Original Research Article

Effectiveness of Mulligans Mobilizations with Upper Limb Movement and McKenzie Exercises with Neural Mobilizations in Patients with Cervical Spondylitis

Sreenivasu Kotagiri[1]*, Anup Kumar Songa[2], Mayuri Vijay Gad[3], Nazz Sulthan[4]

[1]Assisstant Professor, KIMS College of Physiotherapy, Minister Road, Secunderabad, Telangana, India
[2]Vice Principal, KIMS College of Physiotherapy, Minister Road, Secunderabad, Telangana, India
[3]Assistant Professor, Nanded Physiotherapy College and Research Center, Maharashtra, India
[4]Mpt 2nd KIMS College of Physiotherapy, Minister Road, Secunderabad, Telangana, India
*Corresponding author email: **sreenivaskotagiri7@gmail.com**

International Archives of Integrated Medicine, Vol. 5, Issue 5, May, 2018.

Available online at http://iaimjournal.com/
ISSN: 2394-0026 (P) **ISSN: 2394-0034 (O)**
Received on: 02-05-2018 **Accepted on:** 10-05-2018
Source of support: Nil **Conflict of interest:** None declared.
How to cite this article: Sreenivasu Kotagiri, Anup Kumar Songa, Mayuri Vijay Gad, 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.

Abstract

Background: Cervical Spondylitis (CS) is a common term that denotes degenerative changes that develop with of trauma-centre patients, specific age groups, and head injury patients. A study done on Indian population reported 78% of radiological changes of CS at C5-C6 and C6-C7 levels in asymptomatic individuals. These degenerative changes in the cervical spine may remain asymptomatic or can present as pure axial neck pain, cervical radiculopathy, cervical myelopathy, or cervical myeloradiculopathy. So, the aim of the study was to check the effectiveness of Mulligans Mobilizations with Upper Limb Movement and McKenzie Exercises with Neural Mobilizations in Patients with Cervical Spondylitis.

Materials and methods: 60 patients were included in the study which was divided into two groups ; Group A and Group B, 30 patients in each group. Subjects were randomly selected and assigned to each group A pre-test measurement with the help of two measures - Northwick Park Neck Pain Questionnaire (NPNPQ) for disability and Visual Analog Scale (VAS) Inclinometer for a range of

motion cervical spine movements was done in each group. Subjects in Group-A were given Mulligan Mobilization with Upper Limb Movement for cervical regain for 45 minutes 4 days for one week in four weeks subject were sitting Subjects in Group-B was given McKenzie Exercises with Neural Mobilization for 45 minutes 4 days for one week in four weeks subject were in supine position and remains relaxed with the feet uncrossed. Result analysis was done by Wilcoxon Sum Rank Test (Mann Whitney U Test).

Results: On comparing Group A and Group B for post-treatment VAS score and NPNPQ score, results showed a significant difference (p=0.001) in improvement in terms of VAS and NPNPQ. The overall study proved that both Mulligan mobilization with upper limb movement and McKenzie exercises with neural mobilization were effective in improving Pain and decreasing the disability level in cervical radiculopathy subjects.

Conclusion: 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.

Key words

Cervical radiculopathy, McKenzie exercises, Mulligan mobilization, Neural mobilization.

Introduction

Cervical Spondylitis was clearly defined (Brain, Knight, and Bull, 1948), but this is in terms of natural history, and it is not surprising that little has been written on this aspect of the disease.

Brain (1962) considered that the natural tendency of cervical spondylitis was to become arrested, but most of those affected were left with a variable degree of disability.

Wilkinson (1962) wrote that the prognosis of cervical spondylitis was good, provided that the condition was recognized early, appropriate treatment was given, and the patient was told how to cope with his disability.

Cervical Spondylitis (CS) is a common term that denotes degenerative changes that develop with of trauma-center patients, specific age groups, head injury patients, patients with other specific organ injuries, military populations and patients with specific trauma mechanisms (pedestrians, diving, horseback riding, Trampoline, soccer, among others pathological condition. These degenerative changes in the cervical spine may remain asymptomatic or can present as pure axial neck pain, cervical radiculopathy, cervical myelopathy, or cervical myeloradiculopathy [1]. Radiological evidence of asymptomatic CS is seen frequently, with an incidence of 50% over the age of 40 and 85% over the age of 60, neck pain and radiculopathy are relatively common, with about two-thirds of the UK population having neck pain at some point in their lives [2, 3]. A study done on Indian population reported 78% of radiological changes of CS at C5-C6 and C6-C7 levels in asymptomatic individuals [6].

The earliest event is probably a biochemical change in the substance of the disc, resulting in decreased water content. This causes an alteration in the biomechanics of the spine due to loss of the shock absorber-like action of the discs. As a result, secondary changes occur in the other component tissues (facet joints and ligaments) comprising the other elements of articulation between the vertebrae. The human body reacts to this abnormal state by producing bridging bony deposits called marginal osteophytes. If this process successfully goes to completion, it results in an auto-fusion. Bony hypertrophy can affect all five joints of the cervical vertebral segment, i.e. the disc-vertebral body unit or joint, the two facet joints, and the

two uncovertebral joints. Osteophyte hypertrophy of the uncovertebral joints is closely linked to cervical disc degeneration. The three lowest cervical motion segments are commonly involved

The symptoms of CS include pain which might be radiating or localized in the neck, limitation of neck movements, postural abnormalities, headache, paraesthesia, and symptoms of vertebra-basilar insufficiency may be present. These signs and symptoms may occur singly or in any combination and may affect the vertebral bodies, intervertebral discs, facet joints, longitudinal ligaments and ligamentous flavum [5].

Brian R. Mulligan qualified as a physiotherapist in 1954 and gained his diploma in Manipulative Therapy in 1974. He has been the author of numerous articled published in New Zealand Journal of Physiotherapy Mulligan proposed that injuries or sprains might result in a minor "positional fault" to a joint causing restrictions on physiological movement. The techniques have been developed to overcome joint `tracking' problems or `positional faults', i.e. joints with subtle biomechanical changes. Normal joints have been designed in such a way that the shape of the articular surfaces, the thickness of the cartilage, the orientation of the fibers of ligaments and capsule, the direction of pull of muscles and tendons, facilitate free but controlled movement while simultaneously minimizing the compressive forces generated by that movement Normal proprioceptive feedback maintains this balance [4]. Alteration in any or all of the above factors would alter the joint position or tracking during movement and would provoke symptoms of pain, stiffness or weakness in the patient. It is common sense then that a therapist would attempt to re-align the joint surfaces in the least provocative way while applying "MWMS" as an assessment, the therapist should look for PILL response to use the same as a Treatment: P- Pain-free, I- Instant result, LL- Long Lasting.

Mulligan's spinal mobilization with arm movements are transverse glide applied to the spinous process with active arm movement spinal movement had an important role to play in the peripheral joint by combining extremity joint mobilizations with extremity joint movement. This mobilization with movement developed because of the fact that when the shoulder girdle is moved spinal movement also takes place because of the muscle attachments from the scapula to the cervical and upper thoracic vertebra. And relieving of symptom according to mulligan when movements of the spinous process of above the affected vertebra to one side result rotation in opposite direction on below vertebra. This causes the facets to separate on opposite side and relieving the symptoms [7].

Robin McKenzie physiotherapist from New Zealand and Dr Cyrix strong influence on McKenzie's initial training consider the framework for NDT population 50-80% experience neck pain and peak prevalence 35- 55 years and most women The McKenzie method utilizes a loading strategy that incorporates the centralizing phenomenon; this is defined as a rapid change in the location of pain from a distal or peripheral location to a more proximal or central position to the spine. This has been shown to be an accurate predictor of successful conservative treatment outcome in the low back. Peripheralization occurs when symptoms move from an area more proximal to an area more distal or lateral from the midline of the spine.

Neural mobilization of the nervous system was described by Maitland in 1955 Elvey in 1986 and referred by Butler in 1991 is an adjunct to assessment and treatment of treatment of cervical radiculopathy Neural mobilization is a gentle movement technique used by a physiotherapist to move the nerves is based on neurodynamic [8-11]. Neurodynamic is now a more excepted term referring to the integrated biomechanical,

physiological and morphological function of nervous system. The benefit of such technique includes facilitation of nerve gliding, reduction of nerve adherence, dispersion of noxious fluids, increase inneurovascularity and axoplasmic flow. Neurodynamic assessment techniques are incorporated into treatment involving the passive movement of the nerve relative to its environment [12].

Materials and methods

Sample collection: Simple Random Sampling.

Source of data: This study was conducted in Kim's college of Physiotherapy and Hospital, in and around clinics, Hospital Hyderabad.

Sample selection: 60 patients. Group A: 30 patients. Group B: 30 patients.

Study duration: 4 days per week for 4 weeks, one session daily

Outcome measure:

- Northwick Park Neck Pain Questionnaire
- Vas Scale
- Inclinometer

Inclusion criteria:

- Both Genders Male and Female
- Age limit 25 -60 Years
- Unilateral C5-C7 Radiculopathy Pain
- Spurling's Test and Upper Limb Tension Test Positive
- Decreased neck ROM
- Decreased Dermatomes and Myotomes.
- Radiating pain from neck to upper limb more than 3 weeks with Spurling test positive, Cervical distraction test positive
- Physical impairment unrelated to the spine that would prevent the subjects from safely participating in any aspect of the study.

Exclusion criteria:

- Fracture of the cervical spine.
- Cervical instability/Subluxation /spondylolisthesis.
- Bilateral upper extremity radicular symptoms.
- Vestibular Basilary insufficiency.
- Cervicogenic Headache
- Vertigo
- Dizziness
- Hypermobility joints
- Thoracic outlet syndrome

Method

All the subjects were informed in detail about the type and nature of the study. The subjects were divided into two groups; Group A and Group B, 30 patients in each group. All the subjects were randomly selected and assigned to each group. A pretest measurement with the help of two measures - Northwick Park Neck Pain Questionnaire (NPNPQ) for disability and Visual Analog Scale (VAS) Inclinometer for a range of motion cervical spine movements was done in each group.

Subjects in Group-A were given Mulligan Mobilization with Upper Limb Movement for cervical regain subject were sitting. The position of the therapist: Stands beside the patient, while the his\her head was cradled between your body and your right forearm (when you stand at the his\her right side) Therapist places one thumb reinforced over other on the spinous process of the chosen vertebra (C5/C6 vertebra) as palpated with reference to C7 vertebra. The therapist then pushes down on the chosen spinous process. This pressure was sustained and the patient actively performs shoulder abduction supported by the assistant provided there is no pain. If this approach is successful, on subsequent visits, as the patient improves, an assistant applies overpressure, the glide had been chosen it must be sustained throughout the physiological movement until the joint returns to its original starting position Mobilizations performed were always into resistance but without pain provided there is no discomfort. This was quietly taken forward until end range was felt and this position is maintained for at least 10 seconds. Mobilization was given by active movement followed by passive overpressure based on the

movement restricted. 30 patients were treated mulligans mobilizations with upper limb movement for 45 minutes, 4 days for one week in four weeks [7, 8].

Subjects in Group-B were given McKenzie Exercises with Neural Mobilization subject were in supine position and remain relaxed with the feet uncrossed. The initial procedure was chin tucks or retraction exercise. A small pillow was used under the occiput to maintain slight flexion. Exercises were performed at a frequency of ten to fifteen times for three to four sets with clinician overpressure applied. The patient was given ergonomic advice on the importance of maintaining proper spinal mechanics. The individual was to avoid a forward head or chin poking posture and perform the home exercise [8, 11].

The patient was to pull his head and neck posterior into a position in which the head was directly over the shoulder girdle, while the head and eyes remained level. The end position was to be maintained for one second and then allowed to relax into a resting posture. This procedure was to be done at home for 10-15 repetitions.

- On the second and third sessions, the patient performed chin tucks without restriction and reported no pain. Progressive exercises were given, consisting of chin retractions with the addition of cervical extensions in the supine position. These were done for four sets of fifteen repetitions.
- In the second week of care, exercises were performed with the patient in the seated position. They consisted of chin tucks and neck extension exercises with clinician-applied overpressure in the end range of motion
- In the third week, retraction and extension exercises with practitioner-applied traction were performed. This involved the patient lying supine with the head off the treatment table to the upper thoracic spinal level with clinician-applied traction and extension maintained throughout the range of motion to end range
- In the fourth week of care, previously avoided movements were incorporated into the treatment regime: the first retraction with lateral flexion, then neck rotation and finally combined retraction and neck flexion with overpressure done in the sitting posture.
- These were done in four sets of fifteen repetitions. Following each exercise, ten repetitions of neck extensions were performed.

Upper Limb Movement for cervical regain subject was Position of patient supine position and remains relaxed with the feet uncrossed. The patient was slightly angled obliquely for easier access to the scapula. The therapist position was next to the plinth facing the direction of subjects face. The therapist depresses the scapula with concomitant upper extremity joint positioning as per nerve bias. The wrist was used as a tension factor and at the point where tension was felt by the therapist and perceived by the subject, grade 3 oscillations were given rhythmically and slowly to each joint from proximal to distal. A total of 20 oscillations (1 oscillation/1 second) were given to each joint with a total duration of 15 minutes. 30 patients will be treated McKenzie's exercises with Neural Mobilization for 45 minutes, 4 days for one week in four weeks [8].

Results

Wilcoxon Sum Rank Test (Mann Whitney U Test) was applied for between-group comparison of Group A and Group B, and it was as follows:
For On comparing Group A and Group B for post-treatment VAS score, results showed a significant difference in improvement in terms of VAS.

For On comparing Group A and Group B for post-treatment NPNPQ score, results showed a

significant difference in improvement in terms of NPNPQ.

Group A received for a period of 4 weeks and 4 days a week. The outcome measures were NPNPQ and VAS for disability, Pain and flexiometry for a range of motion. Values were taken before and after completion of treatment. They were then assessed statistically.

NPNPQ in group A. prior to treatment, the mean score was 31.00±3.65 and decreased to 19.83±3.51 after treatment. There was a significant improvement in their function by 11.167.

VAS in group A. prior to treatment, the mean score was and 7.40±1.04 decreased to 4.03±1.00 after treatment. There was a significant improvement in their function by 3.367.

The range of motion was considered in all planes, Flexion, Extension, Lateral flexion, Rotation was considered. In flexion, pre-treatment mean score is 24.07±6.06 degrees and post-treatment it was 37.07±5.48 degrees. There was a significant increase in the range of flexion by 13.000 degrees.

In extension pretreatment mean was 27.40±7.75 degrees and post-treatment mean score is 38.67±7.03 there was a significant increase of 11.267degrees.

In lateral flexion, the pretreatment means score was 19.23±5.21degrees and post-treatment score was 32.37±5.25 degrees. There was a significant increase of 13.133 degrees.

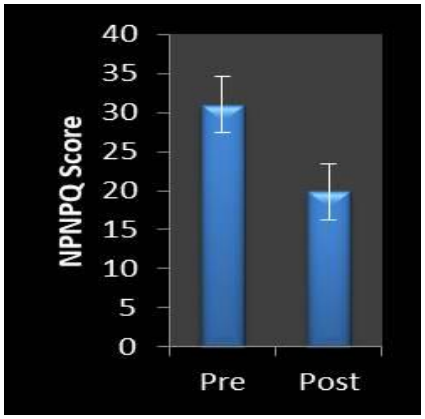
In the rotation, the pretreatment means score was 28.83±9.89 degrees and post-treatment was 41.37±9.63 degrees. There was a significant increase of 12.533 degrees after the treatment.

In shoulder abduction, the pretreatment mean scores was 93.73±8.91 degrees and post-treatment 124.87±16.55 degrees. There was a significant increase 31.133 of degrees after the treatment (**Table – 1, Graph – 1 to 6**).

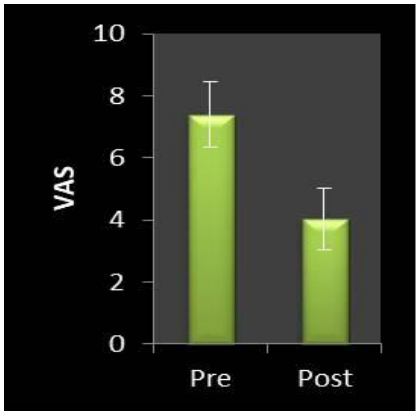
Table – 1: Assessment of outcome variables pre and post assessment in group A patients studied.

variables	Pre	Post	difference	t value	P value
NPNPQ Score	31.00±3.65	19.83±3.51	11.167	29.000	<0.001**
VAS	7.40±1.04	4.03±1.00	3.367	29.000	<0.001**
Flexion	24.07±6.06	37.07±5.48	-13.000	29.000	<0.001**
Extension	27.40±7.75	38.67±7.03	-11.267	29.000	<0.001**
Lateral flexion	19.23±5.21	32.37±5.25	-13.133	29.000	<0.001**
Rotation	28.83±9.89	41.37±9.63	-12.533	29.000	<0.001**
Shoulder abduction	93.73±8.91	124.87±16.55	-31.133	29.000	<0.001**

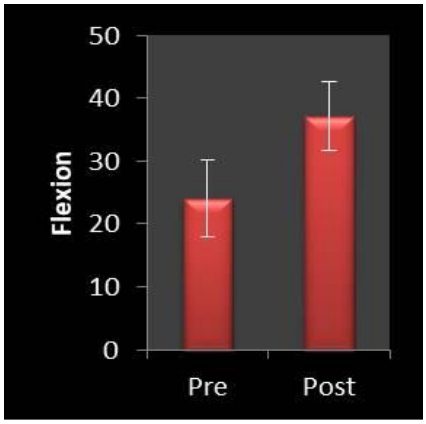
Graph – 1: NPNPQ Score.



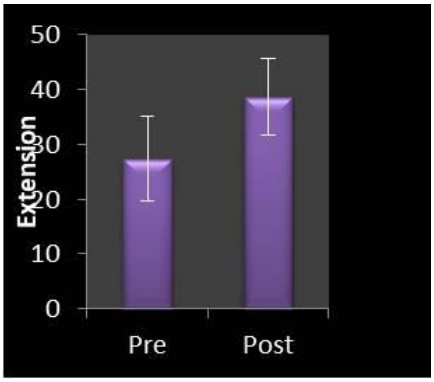
Graph – 2: VAS.



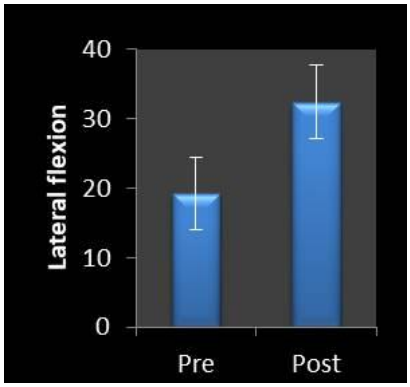
Graph – 3: Flexion.



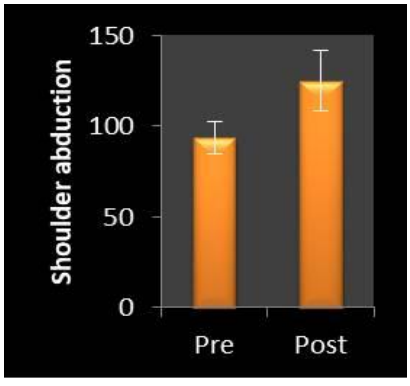
Graph – 4: Extension.



Graph – 5: Lateral flexion.



Graph – 6: Shoulder abduction.



Group-B McKenzie Exercises with Neural Mobilizations

Group B McKenzie Exercises with Neural Mobilizations for disability, Pain and flexiometry for a range of motion Values were taken before and after completion of treatment. They were then assessed statistically.

NPNPQ in group B prior to treatment the mean score was 30.87±3.39 and decreased to 8.83±1.97 after treatment. There was a significant improvement in their function by 22.03 degree.

VAS in prior to treatment the mean score was 7.13±0.68 and decreased to1.97±0.62 after treatment. There was a significant improvement in their function by 5.166 degree. The range of motion was considered in all planes. Flexion, extension, abduction, internal rotation and rotation ROM were considered.

In flexion, pre-treatment mean score was 25.30±5.31 degrees and post-treatment it is 40.07±5.13 degrees. There was a significant increase in the range of flexion by 14.767 degrees.

In extension, pre treatment means the score was 23.20±5.29 degrees and post treatments mean score was 40.40±4.15there was a significant increase of 17.200degrees.

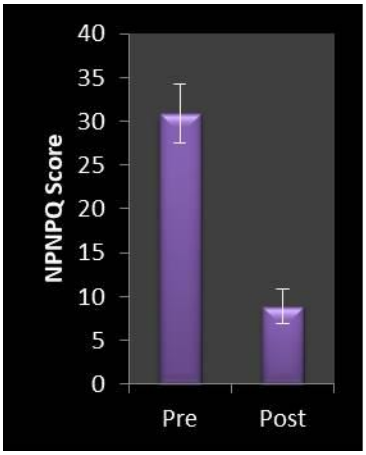
In lateral flexion, the pre treatment score was 20.33±5.48degrees and the post-treatment score is 35.60±3.64 degrees. There was a significant increase of 15.267 degrees.

In Rotation, the pre treatment score was 28.37±6.75degrees and post-treatment was 43.87±5.93degrees. There is a significant increase of 15.500degrees after the treatment. In shoulder abduction, the pre-treatment scores were 91.37±22.94 degrees and post-treatment 144.33±11.65 degrees. There was a significant increase of 52.967degrees after the treatment (**Table – 2, Graph – 7 to 12**).

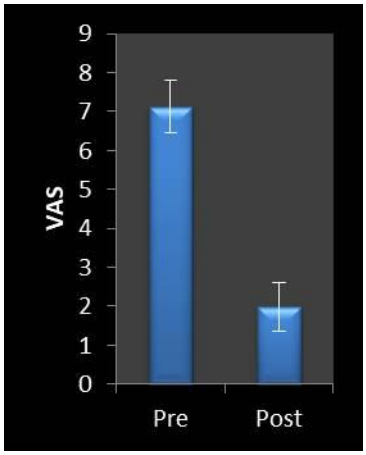
Table – 2: Assessment of outcome variables pre and post assessment in group B patients studied.

variables	Pre	Post	difference	t value	P value
NPNPQ Score	30.87±3.39	8.83±1.97	22.03	32.784	<0.001**
VAS	7.13±0.68	1.97±0.62	5.166	29.792	<0.001**
Flexion	25.30±5.31	40.07±5.13	-14.767	-20.322	<0.001**
Extension	23.20±5.29	40.40±4.15	-17.200	-19.083	<0.001**
Lateral flexion	20.33±5.48	35.60±3.64	-15.267	-13.767	<0.001**
Rotation	28.37±6.75	43.87±5.93	-15.500	-10.173	<0.001**
Shoulder abduction	91.37±22.94	144.33±11.65	-52.967	-14.633	<0.001**

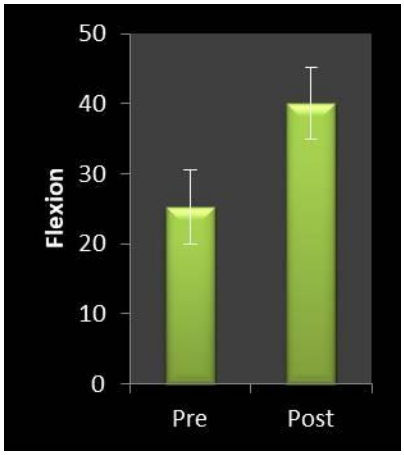
Graph – 7: NPNPQ Score.



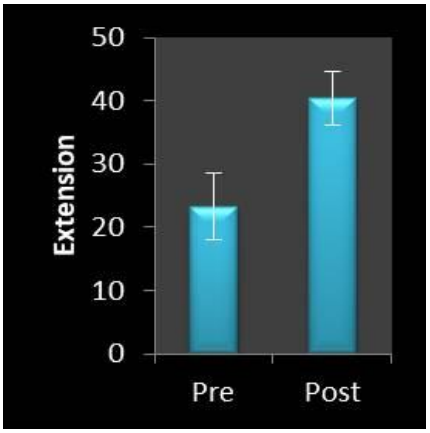
Graph – 8: VAS.



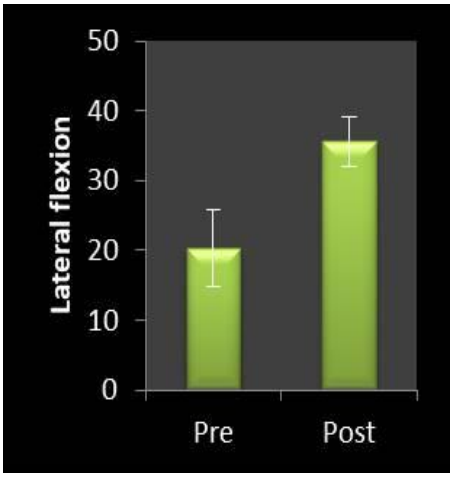
Graph – 9: Flexion.



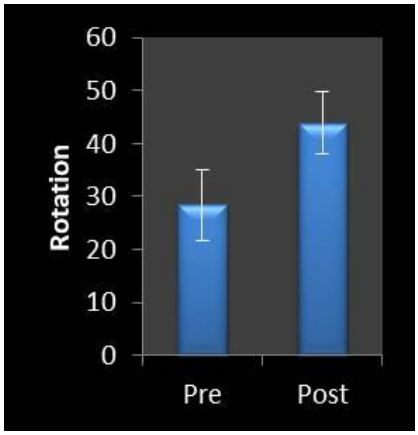
Graph – 10: Extension.



Graph – 11: Lateral flexion.



Graph – 12: Rotation.



Discussion

The overall study proved that both Mulligan mobilization with upper limb movement and McKenzie exercises with neural mobilization is effective in improving Pain and decreasing the disability level in cervical radiculopathy subjects. Vincenzino proposed that Mulligan techniques help in improving patient's symptoms by correcting minor positional fault and by the neurophysiologic mechanism [13, 14].

According to paungmali et al MWM produces a hypoalgesia and concurrent sympathoexcitation. It has been previously proposed that the combination sympathoexcitation [16], non-opioid hypoalgesia and improvement in motor function are indirect signs of possible involvement of endogenous pain inhibitory systems in manual therapy treatment effects. Individuals with cervical radiculopathy show altered neurodynamic so neural mobilization technique was used to improve altered neurodynamics [8].

McKenzie in the treatment of the derangement syndrome causes extension of the lower cervical segments and may alleviate stress on the posterior annulus and thereby relieve pain. In patients with neck and radicular pain, repeated neck retraction was shown to result in a significant decrease in peripheral pain and decreased nerve root compression, whereas neck flexion produced an increase in peripheral pain and nerve compression. Additional benefits may occur. In a study of normal subjects, individuals adopted a less protracted posture after repeated neck retraction movements [17-20].

Ellis RF and Hing WA did an analysis of studies and concluded a positive benefit from using neural mobilization in the treatment of altered neurodynamics [11]. Neural mobilisation restores the dynamic balance between the relative movement of neural tissues and surrounding mechanical interfaces allowing reduced intrinsic pressures on the neural tissue promoting optimum physiologic function [12]. There is the facilitation of nerve gliding, reduction of nerve adherence, dispersion of noxious fluids, increased neural vascularity and improvement of axoplasmic flow which reduces disability level and improves range of motion [15].

Conclusion

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.

Reference

1. Jeffery Mullin, Daniel Shaded, Bezels. Overview of Cervical Spondylosis Pathophysiology and Biomechanics. WSCJ, 2011; 2: 89-97.
2. Ortho Info. Org, American Academy of Orthopaedic Surgeong, Cervical Spondylosis Arthritis of Neck. Accessed from https://orthoinfo.aaos.org/en/diseases--conditions/cervical-spondylosis-arthritis-of-the-neck/
3. Cervical radiculopathy. American Academy Of Orthopaedics Surgeons, Copyright 1995-2015. Accessed from https://slidex.tips/download/org-cervical-radiculopathy-pinched-nerve-anatomy-cause
4. Dr. Sarathbabu V. Effects of Mobilizations, Stretchings, And Traction In Sports Professional With Cervical Radiculopathies. Issn 2249-717. Accessed from https://www.scribd.com/doc/76542669/Effects-of-Mobilization-Stretching-and-Traction-in-Sports-Professionals-With-Cervical-Radiculopathies-For-Merge
5. Wainner RS, Gill H. Diagnosis and nonoperative management of cervical radiculopathy. J Ortho Sports Phys Ther., 2000; 30: 728–744.

6. Radhakrishnan K, Litchy WJ, O'Fallon WM, Kurland LT. Epidemiology of cervical radiculopathy: A population-based study from Rochester, Minnesota, 1976 through 1990. Brain, 1994; 117(Pt 2): 325-35.
7. Brain R Mulligan. Manual therapy: "NAGS", "SNAGS", "MWM" etc., 4th edition, New Zealand, Wellington, 1999; p. 16-24.
8. David S. Butler. Mobilization of the nervous system. 1st edition, Elsevier Churchill Livingstone, 1994; p, 189.
9. Hendiani JA, Westlund KN, LAwand N, et al. Mechanical sensation and pain thresholds in patients with chronic arthropathies. J Pain, 2003; 4: 203-211.
10. Mulligan BR. Manual Therapy "NAGS", "SNAGS", and "MWMS" etc. 6th revised edition, 2010.
11. Ellis RF, Hing WA. Neural mobilization: a systematic review of randomized controlled trials with an analysis of therapeutic efficacy. J Man Manip Ther., 2008; 16(1): 8-22.
12. Jeffrey Alan Schroder. Manual Therapy and Neural Mobilization: Our Approach and Personal Observations. Orthopaedic Practice, 2004; 16(4): 23- 27.
13. Fuentes JP, Olivo SA, David J. Magee DJ, Gross DP. Effectiveness of interferential current therapy in the management of musculoskeletal pain: a systematic review and meta-analysis. Phys Ther 2010; 90(9): 1219–1238.
14. Mohammad Taghi Joghataei. The effect of cervical traction combined with conventional therapy on grip strength on patients with cervical radiculopathy: clinical rehabilitation, 2004; 18: 879-887.
15. Alired A. Rim., Arthur J Hartex, Bill Vincenzino, Aatit Paungmali, Pamela Teys. Basic Biostatistics in Medicine and Epidemiology, Mulligan's mobilization with movement, positional faults and pain relief: current concepts from a critivcal review of literature. Manual Therapy, 2007.
16. Aatit Paungmali, Shaun O Leary, Tina Soulvis. Hypoalgaesic and sympathoexcitatory effects of mobilization with movement for lateral epicondyalgia. Physical Therapy; 2003; 83: 374-83.
17. Butler DS. Adverse mechanical tension in the nervous system: a model for assessment and treatment. Aust J Physiother, 1989; 35(4): 227-38.
18. Rebecca Reisch, Kimberly Williams, Robert J. Nee, Richard A. Rutt. Median Nerve Bias-Examiner Reliability and Sensory Responses in Asymptomatic Subjects. Journal of Manual and Manipulative Therapy, 2005; 13(1): 44-55
19. Bernard Rosner. Fundamentals of Biostatistics, 5th Edition, Duxbury, 2000, p. 80-240.
20. Robert H Riffenburg. Statistics in Medicine, second edition, Academic press, 2005; 85-125.