ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25sep118

Effectiveness of Action Observation Therapy with Neural Tissue Mobilization for Pain Modulation and Disability in Lumbar Radiculopathy: An Experimental Study

Simran Kanojia[1*]; Dr. Tayyaba Munawar[2]

[1]Bpth Intern, Rashtrasant Janardhan Swami College of Physiotherapy (Affiliated to Maharashtra University of Health Sciences, Nashik) Ahilyanagar, Maharashtra, India
[2]Mpth (Neuro Physiotherapy), Associate Professor, Department of Neuro Physiotherapy, Rashtrasant Janardhan Swami College of Physiotherapy (Affiliated to Maharashtra University of Health Sciences, Nashik) Ahilyanagar, Maharashtra, India

Corresponding Author: Simran Kanojia[1*]

Publication Date: 2025/09/08

Abstract:

- ***Introduction*:**

Lumbar radiculopathy is one of the consequence of Lumbar Disc Herniation which leads to functional impairment, sensory abnormalities, and radiating discomfort. Conventional physiotherapy includes exercise therapy use of electrical modalities Neural mobilization technique offers symptomatic relief. However, techniques like AOT (Action Observation Therapy) works on cortical neuroplasticity and possible results in pain modulation. NTM (Neural Tissue Mobilizaton) works on lengthening of of nerve leading to pain relief and improving functional recovery.

- ***Methodology:***

The experimental study included thirty-four people between 20 and 50 years with unilateral lumbar radiculopathy brought on by grade 1–2 disc protrusion. Participants underwent AOT (action observation followed by imitation of lumbar stabilization and stretch exercises) and NTM (slider technique in supine and slump sitting) over four weeks. Baseline assessment and four weeks measurements of pain intensity were done using the Numerical Pain Rating Scale (NPRS) and disability using the Modified Roland-Morris Disability Questionnaire (RMDQ).

- ***Results:***

Post-intervention, pain was substantially decreased (mean NPRS: 5.03 to 2.26; $p < 0.01$, 55.4% reduction) and disability was reduced (mean RMDQ: 14.59 to 5.21; $p < 0.01$; 65.2% reduction). These improvements show that the combined protocol successfully controlled pain and improved functional condition.

- ***Conclusion:***

AOT in conjunction NTM is an effective therapy for pain modulation and disability reduction in lumbar radiculopathy. The method builds on neuroplasticity via visual-motor engagement while addressing mechanical nerve mobility, therefore implying a synergistic benefit over conventional therapy.

- ***Abbreviations:***

AOT: Action Observation Therapy, NTM: Neural Tissue Mobilization NPRS: Numerical Pain Rating Scale, RMDQ: Roland Morris Disability Questionnaire, ROM: Range of motion, TENS: Transcutaneous Electrical Neuromuscular Stimulation, IFT: Interferential Therapy, MNS: Mirror Neuron System, ICC: Intraclass Correlation Coefficient, SLR: Straight Leg Raise, MRI: Magnetic Resonance Imaging, SIP: Sickness Impact Profile.

Keywords: *Lumbar Radiculopathy, Action Observation Therapy, Neural Tissue Mobilization, Neuroplasticity, Conventional Therapy.*

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25sep118

How to Cite: Simran Kanojia; Dr. Tayyaba Munawar (2025) Effectiveness of Action Observation Therapy with Neural Tissue Mobilization for Pain Modulation and Disability in Lumbar Radiculopathy: An Experimental Study. *International Journal of Innovative Science and Research Technology*, 10 (9), 24-30. https://doi.org/10.38124/ijisrt/25sep118

I. INTRODUCTION

"Lumbar Radiculopathy" also referred to as low back pain radiating down to either one or both extremities.[1] It is a pain syndrome resulting from irritation or compression of nerve roots caused by degeneration of lumbar vertebral spine, herniation of lumbar disc which can cause foraminal narrowing, where the spinal nerves are compressed as they exit the spinal canal, leading to potential symptoms such as pain, numbness, and weakness in the lower back and legs.[2] And based on the level of spinal nerve root involved it determines the particular dermatome affected.[1] It is one of the most frequent neurological complaints to be found by neurosurgeon who practices in the rural community.[3]

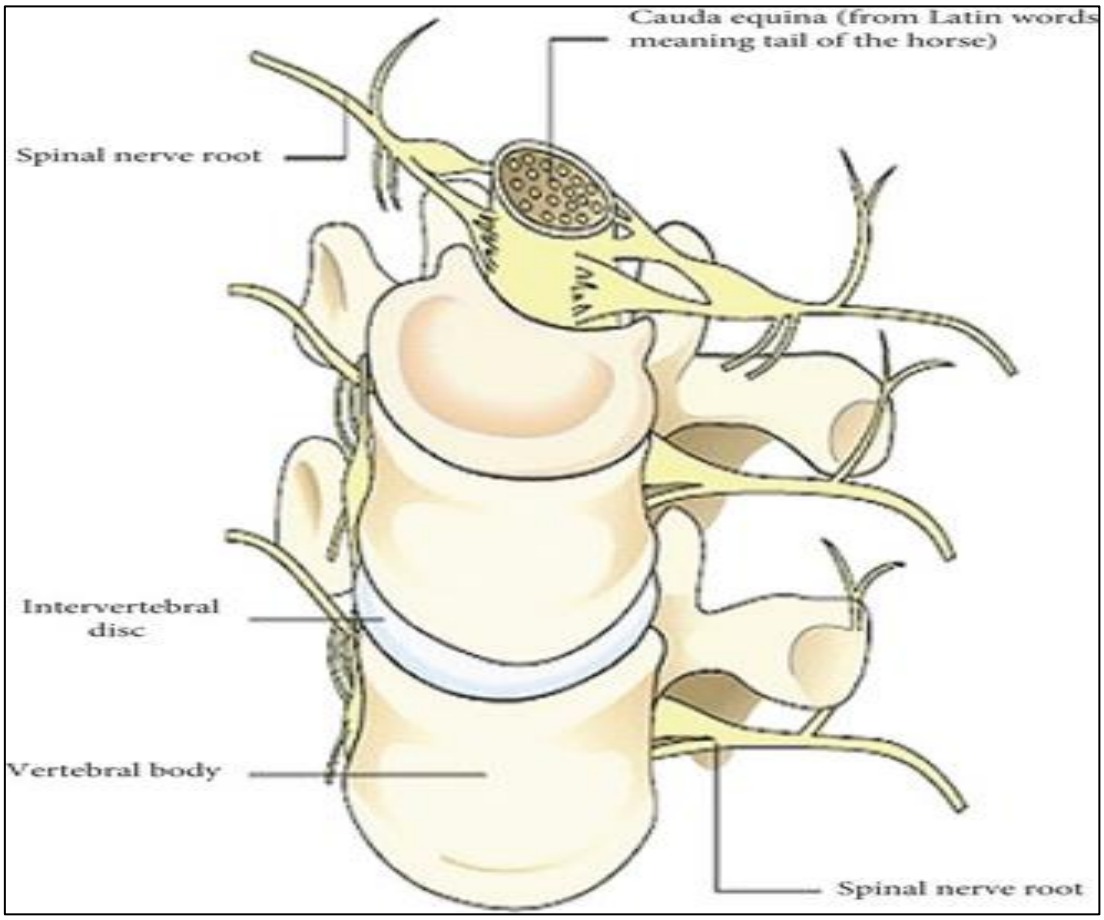

Fig 1 Normal Intervertebral Disc and Spinal Nerve Root [15]

Lumbar disc herniation affects 60-80% of the general population at some point in their lifetime. In India, the incidence of lumbar radiculopathy is reported to be around 23.09%.[1] And more than 1 crore patients per year suffers from pain radiating through lower back to buttocks and leg along the nerve distribution.[2] Sciatic nerve is the thickest nerve of the body. And it is the terminal branch of the lumbosacral plexus, having root value – Ventral rami L_4, L_5, S_1, S_2, S_3 and is made up of two parts- the Tibial and the common peroneal part. Compression of one or more nerve roots forming the sciatic nerve can result in sharp shooting pain along the cutaneous distribution of sciatic nerve and its terminal branch, chiefly the common peroneal is known as "Sciatica".[4]The primary causes for nerve root compression can be degenerative changes or intervertebral disc herniation, additionally the commonly involved etiology with Lumbar Radiculopathy are inflammation, neoplasm, infection, vascular disease or congenital abnormalities[5] Disc prolapse or herniated disc is classified into "protrusion", "extrusion" and "sequestration". Among all these disc protrusion is characterized by a focal bulging of the disc that is less in diameter than the base of the herniation, typically a wider base than a disc extrusion, whereas in disc extrusion the nucleus pulposes ruptures through the annulus fibrosus, resulting in a herniation with smaller base and a larger diameter in the spinal canal and eventually in sequestration, a fragment of the herniated disc breaks off and migrates away from the parent disc, losing continuity and contact with the remaining disc tissue.[6] Due to these underlying causes, several commonly presenting symptoms are observed such as electric, burning, sharp radiating pain along the dermatomal distribution, tingling sensation, paresthesia, numbness, weakness with myotomal distribution radicular pain and altered deep tendon reflexes depending upon the nerve root

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25sep118

involved.[3,7]Lumbar disc herniation often causes radiculopathy. Mild symptoms may resolve with conservative treatment, while severe cases require surgery. Discectomy, removing the herniated disc and relieving pressure on the affected nerve, is the gold standard surgical approach. "Discectomy, via open, mini-open, or endoscopic approaches, aims to: Remove herniated disc material, Decompress affected nerve roots and alleviate symptoms"[8]. Physiotherapy for lumbar disc herniation offers various conservative care options, including:

- Exercises (stretching, strengthening, ROM, Lumbar stabilization).
- Massage therapy
- Modalities (Traction, TENS, IFT)
- Mobilization techniques (spinal, neural tissue)

These approaches promote pain relief, improved mobility, and functional recovery."[1, 9] But recently, advanced physiotherapy rehabilitation interventions have evolved to reflect new perceptions of neuroscience. Neuroplasticity refers to the dynamic capacity of the nervous system to reorganize and adapt in response to the environmental factors, physiological fluctuations and life experiences. Breakthroughs in neurophysiology have enabled the development of sophisticated treatment methods aimed at harnessing cortical plasticity or reorganization. Ever since, the unveiling of the Mirror Neuron System it has led to the establishment of Action Observation Therapy. The followings also refers to AOT (Action Observation Therapy) are “visual feedback” “action stimulation” “motor stimulation” and “mirror neuron”.

As mentioned the MNS refers to a set of neurons dispensed throughout the brain. And these set of neurons fires equally when one is observing the action and when one is physically executing the action by themselves. Over the past few years, AOT has emerged as a novel therapeutic approach which involves observation of purposeful actions with intent to mimic or imitate followed by self-execution promoting functional independence. Action Observation Therapy (AOT) boosts motor recovery by observing movements, engaging the motor system, and reorganizing cortical changes. It's time-efficient, can be done independently, and often precedes physical practice [10] Whereas, prolonged peripheral nerve compression can disrupt the nerve’s ability to stretch and slide, leading to nerve damage. So, Neural Tissue Mobilization (NTM) relieves compressed nerves by sliding, lengthening, breaking adhesions, and restoring neural plasticity. And neural mobilization utilizes the sliding principle which was introduced by Shacklock, incorporates combining movements of two joints to facilitate neural gliding and reduces tension. NTM provides immediate pain relief and improved mobility [1] in lumbosacral radicular symptoms, the most common complaints are pain and inability to perform normal daily activities. The outcome measure for pain assessment is Numerical Pain Rating Scale (NPRS) having (ICC 0.95) reliability and good validity (r = 0.941) [11] whereas for disability the outcome measure is Modified Roland-Morris Disability Questionnaire (RMDQ) having (ICC 0.91) reliability and good validity [12]

II. METHOD

This study was designed as a pre-post experimental investigation to assess the effectiveness of Action Observation Therapy with Neural Tissue Mobilization for pain modulation and disability in Lumbar Radiculopathy. First of all, ethical clearance for the study was obtained from the Institutional Ethics Committee of Rashtrasant Janardhan Swami College of Physiotherapy, Kopargaon. The research was conducted over a period of six months at the Physiotherapy Department of RJS College of Physiotherapy, Kokamthan, in association with SJS Hospital. The sample consisted of 34 participants, in between the Age of 20-50 years including both male and female patients, selected through a convenient sampling method.

Participants diagnosed with pre- operative protruded lumbar disc with grade 1 and 2 were included specifically. Prior to participation, all individuals were screened for eligibility based on specific inclusion and exclusion criteria. Participants presenting with unilateral radiculopathy in the distribution of sciatic nerve were included. SLR-I and SLUMP test for sciatic nerve and MRI of spine were used as a primary screening tool to confirm Lumbar Radiculopathy. All participants provided written informed consent before commencing the intervention. The two standardize outcome measure used in this study was the Numerical Pain Rating Scale (NPRS) to evaluate pain intensity which should be less than or equal to 7. And The Modified Roland-Morris Disability Questionnaire (RMDQ) was employed to assess functional disability caused by lumbar disc herniation. Both tools are well-established, valid, and reliable in clinical and research settings.

Participants were assessed before and after a 4-week session of treatment. The pre- and post-intervention scores of NPRS and Modified RMDQ were statistically compared to determine the effectiveness of the treatment.

- *Inclusion Criteria:*

- Age of 20 -50 years of both sexes
- Protruded Lumbar disc Grade 1 and 2
- Unilateral radiculopathy in the distribution of sciatic nerve
- Positive Straight leg raise I (SLR) at 30^{o} with provocation
- Positive Slump test
- Mild to moderate pain on pain scale of NPRS <7

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25sep118

III. PROCEDURE

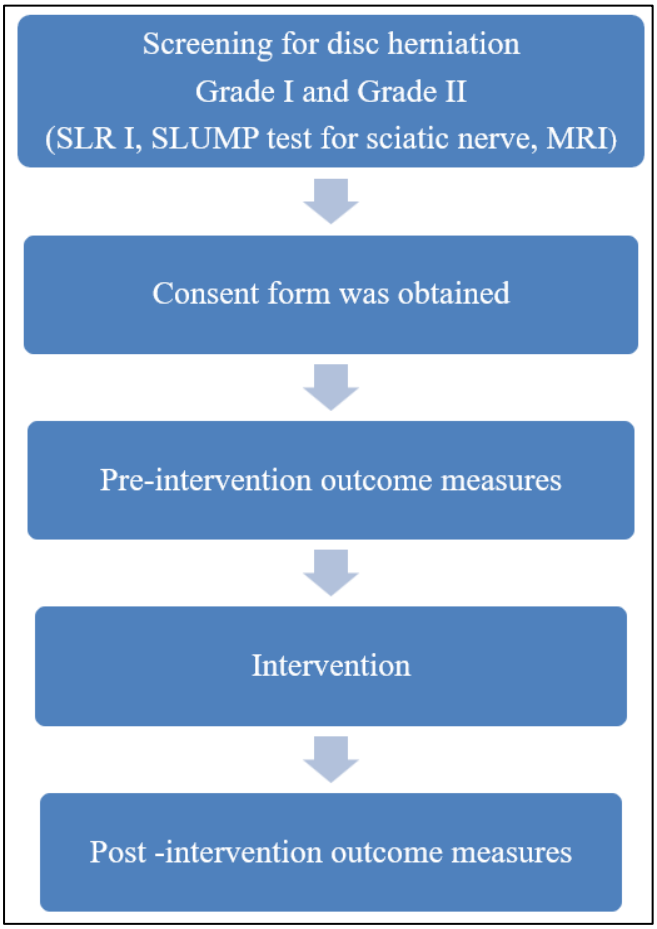

Fig 2 Flow Chart

Firstly, the screening of the subjects were done and the consent was obtained. Then, the pre –intervention assessment was evaluated and based on that, the eligible participants received a 4-week combination therapy of Action Observation Therapy (AOT) and Neural Tissue Mobilization (NTM). The sessions were administered once daily six days per week for 4 weeks, including video observation, exercise simulation , which involves, Back isometrics, Back extension exercise, straight leg raise with 10 seconds hold, Lumbar stabilization exercises (cat and camel, bird dog , lumbar lateral rotation exercise), etc stretching exercises(hamstring and calf), 10 repetitions x 5 set with 2 minutes of break between each set for 4 weeks, neural gliding (in sitting and supine position) each oscillation was of 4 seconds (4seconds x 5sets x 2minutes) and 2 minutes of break between 2 sets, superficial moist heat for 10 minutes and ergonomic training, each session lasted for 30 to 40 minutes. Also, throughout the trial, volunteers were observed for clinical response and adherence. For clinical follow-up, therapists noted pain intensity changes as well as functional performance following each session. And lastly, the participants had the same baseline evaluation after finishing 4 weeks of therapy.

The pre- and post-intervention scores were then statistically analysed to determine the combined effect of both action observation therapy and neural tissue mobilization in individuals with Lumbar Radiculopathy.

➢ *Outcome Measures*

To evaluate the effectiveness of the intervention, two standardized outcome measures were used before and immediately after the treatment. The Numerical Pain Rating Scale (NPRS) was utilized to assess the intensity of Lumbar Radiculopathy, where participants rated their pain on a scale from 0 (no pain) to 10 (worst possible pain). Secondly, the Modified Roland-Morris Disability Questionnaire (RMDQ) is a health condition assessment meant to be completed by patients to evaluate physical disability caused by low back discomfort. Sickness Impact Profile (SIP), a 136-item health status instrument encompassing all facets of physical and psychological performance, generated the RMDQ. From SIP twenty-four things were picked by the original authors since they were directly connected to physical processes probably impacted by low back pain. To differentiate back pain disability from disability resulting from other reasons, every object was labelled with the phrase "because of my back pain." Consequently, several researchers have suggested revisions for the RMDQ. From "because of my back" to "because of my back or leg problem," the most basic change to the questionnaire's language has been made to the final line of each statement. This makes the questionnaire more appropriate for use in a population of sciatica patients and is a suitable modification. The outcome measure for pain assessment is Numerical Pain Rating Scale (NPRS) having (ICC 0.95) reliability and good validity (r = 0.941) whereas for disability the outcome measure used was Modified Roland-Morris Disability Questionnaire (RMDQ) having (ICC 0.91) reliability and good validity.

Hence, Both the outcome measures are widely accepted for their reliability and validity in assessing musculoskeletal pain and functional limitations.

➢ *Data Analysis*

The statistical analysis was carried out using STATISXL version 2.0. The study used a paired t-test to examine the effect of the intervention on two important outcome metrics—Numerical Pain Rating Scale (NPRS) and Modified Roland- Morris Scale (RMDQ) by comparing pre-intervention and post- intervention values in the same participants (n=34). The mean pre-intervention NPRS score of 5.03± 0.94 dropped to 2.26 ± 0.90 post- intervention. NPRS had an average decrease of 2.76 points. With a 'p' value less than 0.01, the paired t-test produced a t-value of 18.86 (df =33), indicating a statistically significant decrease in pain levels after the treatment. The mean pre-intervention RMDQ score of 14.59 ± 2.73 fell to 5.21 ± 2.14 post-intervention. The paired t-test revealed a 't'value of 29.96 (df=33) with a 'p'value <0.01, showing a statistically significant improvement in functional capacity; the mean decrease in RMDQ was 9.38 points. So, we can confidently say that the treatment worked well in helping the participants feel better.

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25sep118

Table 1 Comparison of Numerical Pain Rating Scale (NPRS) Score Pre and Post Intervention

Pre – NPRS	Post – NPRS	Mean Difference	% decrease in post NPRS	'P' Value	't' Value
5.03	2.26	2.76	55.44%	< 0.01	18.857

This table shows that mean NPRS differs significantly between pre and post-tests. From the table it can be observed that the mean NPRS in the post-test 2.26 is less than that of the pre-test score 5.03. The 't' value 18.857 is significant ('p' <0.01). Hence the intervention used in the study group decreases the NPRS.

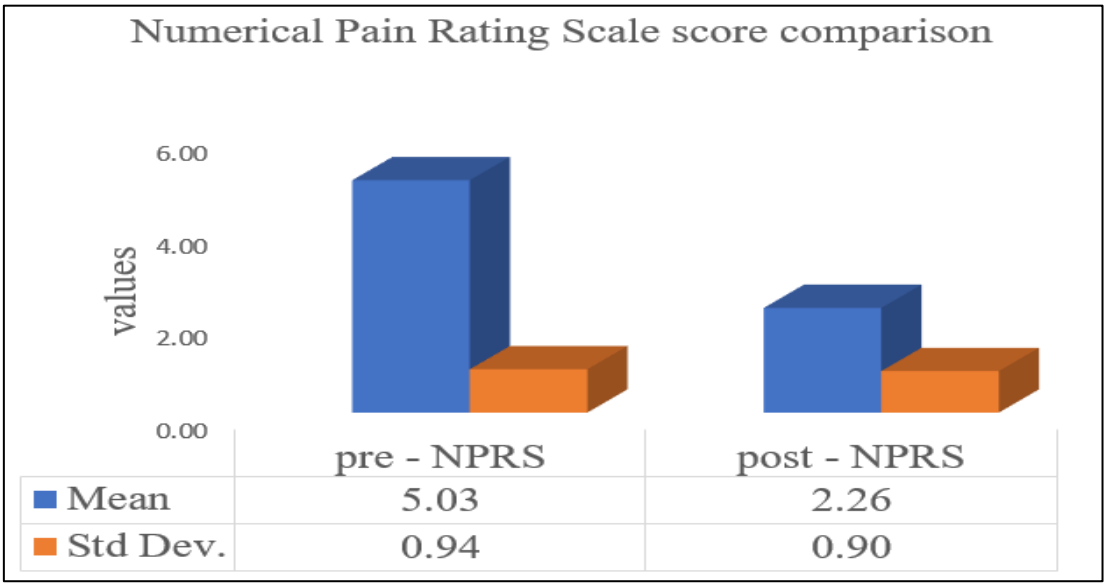

Fig 3 Numerical Pain Rating Scale Score Comparison (NPRS)

The Figure 3 represents that mean NPRS differs significantly between pre and post-tests. From the table it can be observed that the mean NPRS in the post-test 2.26 is less than that of the pre-test score 5.03.

Table 2 Comparison of Modified Roland – Morris Disability Questionnaire (RMDQ) Score Pre and Post Intervention

Pre – RMDQ	Post – RMDQ	Mean Difference	% decrease in post RMDQ	'P' Value	't' Value
14.59	5.21	9.38	65.2	<0.01	29.961

This table shows that mean Modified Roland–Morris Disability Questionnaire differs significantly between pre and post-test. From the table it can be observed that the mean RMDQ in the post-test 5.21 is less than that of the pre-test score 14.59. The 't' value 29.961 is significant ('p' <0.01). Hence the intervention used in the study group decreases the Modified RMDQ.

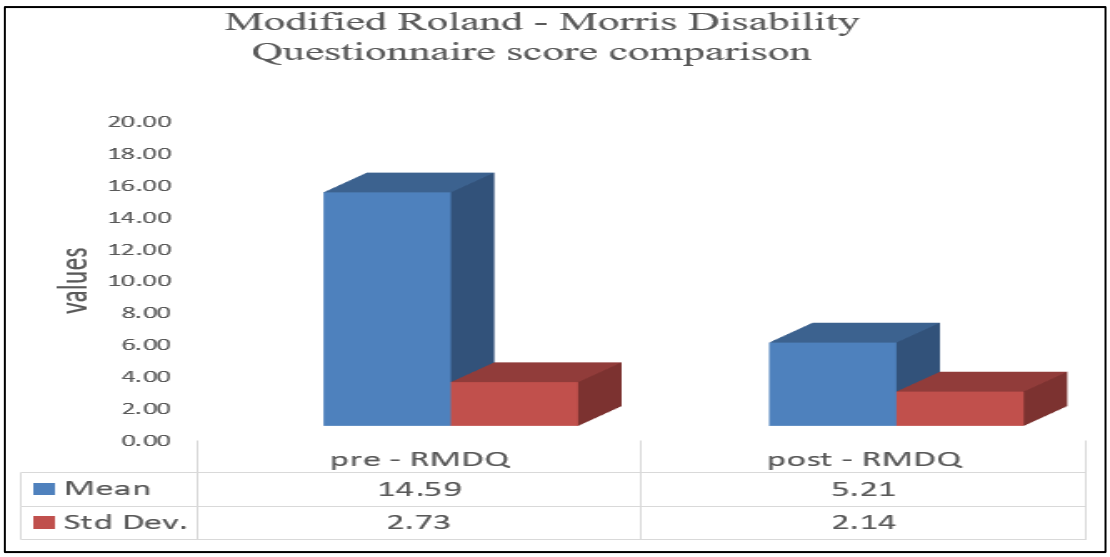

Fig 4 Comparison of Modified Roland- Morris Disability Questionnaire Score

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25sep118

The Figure 4 represents that mean Modified RMDQ differs significantly between pre and post-tests. From the table it can be observed that the mean RMDQ in the post-test 5.21 is less than that of the pre-test score 14.59.

IV. RESULTS

In this study, a total of 34 participants (16 males, 18 females; age range: 20–50 years; mean age: 41.7 ± 7.3 years) with unilateral lumbar radiculopathy completed the four-week intervention plan consisting of Action Observation Therapy (AOT) and Neural Tissue Mobilization (NTM). Using the Numeric Pain Rating Scale (NPRS) and the Modified Roland-Morris Disability Questionnaire (RMDQ), pain and functional impairment were assessed at baseline and at the end of the intervention period. Out of the 34 participants 16 (47.1%) were males; 18 (52.9%) were females. Participants were 41.7 ± 7.3 years old on average. For Pain Outcomes the Mean NPRS fell from 5.03 ± 0.94 before the intervention to 2.26 ± 0.90 after the intervention. And the mean difference was 2.76 points, which represented a 55.4% decrease in pain severity. Paired t-test analysis revealed a t-value of 18.86 (df =33, $p < 0.01$), therefore validating a very significant reduction in pain intensity after the therapy. And it shows a regular percent reduction in reported pain in the participants. Regarding the Disability Outcomes (RMDQ) The Mean RMDQ declined from 14.59 ± 2.73 prior to intervention to 5.21 ± 2.14 after the intervention with an average mean change of 9.38 points, disability levels were reduced by 65.2%. Confirming a very significant increase in functional ability, paired t-test analysis produced a t-value of 29.96 (df =33, $p < 0.01$). This shows a significant decrease in RMDQ scores across participants after the intervention. Both pain intensity and functional incapacity showed statistically significant improvement after four weeks of combined AOT and NTM treatment. And the study's Interpretation notes 55.4% reduction in pain and 65.2% drop in disability—both of which are clinically significant improvements. Participants showed no negative consequences during or after the intervention.

These results validate the synergistic advantage of combining neurocognitive rehabilitation (AOT) with biomechanical intervention (NTM) to treat both central and peripheral aspects of lumbar radiculopathy.

V. DISCUSSION

The results of this study show that managing lumbar radiculopathy results in significant advantages when AOT and NTM are combined. The statistically significant changes in NPRS and Modified RMDQ ratings point to the complementary means by which these treatments work. Using the mirror neuron system of the brain, AOT involves motor cortical regions by observing and mimicking of practical motions. Besides helping motor learning, this method may also activate endogenous pain suppression channels. The significant functional improvements seen in this study may be explained by the neuroplastic changes prompted by AOT. NTM improves the capacity of nerve tissues to slide and elongate, lowers mechanosensitivity, and restores normal neural mobility—thus addressing their mechanical interface. Directly lowering peripheral nociceptive input, which may synergize with central modulation to lessen the pain, NTM relieves nerve compression and breaks adhesions.

Using a paired t-test, the study assessed the impact of the intervention on two main outcome indicators: Numeric Pain Rating Scale (NPRS) and Modified Roland Morris Questionnaire (RMDQ) by contrasting post-intervention and pre- intervention scores in the same subjects (n=34). The mean pre-intervention NPRS score was 5.03 ± 0.94; post-intervention, this dropped to 2.26 ± 0.90. Average decrease in NPRS was 2.76 points. The paired t-test produced a t-value of 18.857 (df =33), with a p- value < 0.01 showing a statistically significant drop in pain levels after the treatment. The mean pre- intervention RMDQ score was 14.59 ± 2.73; post-intervention, it fell to 5.21 ± 2.14. The paired t-test yielded a t-value of 29.961 (df =33), with a p-value less than 0.01, suggesting a statistically significant improvement in functional capacity. The mean decrease in RMDQ was 9.38 points. The observed percentage reductions in pain (55.4%) and disability (65.2%) over four weeks are clinically relevant and suggest that combining AOT + NTM might be a useful complement to conventional physiotherapy practices. Nevertheless, the study limitations should be noted: a little sample size, one-centre recruitment, and brief follow up. Future research should compare combined AOT + NTM with each intervention alone and assess long-term results to see whether sustained efficacy is achievable. Thus, this study revealed that combining Action Observation Therapy (AOT) with neural tissue mobilization (NTM) greatly lowered disability and pain in lumbar radiculopathy. Consistent with David Morales Tejera et al. (2020), AOT enhances pain modulation and motor imagery through mirror neuron system activation, hence supporting central neuroplastic alterations. Similarly, Subarna Das et al. (2018) found that NTM enhances pain, disability and straight leg raise, while Lin et al. validated its consistent benefits across acute and chronic cases.

Therefore, the combination here appears to provide enhanced benefits when contrasted with earlier research using AOT or NTM independently. Although neural mobilization alone has been proven to reduce pain and disability, its integration with a neurocognitive approach like AOT targets both peripheral and central factors contributing to radiculopathy. By tackling both neurocognitive and biomechanical aspects of lumbar radiculopathy, AOT combined with NTM might thus be an efficient pain alleviation and functional improvement strategy.

VI. CONCLUSION

The study comes to the conclusion that Action Observation Therapy (AOT) together with Neural Tissue Mobilization (NTM) helps to alleviate pain and increase functional capacity in patients with lumbar radiculopathy. Important drops in NPRS and Modified Roland-Morris Disability Questionnaire after four weeks imply that this

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25sep118

hybrid strategy tackles both the mechanical and neuroplastic aspects of the disorder.

The treatment offers a thorough rehabilitation approach by combining peripheral nerve mobility restoration with cortical reorganization techniques. For lumbar radiculopathy, this method is a useful complement to traditional physiotherapy therapy.

REFERENCES

[1]. Das S, Dowle P, Iyengar R. Effect of spinal mobilization with leg movement as an adjunct to neural mobilization and conventional therapy in patients with lumbar radiculopathy: Randomized controlled trial. J Med Sci Res [Internet]. 2018;6(1):11–9.

[2]. Madavi SK, Chakole V, Sen J, Singam A, Rallabhandi S, Verma N. Comparison of Lumbar Transforaminal Epidural Dexamethasone and Triamcinolone for Lumbar Radiculopathy. J Evol Med Dent Sci [Internet]. 2020;9(42):3133–8.

[3]. Berry JA, Elia C, Saini HS, Miulli DE. A review of lumbar radiculopathy, diagnosis, and treatment. Cureus [Internet]. 2019;11(10): e5934.

[4]. Chaurasia BD. BD chaurasia's human anatomy, volume 2: Regional and applied dissection and clinical:Lower limb, abdomen and pelvis. Vol. 2. New Delhi, India: CBS Publishers & Distributors; 2019.

[5]. Clark R, Weber RP, Kahwati L. Surgical management of lumbar radiculopathy: a systematic Reviews. Journal of general internal medicine. 2020; 35:855–64.

[6]. Singh V, Department of Physiotherapy, Guru Jambheshwar University of Science and Technology, Hisar, India, Malik M, Kaur J, Punia S, Department of Physiotherapy, Guru Jambheshwar University of Science and Technology, Hisar, India, et al. Disentangling the lumbar PIVD puzzle: A narrative review. Rom J Neurol [Internet]. 2020;19(4):228–36.

[7]. Vanti C, Panizzolo A, Turone L, Guccione AA, Violante FS, Pillastrini P, et al. Effectiveness of mechanical traction for lumbar radiculopathy: A systematic review and meta-analysis. Phys Ther [Internet]. 2021;101(3).

[8]. Lorio M, Kim C, Araghi A, Inzana J, Yue JJ. International Society for the Advancement of Spine Surgery Policy 2019-surgical treatment of lumbar disc herniation with radiculopathy. International journal of spine surgery. 2020; 14:1–7.

[9]. Lin L-H, Lin T-Y, Chang K-V, Wu W-T, Özçakar L. Neural mobilization for reducing pain and disability in patients with lumbar radiculopathy: A systematic review and meta-analysis. Life (Basel) [Internet]. 2023;13(12):2255.

[10]. Ryan D, Fullen B, Rio E, Segurado R, Stokes D, O'Sullivan C. Effect of action observation therapy in the rehabilitation of neurologic and musculoskeletal conditions: A systematic review. Arch Rehabil Res Clin Transl [Internet]. 2021;3(1):100106.

[11]. Alghadir A, Anwer S, Iqbal A, Iqbal Z. Test–retest reliability, validity, and minimum detectable change of visual analog, numerical rating, and verbal rating scales for measurement of osteoarthritic knee pain. J Pain Res [Internet]. 2018; 11:851–6.

[12]. Roland M, Fairbank J. The Roland-Morris disability questionnaire and the Oswestry disability questionnaire. Spine (Phila Pa 1976) [Internet]. 2000;25(24):3115–24.

[13]. Asghari A. Psychometric properties of a modified version of the Roland- Morris Disability Questionnaire (M-RMDQ).

[14]. Paolucci T, Pezzi L, Coraci D, Tognolo L, Pantalone A, Attanasi C, et al. Reliability, concurrent validity, and clinical performances of the shorter version of the Roland Morris Disability Questionnaire in a sample of Italian people with non-specific low back pain. J Pers Med [Internet]. 2024;14(7):740.

[15]. Liyew WA. Clinical presentations of lumbar disc degeneration and lumbosacral nerve lesions. Int J Rheumatol [Internet]. 2020; 2020:2919625.

[16]. Morales Tejera D, Fernandez-Carnero J, Suso-Martí L, Cano-de-la-Cuerda R, Lerín-Calvo A, Remón-Ramiro L, et al. Comparative study of observed actions, motor imagery and control therapeutic exercise on the conditioned pain modulation in the cervical spine: a randomized controlled trial. Somatosens Mot Res [Internet]. 2020;37(3):138–48.

[17]. Fu J, Zeng M, Shen F, Cui Y, Zhu M, Gu X, et al. Effects of action observation therapy on upper extremity function, daily activities and motion evoked potential in cerebral infarction patients. Medicine (Baltimore) [Internet]. 2017;96(42): e8080.

[18]. Bello B, Danazumi MS, Kaka B. Comparative effectiveness of 2 manual therapy techniques in the management of lumbar radiculopathy: A randomized clinical trial. J Chiropr Med [Internet]. 2019;18(4):253–60.