sets of 10 repetitions with one-minute rest between sets [13]. Before mobilization, all participants received ICT (15 minutes) [14, 15] and IFT (15 minutes) [7, 15, 16] treatment and were advised to perform isometric neck exercise [17] as a home program.

Mulligan (SMWAM) with Neurodynamics (medial nerve) [3, 5, 18]

Patient is sitting in the chair / plinth. Therapist's standing behind the patient.

Hand placement:

Therapist approaches the desired level of spinous process from medial aspect of the thumb of one hand which is reinforced by the index finger of the other hand. Second therapist places his axilla over the patient's shoulder to add shoulder depression component. The second therapist performs components of the nerve to be test one by one (distal to proximal or proximal to distal sequence) depending upon patient's offending movements and painful range.

Mobilization:

Pure transverse glide is performed from affected to unaffected side. While the glide is sustained, another therapist mobilizes the median nerve by performing desired neurodynamic movement for median nerve repeatedly within the new pain-free range. Repeat the procedure thrice and reassess patient's symptoms by performing neurodynamic test. 3 sets of 10 repetitions. **Figure – 1** shows the sequences of mulligan (SMWAM) techniques along with neurodynamics.

Figure – 1: shows the sequences of mulligan (SMWAM) techniques along with neurodynamics.

Results

Significant changes in pre- and post-measurements were studied using the Paired sample 't' test for NPRS, cervical ROM, and Northwick park neck pain questionnaire (NPQ). The comparison of improvement between groups was analyzed by the independent sample t-test for the outcome variables. The entire statistical procedure was carried out by the Statistical Packages for the Social Sciences-18.

The mean age for the experimental group was 46 ±11.69 years, whereas the control group was 44±13.20 years. The average duration of the experimental and control groups was 21.95±16.86 months and 27.40 ±17.95 months respectively. In the experimental group, both Male and female patients were equally represented, whereas in control group, male patient were 60 % and female patient were 40% (**Table - 1**).

The mean NPRS score at the beginning of the study was 6.5±1.64 and 5.80±1.28 for the experimental and control groups, respectively. The post NPRS score was 3.75 ±1.33 and 4.45±1.09 for the experimental and the control groups respectively. The mean improvement was 2.75±0.78 for the experimental group and 1.35 ± 0.48 for the control group. The ' p' value was significant (p=0.001 < 0.05) and therefore the pain was significantly reduced in both groups following treatment (**Figure - 2**).

The mean cervical extension was improved from 5.05±1.27 cm to 5.80±1.19 cm after the study period in experimental group. The difference was statistically significant. The mean cervical extension was improved from 5.20±0.89 at the start of the study to 5.55±0.88 at the end of the study period in the control group. Again, the difference was statistically significant (t=3.19, p=0 .005).

The mean improvement in the right and left rotation of the cervical was 0.90±0.97 and 1.05±1.14 cm respectively in the experimental group, whereas the mean improvement in the right and left rotation of the cervical was 0.35 ± 0.04 and 0.35 ± 0.67 respectively in the control group. The difference in improvement was statistically significant for both groups (p < 0.05) (**Figure - 3**).

Figure - 4 shows that there was a significant reduction in NPQ from 21.15±5.84 at the start of the study to 15.95±5.93 at the end of the study, t=13.08, p=0.001 in the experimental group. There was also a significant reduction in the NPQ from 17.65 ±3.88 at the start of the study to 15. 55±3, 63 at the end of the study period, t = 2.94, p=0.008 in the control group. The mean improvement was 5.20±7.90 in the experimental group, compared to 2.10±0.72 in the control group.

The mean difference in the improvement level of NPRS was 1.40 between the groups and the difference was statistically significant, t=6.76, p=0.001. There was a significantly higher improvement in the extension ROM in the experimental group than in the controls, t=1.93, p= 0.049. The improvement in the NPQ was significantly higher in the experimental group,

with a mean difference of 3.05. T=1.72; p=0.043. The improvement in the right neck rotation (t=2.26, P=0.02) as well as in the left neck rotation (t=2.36, p=0.02) was significantly higher in the experimental group than in the controls. The mean improvement in the right rotation of the neck was 0.55, where it was 0.70 for the left rotation (**Table - 2**).

Table - 1: Baseline characteristics of patients in the study.

Experimental Group			**Control Group**	
	Mean	**SD**	**Mean**	**SD**
Age	46	11.69	44	13.20
Duration (months)	21.95	16.86	27.40	17.95
Gender	**Number**	**%**	**Number**	**%**
Male	10	50	12	60
Female	10	50	8	40
Total	20	100	20	100

Figure - 2: Comparison of NPRS for Experimental and Control Group in Pre and Post Treatment.

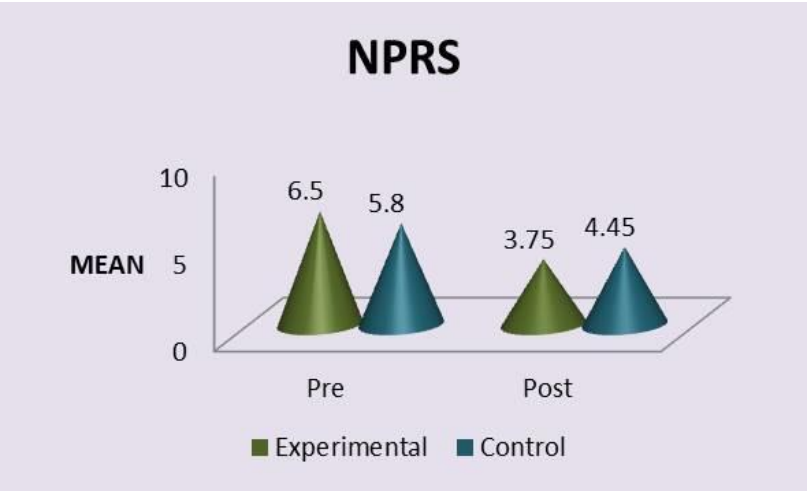

Figure - 3: Comparison of Cervical Extension and Rotation for Experimental and Control Group in Pre and Post Treatment.

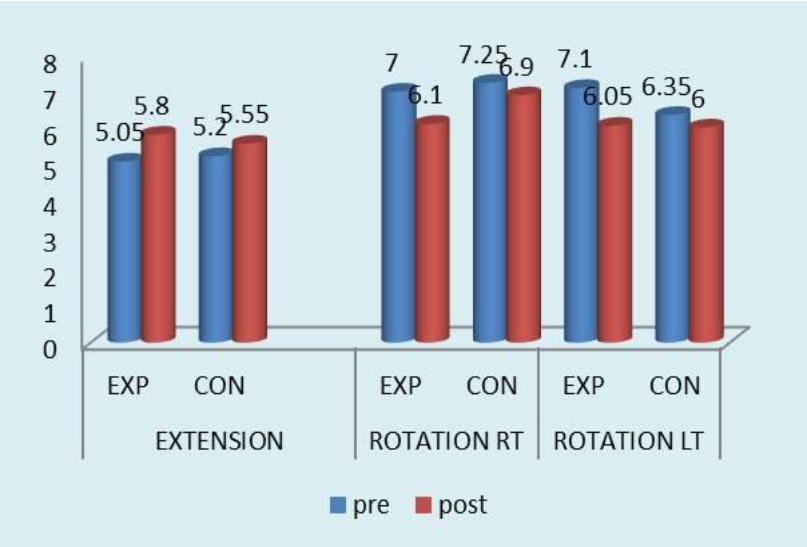

Figure - 4: Comparison of NPQ for Experimental and Control group in Pre and Post Treatment.

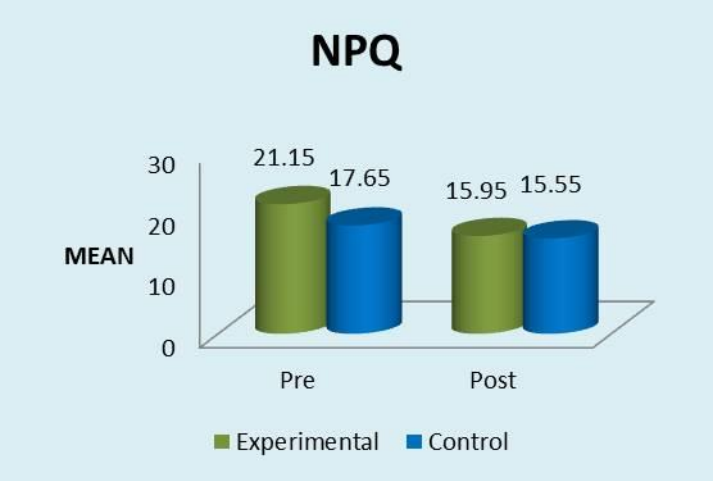

Table - 2: Shows the Comparison of Outcome Measures Between Groups.

Outcome Measures	Mean Difference	Independent Sample Test	
		't'	'p'
NPRS	1.40	6.76	0.001
Cervical ROM Extension	0.40	1.93	0.049
Rotation Right	0.55	2.26	0.03
Rotation Left	0.70	2.36	0.02
NPQ	3.05	2.94	0.008

Discussion

Cervical radiculopathy usually results in pain, limited ROM, and difficulty in performing activities of daily living in the patients. The main focus of the treatment is on controlling pain, improving ROM, and preventing recurrence of the condition. IFT, isometric neck exercises, ICT, neurodynamics and mobilization exercises are the treatment protocols usually followed in patients with cervical radiculopathy.

The current study was conducted to determine the effects of mulligan SMWAM technique along with neurodynamics on pain, cervical ROM and functional disability in cervical radiculopathy patients. Both the groups showed significant improvement in pain, cervical ROM and functional disability, but, when compared, the experimental group showed more improvement for pain ($p<0.05$), cervical ROM ($p<0.05$) and decrease in disability ($p<0.05$).

The Nature of Study Population

The gender distribution was equal in the experimental group, while in the control group, the male patient was 60% and the female patient was 40%. The number of male patients was higher than that of female patients. Many previous studies report that female patients are the maximum for this cervical condition [19, 20]. The age distribution shows that 40 to 45 years was the common age denoted by 53.3% in experimental group and 40% in control group. The present study result of age of occurrence coincides well with the recent studies [21, 22]. The majority of the study patient was a manual worker reported by 66.7% in experimental group and 33.3% in the control group. The present study was conducted in a rural region of Chidambaram where manual labor represents maximal numbers. Repetitive physical work demands and practice of carrying heavy loads on the head to make them vulnerable to undue stress on the joint and surrounding structures that contribute to early wear and tear. The common duration of the condition was reported in the

experimental and control groups at 21.95±16.86 months and 27.40±17.95 months, respectively.

Interpretation of Improvement in Mulligan (SMWAM) Technique with Neurodynamics

The physiological effects of Mulligan SMWAM technique with neurodynamics are that it helps to stretch the structures on the convex side of the offending movement and opens the intervertebral foramen on the convex side, which helps to unlock the jammed facet. This might also correct the positional fault between the vertebrae, thus correcting the biomechanics of the joints and if present might also release entrapped meniscoid between the facet joints. The neurophysiological effects are that it stimulates mechanoreceptors and proprioceptors in and around the joints, thus helps to release the muscles around the joints. Mobilization-induced movements contribute to the nutrition of the facet joints and disc [18].

Neurodynamics is said to affect the axoplasmic flow, movement of the nerve and its connective tissue and the circulation of the nerve by alteration of the pressure in the nervous system and dispersion of intraneural oedema. Neurodynamics decreases the excitability of dorsal horn cells. It can be performed in various ways using passive movement, manual mobilization of the nerve or interface, and exercise. The aim of neural mobilization is to restore the mechanical and neurophysiological function of the nerve [23-25].

Interpretation of Improvement in Interferential Therapy

The pain reduction in IFT is due to the analgesic effects it produces and is due to the pain gate theory. According to this theory, IFT may stimulate the large diameter of afferent fibers, which may reduce pain signal transmission through the small nociceptive afferent fibers and thus prevent pain discrimination and perception. Analgesia may be caused by the modulation of the nociceptive input of large sensory afferent nerves into the spinal cord through peripheral electrical stimulation. Endorphin and encephaline can be released by electrical stimulation of certain receptor sites in the dorsal horn of the spinal cord [26, 27].

Interpretation of Improvement in Intermittent Cervical Traction

Intermittent cervical traction helps to relax the muscles, which can significantly relieve pain and stiffness while increasing flexibility. It's also used to treat and flatten bulging or herniated disks. It can alleviate pain from joints, sprains, and spasms. It's also used to treat neck injuries, pinched nerves, and cervical spondylosis. Cervical traction devices work by stretching the spinal vertebrae and muscles to relieve pressure and pain. Force or tension is used to stretch or pull the head away from the neck. Creating space between the vertebrae relieves compression and allows the muscles to relax. This lengthens or stretches the muscles and joints around the neck [14, 15].

Interpretation of Improvement in Isometric Neck Exercises

The postural muscles work in an isometric fashion and provide a strengthening base for a dynamic exercise. Isometric neck exercises assist to increase muscle strength and as they are done in one position, improve strength in one particular position. They help to improve stability due to the fact that the muscles contract isometrically. These exercises help to improve muscle imbalance, which also leads to adequate alignment. All of these variables help to improve the posture of the patient. This strength training helps in pain reduction and improves physical function [17, 28].

Comparison of Improvement of Mulligan SMWAM Technique with Neurodynamics and Conventional Therapy Group-Wise Analysis

For NPRS, the mean difference of improvement in experimental group was comparatively higher than in control group. As a result, the NPRS (improvement) was significantly higher in experimental group. The statistical results of both

groups were significant, while the neurodynamics with Mulligan's SMWAM technique showed an additional pain improvement. Mulligan's SMWAM technique can reduce the H-reflex, evoking as an inhibitory reaction in the central nervous system and increasing the firing threshold of the individual alpha motor neurons resulting in relaxation of the spinal muscles. For cervical ROM, the mean difference of improvement is comparatively higher in experimental group than in control group. The reason is probably the sustained gliding force could unlock the jammed facet, helps in stretching the posterior structures and open intervertebral foramen, the mobilization of induced movements helps to provide nutrition to the facet joint and disc [18].

The NPQ in our study was found to be highly effective in assessing the pain, disability, affective, and cognitive aspects of the patient. The questionnaire shows high sensitivity, good validity, and reliability in patients with neck pain. The overall score was seen to be lower in the experimental group compared to the control group, with a mean difference of 5.20±7.90 for the experimental group.

Interpretation of Results

Our study supports the previous study done by Sadaf Shafique, et al. (2019) [29] in which they studied the effect of Mulligan Spinal Mobilization with Arm Movement along with neurodynamics and manual traction on pain, disability and cervical range of motion in cervical radiculopathy patients and concluded that patients treated with Spinal Mobilization with Arm Movement along with neurodynamics and manual traction had better outcome compared to those who only got neurodynamics and manual traction.

The findings of this study, consistent with Apurva Godsc, et al. (2019) [30] compared the effect of SMWAM, neural tissue mobilization, hot moist packs and interferential therapy on pain and functional disability in treatment cervical spondylosis with unilateral radiculopathy and concluded that SMWAM was effective than neural tissue mobilization in reducing VAS and NDI scores in subjects with cervical spondylosis with unilateral radiculopathy.

Another study that supports our current study was done by Jasmita Kaur Chauthry and Ajit Dabholkar (2017) [31] which determined the efficacy of spinal mobilization with arm movements (SMWAMS), a technique of Mulligan concept, in 50 patients with mechanical neck pain and concluded that SMWAMs was more effective than supervised exercise program, in reduction of pain, disability and improvement of functional ability.

The research result, which contradicts Mayuri Gad, et al. (2018) [32] conducted a comparative study of Mulligans Mobilizations with Upper Limb Movement and McKenzie Neural Mobilization Exercises in Cervical Radiculopathy Patients. They concluded that McKenzie exercise with neural mobilization is better than mulligan mobilization with upper limb movements in cervical radiculopathy. Results supported that McKenzie exercise with neural mobilization was more effective than mulligan mobilization to improve pain and disability in a patient with cervical radiculopathy, which is differs from our present study outcomes.

Limitation and Future Suggestions

- The studied sample size is considerably smaller. In order to further validate this effective therapeutic technique for cervical radiculopathy, it may be necessary to increase the number of participants.
- This study did not focus on follow up; further studies could focus on patient follow up.

Conclusion

The study concludes that mulligan SMWAM technique, along with neurodynamics and

conventional therapy, is effective in reducing pain, improving cervical ROM and functional disability in patients with cervical radiculopathy. However, patients who received mulligan SMWAM technique with neurodynamics showed better improvement in pain reduction, cervical ROM and functional disability than in the control group.

References

1. Smati Sambyal, Sandeep Kumar. Comparison Between Nerve Mobilization and Conventional Physiotherapy in Patients with Cervical Radiculopathy. International journal of innovative research & development, 2013; 2(8): 442-445.
2. Jason David Eubanks**.** Cervical Radiculopathy: Nonoperative Management of Neck Pain and Radicular Symptoms. Am Fam Physician, 2010; 81(1): 33-40.
3. Sadaf Shafique, Shakeel Ahmad Syed, Shakil-ur- Rehman. Effect of mulligan spinal mobilization with arm movement along with neurodynamics and manual traction in cervical radiculopathy patient: a randomized controlled trail. Journal of the Pakistan Medical Association, 2019; 69(11): 1601-1604.
4. Sarfaraj M D. The effect of cervical traction with neural mobilization in cervical radiculopathy patients. International Journal of Advance Research, Ideas and Innovations in Technology, 2018; 3(5): 136-140.
5. Mayur Solanki, Chandni Shah. Effectiveness of Mulligan Mobilization versus Neural Mobilization in Patients with Cervical Radiculopathy: A Comparative Study. International Journal of Science and Research, 2015; 4(5): 2387 – 2389.
6. Jasmita kaur Chaudhery, Ajit Dabholkar. Spinal mobilization with arm movements (SMWAMS) in mechanical neck pain patient: case-controlled trial. International Journal of Therapies and Rehabilitation Research, 2017; 6(1): 18-23.
7. Rajalaxmi V, Manju M, Veena S, Veena Kirthika. Interferential Therapy with and without Neural Mobilization Along with Conventional Therapy in Cervical Radiculopathy Patients. Competitive study. International Journal of physiotherapy, 2015; 1(1): 65- 74.
8. Apurva Godse, Trupti Warude, Amrutkuvar Pawar, Vaishali Jagtap, Krishna. Effectiveness of Spinal Mobilization with Arm Movement (SMWAMS) Versus Neural Tissue Mobilization in Cervical Spondylosis with Unilateral Radiculopathy. Krishna College of Physiotherapy, 2019; 10(5): 66-73.
9. Ian A Young , Joshua A Cleland, Lori A Michener, Chris Brown. Reliability, Construct Validity, and Responsiveness of the Neck Disability Index, Patient-Specific Functional Scale, and Numeric Pain Rating Scale in Patients with Cervical Radiculopathy. American Journal of Physical Medicine & Rehabilitation, 2010; 89(10): 831-839.
10. Christos Savva, Giannis Giakas, Michalis Efstatiou, Christos Karagiannis, Loannis Mamais. Effectiveness of Neural Mobilization with Cervical Traction in the Management of Cervical Radiculopathy: A Randomized Controlled Trial. International Journal of Osteopathic Medicine, 2016; 21(9): 19-28.
11. A M Leak , J Cooper, S Dyer, K A Williams, L Turner-Stokes, A O Frank. The Northwick Park Neck Pain Questionnaire, Devised to Measure Neck Pain and Disability. Br J Rheumatol., 1994; 33(5): 469-74.
12. Gulsah Kose, Simin Hepguler, Funda Atamaz, Gonca Oder. A comparison of four disability scales for Turkish patients

with neck pain. J Rehabil Med., 2007; 39(5): 358–362.

13. Shah S, Mahapatra R K. Effect of Mulligan Spinal Mobilization with Leg Movement and Shacklock Neural Tissue Mobilization in Lumbar Radiculopathy: A Randomised Controlled Trial. Journal Medical Thesis., 2015; 3(2): 27-30.
14. Joshua A Cleland, Julie M Whitman, Julie M Fritz, Jessica A Palmer. Manual physical therapy, cervical traction, and strengthening exercises in patients with cervical radiculopathy: A case series. Journal of Orthopedic and Sports Physical Therapy, 2005; 35(12): 802-811.
15. Edward Bellis Clayton. Clayton's Electrotherapy: Theory and Practice Paperback, W B Saunders Co., 8th edition, 2015, p. 107-111.
16. Nupur Sutariya, Yagna Shukla. Effect of interferential therapy versus shortwave diathermy on pain and function in mechanical neck pain. International journal of science and healthcare research, 2020; 3(1): 552-57.
17. Senthilnathan C V, Gurulakshmi A, Mohan Kumar G. Effects of isometric neck exercise improving cervical range of motion in long time helmet wearers. International Journal of Physiotherapy & Occupational Therapy, 2015; 1(1): 9-16.
18. Kumar D. Manual mulligan concept. International Edition Paperback, Capri Institute of Manual Therapy. 2nd edition, 2015, p. 223-224.
19. Jari Ylinen, Esa-Pekka Takala,Matti Nykänen, Arja Häkkinen, Timo Pohjolainen, Sirkka-Liisa Karppi. Active neck muscle training in the treatment of chronic neck pain in women-A randomized controlled trial. JAMA, 2003; 289(19): 2509-16.
20. Anna Mac Dowall, Yohan Robinson, Martin Skeppholm, Claes Olerud. Anxiety and depression affect pain drawings in cervical degenerative disc diseas. Ups J Med Sci., 2017; 122(2): 99-107.
21. Rose Bist PK, Anil Kumar Peethambaran, Gowri Anil Peethambar. Cervical spondylosis: Analysis of clinical and radiological correlation. International Surgery Journal, 2018; 5(2): 491-95.
22. Brown G, Park K, Bicknell RT. Management of Occupational shoulder injuries in primary care. J Musculo skeletal Discord Treat., 2005; 1: 537-542.
23. Shacklock M. Neurodynamics. Physiotherapy, 1995; 81(1): 9-16.
24. Butler DS, editor. Mobilization of the nervous system, 1st edition, Melbourne: Churchill Livingstone; 1991.
25. Schmid AB, Elliott JM, Strudwick MW, Little M, Coppieters MW. Effect of splinting and exercise on intraneural edema of the median nerve in carpal tunnel syndrome-an MRI study to reveal therapeutic mechanisms. J Orthop Res., 2012; 30(8): 1343-50.
26. Johnson M. Transcutaneous Electrical Nerve Stimulation: Mechanisms, Clinical Application and Evidence. Rev Pain, 2007; 1: 7-11.
27. Vance CG, Dailey DL, Rakel BA, Sluka KA. Using IFT for pain control: The state of the evidence. Pain Management, 2014; 4: 197-209.
28. Laskowski ER. Are Isometric Exercises a Good Way to Build Strength? Available from: http://www.mayoclinic.org.
29. Sadaf Shafique, Shakeel Ahmad, Syed Shakil-ur- Rehman. Effect of Mulligan spinal mobilization with arm movement along with neurodynamics and manual traction in cervical radiculopathy patients: A randomized controlled trial. J Pak Med Assoc., 2019; 69(11): 1601-1604.
30. Apurva Godsc, Trupti Warude, Amrutkuvar Pawar, Vaishali Jagtap,

Krishna Savsaviya, Nilakshi Kandalkar. Effectiveness of Spinal Mobilization with Arm Movement Versus Neural Tissue Mobilization in cervical Spondylo sis with Unilateral radiculopathy. Indian Journal of Public Health and Development, 2019; 10(5): 24-29.

31. Jasmita Kaur Chauthry, Ajit Dabholkar. Efficacy of Spinal Mobilization with Arm movements (SMWAMS) in Mechanical Neck pain patients: Case-Controlled Trial. International Journal of Therapies and Rehabilitation Research, 2017; 6(1): 1026-1032.
32. Mayuri Vijay Gad, Sreenivasu Kotagiri, Anup Kumar Songa, Nazz Sulthan. Effectiveness of Mulligans Mobilizations with Upper Limb Movement and McKenzie Exercises with Neural Mobilizations in Patients with Cervical Spondylitis. IAIM, 2018; 5(5): 146-155.