ijlpr 2023; doi 10.22376/ijlpr.2023.13.6.L211-L226

International Journal of Life science and Pharma Research
ISSN 2250-0480

Research Article

Effects of Neurodynamics Versus Neurodynamic Sustained Natural Apophyseal Glide in Lumbosacral Radiculopathy

Anwesh Pradhan[1*], Muthukumaran Jothilingam[2] and Shabnam Agarwal[3]

[1] *Ph.D. Scholar, SIMATS, Saveetha University, Chennai; Associate Professor, Nopany Institute of Healthcare Studies, Kolkata*

[2] *Ph.D. Professor, SIMATS, Saveetha University, Chennai*

[3] *Ph.D. Professor & Director Education, Nopany Institute of Healthcare Studies, Kolkata*

Abstract: Lumbosacral radiculopathy is a frequently reported health issue in middle-aged people, with a prevalence varying from about 2.2% to 8%. Neurodynamic mobilization (NM) and Neurodynamic sustained natural apophyseal glide (N-SNAG) techniques were proven effective for Lumbosacral radiculopathy. But controversies are prevalent regarding the effectiveness of their treatment in previous studies. N-SNAG is also a comparatively new technique that is clinically being used around, but more literature is needed to analyze its effectiveness. Hence, we aimed to evaluate the efficacy of N-SNAG in comparison with NM and conventional general exercises in treating lumbosacral radiculopathy on pain, mobility, disability, muscle activation, and health-related quality of life (HRQL). One hundred and twenty-seven patients aged between 30 and 50 years were randomly allocated into 3 different treatment groups, where the first and second groups received N-SNAG and NM with general exercises, and the third (control) group received general exercises only. Range of motion of lumbar and hip flexion, active straight leg raising, low back pain, radiculopathy pain, muscle activation of biceps femoris and gastrocnemius muscles, disability, and HRQL were evaluated at baseline, and the end of 1st week, 2nd week, 7th week and 18th week for all the groups. Two-way repeated measure ANOVA with Bonferroni's t-test revealed significant ($p<0.05$) improvement in the range of lumbar and hip flexion, LBP, radiculopathy pain, active SLR, disability, and HRQL in both within groups and between groups. Muscle activation of biceps femoris and gastrocnemius also improved significantly ($p<0.05$) in all three groups, but no significant ($p>0.05$) differences were seen between groups. The study concludes that N-SNAG is more efficient than NM and general exercise in improving pain, lumbar and hip flexion range, SLR, disability, Muscle activation, and HRQL in Lumbosacral radiculopathy patients.

Keywords: Neurodynamic, Neurodynamic sustained natural apophyseal glide, Low back pain, Lumbosacral radiculopathy

***Corresponding Author**

Anwesh Pradhan , Ph.D. Scholar, SIMATS, Saveetha University, Chennai; Associate Professor, Nopany Institute of Healthcare Studies, Kolkata

Received On 22 May, 2023
Revised On 27 July, 2023
Accepted On 4 August, 2023
Published On 1 November, 2023

Funding This research did not receive any specific grant from any funding agencies in the public, commercial or not for profit sectors.

Citation Anwesh Pradhan, Muthukumaran Jothilingam and Shabnam Agarwal , Effects of Neurodynamics Versus Neurodynamic Sustained Natural Apophyseal Glide in Lumbosacral Radiculopathy.(2023).Int. J. Life Sci. Pharma Res.13(6), L211-L226 http://dx.doi.org/10.22376/ijlpr.2023.13.6.L211-L226

1. INTRODUCTION

Lumbosacral radiculopathy with or without low back pain (LBP) is one of the leading conditions for which people seek physiotherapy consultation and treatment over the year. The incidence of LBP was estimated to be 5% to 10%, with a lifetime prevalence of 60% to 90%. [1] The prevalence of lumbosacral radiculopathy varies from about 2.2% to 8%. The incidence ranges from 0.7% to 9.6%. [2] Almost 50% of cases of acute LBP with lumbosacral radiculopathy resolve in one or two weeks, and around 90% of cases resolve by six months. In contrast, chronic LBP with lumbosacral radiculopathy mostly leads to various disabilities.[3] Radiculopathy is a neurological state in which conduction is blocked along a spinal nerve or its roots, where numbness occurs due to sensory fiber block and weakness due to motor fiber block that causes tingling pain in the patients. [4] The pain and numbness may radiate to the foot, leading to functional disabilities and affecting overall health-related quality of life (HRQL). Conservative treatments like medication and physiotherapy have mostly been opted as a first line of treatment. Various Physical therapy interventions, including exercise and manual therapy, have been used for treating lumbosacral radiculopathy and were found to be effective. [5,6] In early times, general exercises were the only treatment used and found effective. Eventually, various manual therapy techniques developed and showed better results. Among them, Lumbar and Neurodynamic mobilization (NM), known as Neural and lumbar exercises, were considered effective in treating Lumbosacral Radiculopathy. [7] Various studies and literature have shown that NM can reduce pain,[8] improve flexibility and range of motion, improving quality of life. [9] The SNAG also addresses hypomobility of the facet joint and hence improves ROM of lumbar flexion better than the general exercise and NM [10,11]. SNAG usually improves pain and mobility of the lumbar spine; hence lumbar flexion ROM improves [12]. Neurodynamic sustained natural apophyseal glide (N-SNAG) is a combination manual therapy where neurodynamic mobilization along with SNAG is given. This multimodal approach usually shows effectiveness. [13] Kumar D mentioned in his book that N-SNAG is useful for sciatic nerve radiculopathy. [14] Few studies also showed that N-SNAG is effective in reducing the symptoms of Lumbosacral radiculopathy. [15] Although this technique is widely used in manual therapy practice, more research and explanation of its effectiveness must be carried. On the other hand, when it comes to NM, it is widely researched and popularly practiced clinically in reducing radicular pain. Therefore, whether the N-SNAG can show a better result than an NM approach arises; in this study, we examined the effectiveness of these two techniques in five different aspects of concern in lumbosacral radiculopathy conditions. Those are pain, freedom of mobility, disability, health-related quality of life (HRQL), and activation of muscles supplied by the sciatic nerve using surface EMG. So the study aims to determine the efficacy of the N-SNAG in comparison with NM and general exercises in treating lumbosacral radiculopathy.

2. MATERIALS AND METHODS

2.1. *Study Design and Setting*

The study was a randomized controlled trial. The study commenced at Nopany Physiotherapy Clinic Out Patient Department, Kolkata, over 2 years. Patients were collected by a convenient sampling method and were allocated randomly using a computer-generated randomization table into 3 different treatment groups (CONSORT Chart, Figure 1).

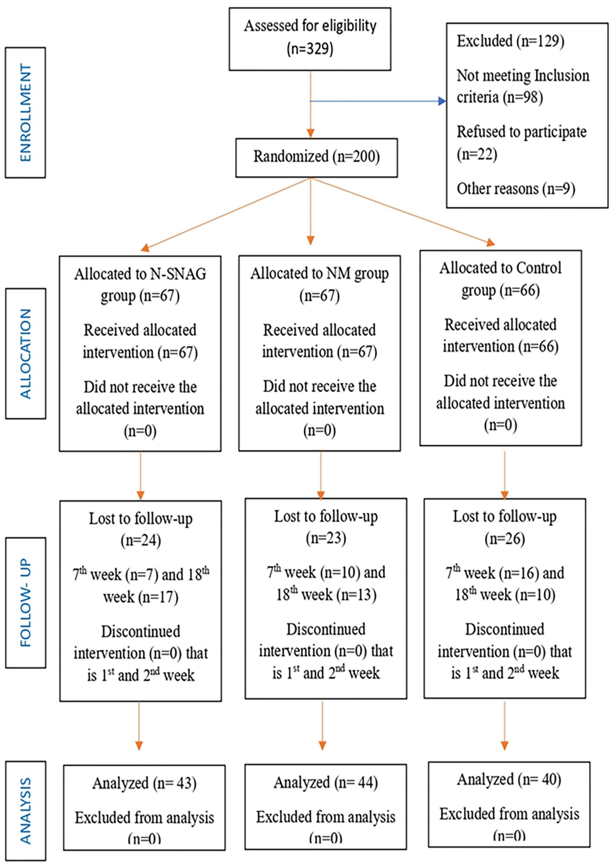

Fig1: Consort Chart

2.2. Ethical Approval Statement

The randomized controlled trial was executed after receiving permission from the Institutional ethics committee (003/05/2019/IEC/SMCH) on 7th May 2019 and registered under World Health Organization's International clinical trial registry platform through the Clinical trial registration of India (CTRI) with unique registration ID, CTRI/2020/04/024554. The study followed the ethical guidance provided by the Declaration of Helsinki, revised in 2013, and National ethical guidelines for biomedical and health research involving human participants, 2017. After obtaining the signed informed consent, all the patients with lumbosacral radiculopathy were recruited for the study.

2.3. Recruitment and participants

Over 329 patients of both genders within the age group of 30-50 years who complained of low back pain with lumbosacral radiculopathy were screened as per inclusion and exclusion criteria. Patients who did not consent or withdrew in between were also excluded from the study. Finally, 200 patients were enrolled in the study and gave consent for the study. Interventions were given to all of them, of which 127 patients completed a full follow-up course and were considered (n=127) for the study. Patients were randomly allocated into 3 different treatment groups. Anthropometric measurements were documented for the recruited patients before allocation into the groups. One experimental group received treatments by N-SNAG (Figure 2) and general exercises, another experimental group received NM (Figure 3) and general exercises, and the control group received general exercises (Figure 4) only.

2.4. Inclusion and Exclusion Criteria

Inclusion Criteria

- Patients having low back pain with lumbosacral radiculopathy
- Patients of both genders
- Patients of 30-50 years of age group
- Patients showing SLR-positive tests for sciatic nerve by 35^0 to 70^0

Exclusion criteria

- Patients with acute herniated discs
- Patients with inflammatory diseases like rheumatoid arthritis and ankylosing spondylitis
- Patients with spinal cord lesions, vertebral fractures
- Patients who have undergone recent spinal or peripheral nerve repairs
- Patients with any other cardiovascular condition or gynecological problem which will be affected by these interventions were excluded

2.5. Study Procedure

All the patients were explained about the intervention and post-intervention follow-up procedure. After receiving the written consent, pre-interventional data was collected before the commencement of the study. After that, all patients received 2 weeks of intervention. During the intervention, data were collected at the end of 1st week, and post-interventional data was collected at the end of 2nd week for all three groups. Short-term follow-up data collection was done on the 7th week, and long-term follow-up data collection was done on the 18th week for all the groups. For 1st intervention group, two physiotherapists qualified and certified to perform N-SNAG applied the intervention (two-therapist technique) on the patients, and pre, post, and follow-up data were collected. For 2nd intervention group, one physiotherapist qualified and certified to perform NM applied the intervention (one therapist technique) on the patients, and pre, post, and follow-up data were collected. For the control group, patients were explained and taught about the exercises they had to perform for two weeks by a qualified physiotherapist. They were given A compliance chart to fill, which we checked to confirm that the patients did exercises regularly, and pre, post, and follow-up data were collected.

2.6. Treatment Procedure

2.6.1. Neurodynamic SNAG

Two therapist techniques were applied to the patients. The patient's position was high, sitting at the edge of the plinth, and the affected lower limb was maintained in a neurodynamic test position below the range where pain first started (P1) by one therapist. The second therapist stood posterolateral to the patient to deliver SNAGs at the desired level of the lumbar spine. Then the therapist placed the hypothenar eminence of one hand under the spinous process of the involved lumbar segment; the other hand grasped the trunk from the front to hug the patient firmly. The therapist then delivered SNAGs (central or ipsilateral) at the desired level. The patient was asked to perform any active movements of the lumbar spine (flexion/side flexion to the opposite side/ rotation to the same side). To facilitate the opening of the foramen, glides were sustained. Doses: Three repetitions per session for three sessions per week for two weeks were given.

Fig 2: Neurodynamic SNAG

[**Illustration:** The figure shows the intervention N-SNAG in the first experimental group. The Patient received the N-SNAG two-therapist technique. One therapist applied SNAG, and another applied sciatic nerve neurodynamic mobilization]

2.6.2. Neural mobilization

The patient's position was supine lying with a comfortable dressing. The therapist raises the affected side lower limb perpendicular to the bed in the standard SLR test with one hand placed under the ankle joint and the other placed above the knee joints until radicular pain restricts the movement. Then the lower limb was removed a few degrees from that symptomatic point. The therapist then mobilized the sciatic nerve by gentle oscillations toward ankle dorsiflexion and reassessed the effect. The number of these sequences was repeated several times, through which the amplitude of the technique was increased according to the patient's response. As the pain was relieved, the therapist increased the range of motion until reaching the maximum range of SLR with pain-free. Doses: The position was held for 30 seconds with 1-minute rest. 5 repetitions for 10 sessions over 2 weeks were given.

Fig 3: Neurodynamic mobilisation

[**Illustration:** The figure shows the application of Neurodynamic mobilization for the Sciatic nerve in the SLR position in the second experimental group. It is a single-therapist technique.]

2.6.3. General Exercise

Patients of all three groups did these exercises. These were the following, (1) Stretching exercises spine and lower limb – Knee to chest exercise and Toe touching in long sitting (2) Strengthening of the abdominal flexor muscles – Abdominal curl-ups (3) Strengthening lumbar extensor muscles – Back extension exercise and (4) Core stabilization - Pelvic bridge. Doses: Patients performed these exercises daily for 2 weeks. Patients received a compliance chart to fill.

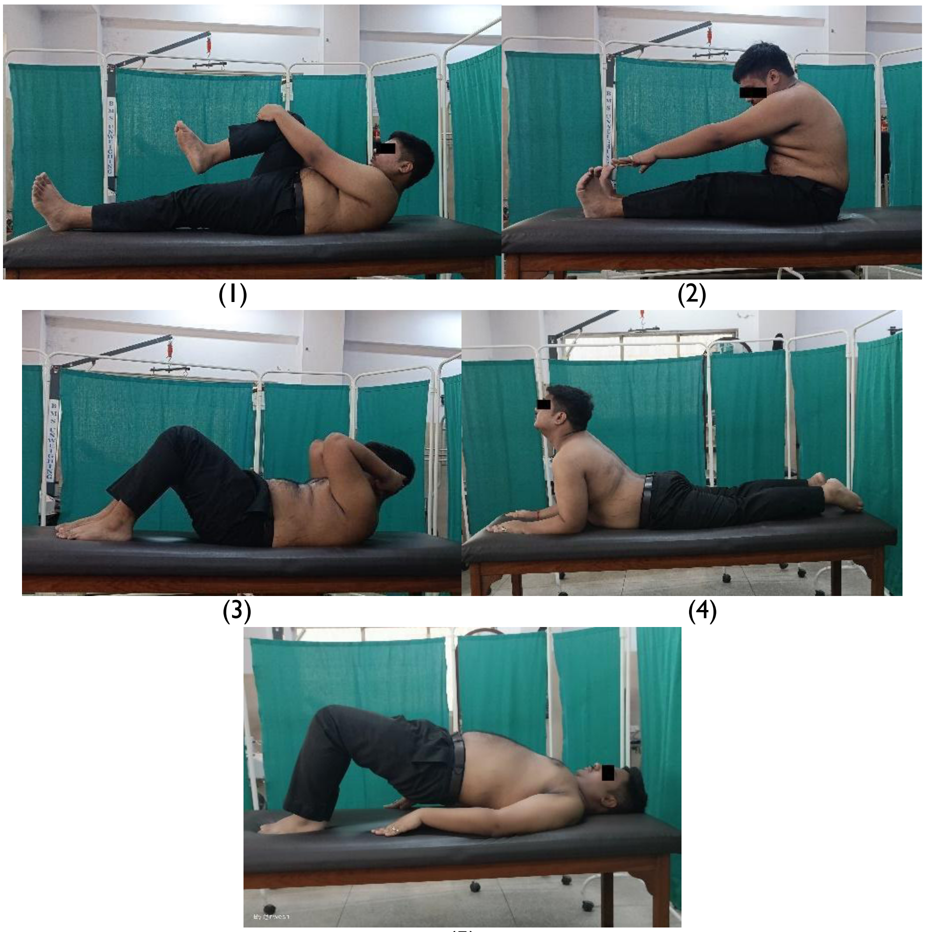

Fig 4: General exercises for Lumbosacral Radiculopathy.

[**Illustration:** The figure shows the patient's general exercises for lumbosacral radiculopathy in the control group. The exercises are as follows (1) Knee chest exercise, (2) Toe touching in long sitting, (3) Abdominal curl-ups, (4) Back extension exercise, and (5) Pelvic bridge.]

2.7. *Outcome measures*

The freedom of mobility of the patients was evaluated with a Range of motion (ROM) of lumbar flexion using a measuring tape and hip flexion by using a universal goniometer and by checking the active straight leg raising (SLR) using a universal goniometer. The 101 Numeric pain rating scale (101NPRS) evaluated the pain for low back pain and radiculopathy. Surface EMG was used to evaluate the functional ability by checking the muscle activation of the biceps femoris and gastrocnemius muscles. Roland Morris Disability Questionnaire for lumbar pain (RMDQ-L) was used to evaluate the disability of the patient, and a Patient-specific questionnaire was used to evaluate the health-related quality of life (HRQL).

3. STATISTICAL ANALYSIS

The normality of collected demographic dimensions was analyzed using descriptive statistics and was expressed in mean ± standard deviation. Two-Way Repeated Measure ANOVA analyzed inferential statistics with Bonferroni's t-test. The significance level was set at $p<0.05$ for all analyses to minimize type-I error (<5%). Sigma plot statistical software was used in the above data analysis. Graphs generated by the software were used to describe the result of the study. Graphs were plotted so that each variable, based on their outcome measures values, can be explained in a single picture for all three experimental groups. Each graph, as per the variables, shows (1) The pre-test result to confirm their homogeneity, (2) Each intervention's efficacy, and (3) a Comparison of week-wise progression among the groups.

4. RESULTS

The demographic dimensions of the sample recruited were tabulated in Table 1. The comparison of the three categories is explained in the table. The mean age of the N-SNAG group was 48.53 ±8.38, the NM group was 47.75 ±9.30, and the control group was 48.18 ±8.73 years. The male-female male ratio in the N-SNAG group was 46.51% and 53.49%, the NM group was 34.09% and 65.91%, and the control group was 65% and 35%, respectively.

Table 1: Demographic characteristics of the subjects recruited in the control group, NM group, and N-SNAG group

	N-SNAG		NM		Control	
N	43		44		40	
Age	Mean	SD	Mean	SD	Mean	SD
	48.53	8.38	47.75	9.30	48.18	8.73
Gender	Number	%	Number	%	Number	%
Male	20	46.51	15	34.09	26	65
Female	23	53.49	29	65.91	14	35

Analysis of N-SNAG, NM, and General exercises effects on LBP and Radiculopathy pain:

Results of Effects on Pain, within groups, the analysis showed that there is a significant ($p<0.05$) reduction in low back pain (Figure 5) and radiculopathy pain (Figure 6) by general exercise, NM, and N-SNAG as well. Whereas, between groups, the analysis showed that the effects of N-SNAG and NM are significantly ($p<0.05$) better than general exercise, and N-SNAG is significantly ($p<0.05$) better than NM in reducing low back pain and radiculopathy pain. All three groups showed that there is immediate relief of pain in 1st week and 2nd week. Additional short-term and long-term follow-ups showed better results for patients treated with NM and N-SNAG.

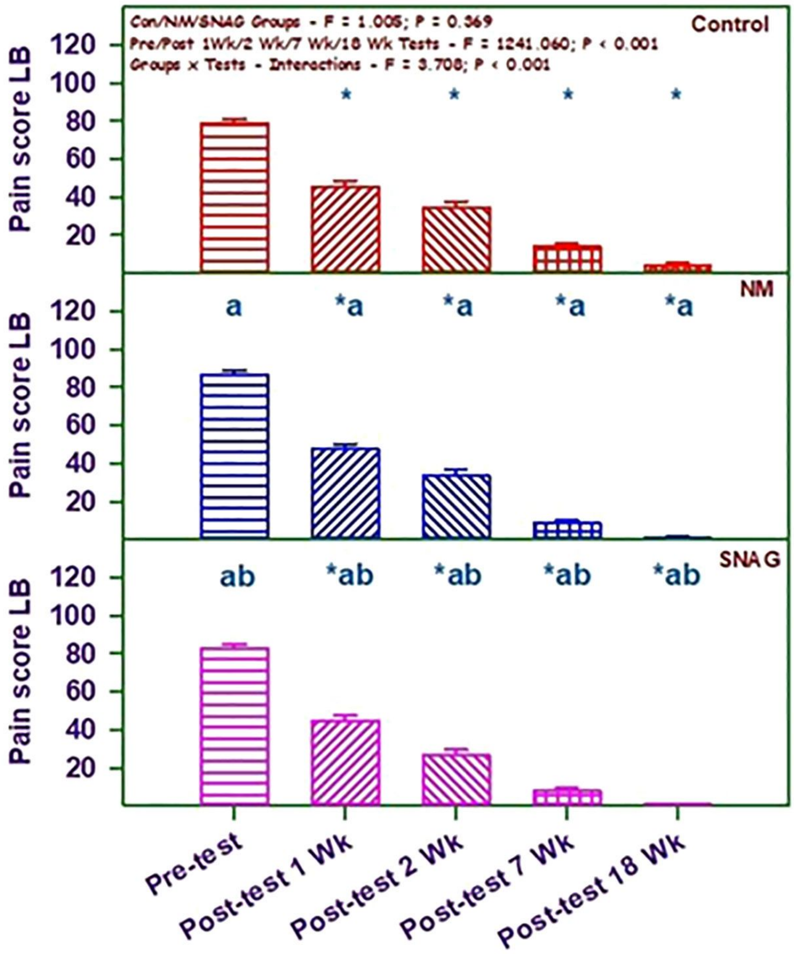

Fig 5: Graph Analysis of N-SNAG (Pink bars), NM (Blue bars), and Control group (Red bars) effects on LBP. [Pain score LB= 101NPRS value for LBP, WK=Week]

[Illustration: Pre-test score comparison between groups showed p= 0.369 and F= 1.005, which shows the data collected was homogenous. Within group analysis of Pre/Post 1st WK/ 2nd WK/ 7th WK/ 18th WK value shows p<0.001 and F= 1241.060, which shows that each group has reduced LBP efficiently. Between-groups, week-wise progression comparison shows p<0.001 and F= 3.708, which shows the NM group performed better than the control group and the N-SNAG group performed better than NM and control group]

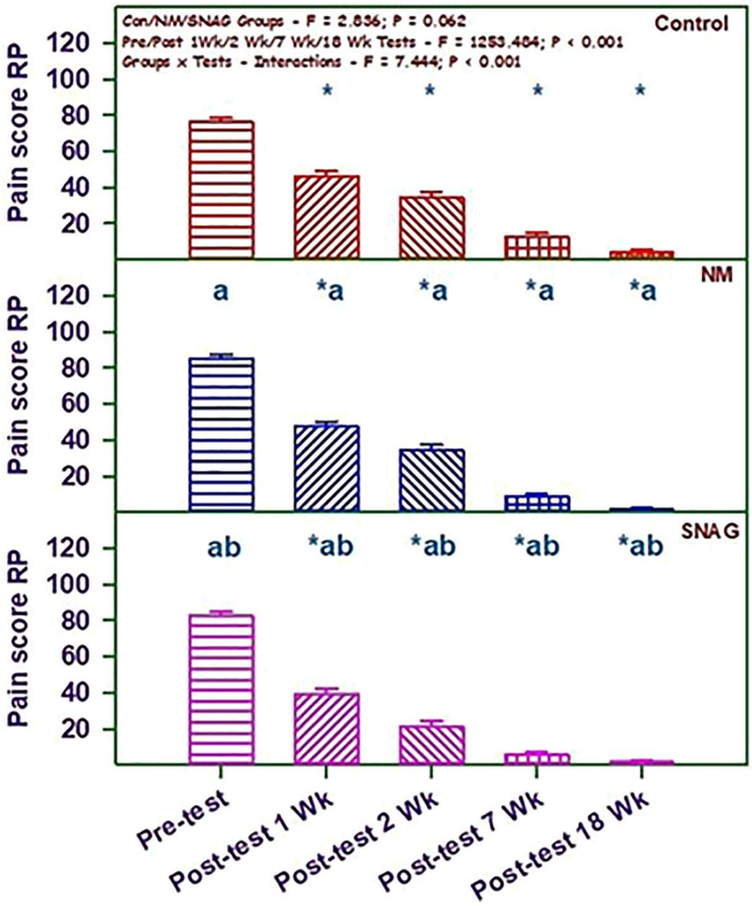

Fig 6: Graph Analysis of N-SNAG (Pink bars), NM (Blue bars), and Control group (Red bars) affects Radiculopathy pain. [Pain score RP= 101NPRS value for Radiculopathy pain, WK=Week]

[Illustration: Pre-test score comparison between groups showed p= 0.062 and F= 2.836, which shows the data collected was homogenous. Within group analysis of Pre/Post 1st WK/ 2nd WK/ 7th WK/ 18th WK value analysis shows p<0.001 and F= 1253.484, which shows that each group has reduced radicular pain efficiently. Between-group week-wise progression comparison shows p<0.001 and F= 7.444, which shows the NM group performed better than the control group and the N-SNAG group performed better than NM and control group]

4.1. Analysis of N-SNAG, NM, and general exercise effects on Lumbar and Hip flexion ROM and SLR

Similarly, in the freedom of mobility result analysis, within groups analysis showed a significant ($p<0.05$) increase in lumber flexion ROM, hip flexion ROM, and active SLR by general exercise, NM, and N-SNAG. But, the between-group analysis showed an insignificant ($p>0.05$) difference in the effects of an increase in lumber ROM (Figure 7) and hip ROM (Figure 8). Whereas N-SNAG and NM significantly ($p<0.05$) improved active SLR than exercise, and N-SNAG significantly ($p<0.05$) better than NM in improving active SLR (Figure 9).

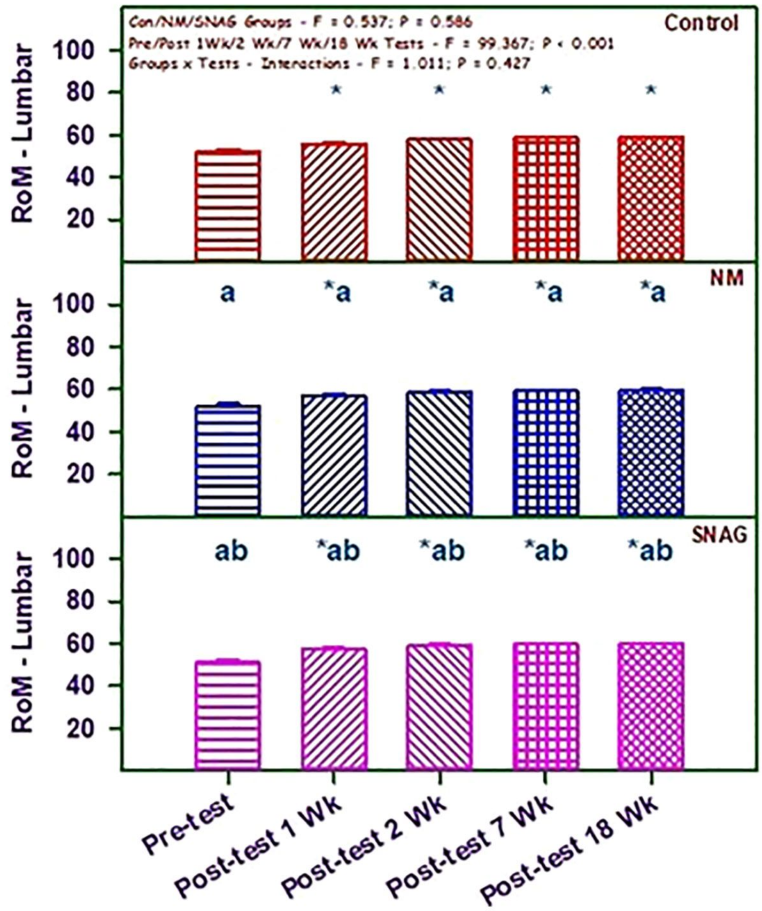

Fig 7: Graph of N-SNAG (Pink bars), NM (Blue bars), and Control group (Red bars) effects on Lumbar flexion ROM [ROM-Lumber = ROM of lumbar flexion, WK=Week]

[Illustration: Pre-test score comparison between groups showed p= 0.586 and F= 0.537, which shows homogeneity of data Within group analysis of Pre/Post 1st WK/ 2nd WK/ 7th WK/ 18th WK value analysis shows p<0.001 and F= 99.367, which shows the lumbar flexion ROM has improved in all three groups. Between-group week-wise progression comparison shows p= 0.427 and F= 1.011, which shows no significant difference between the groups.]

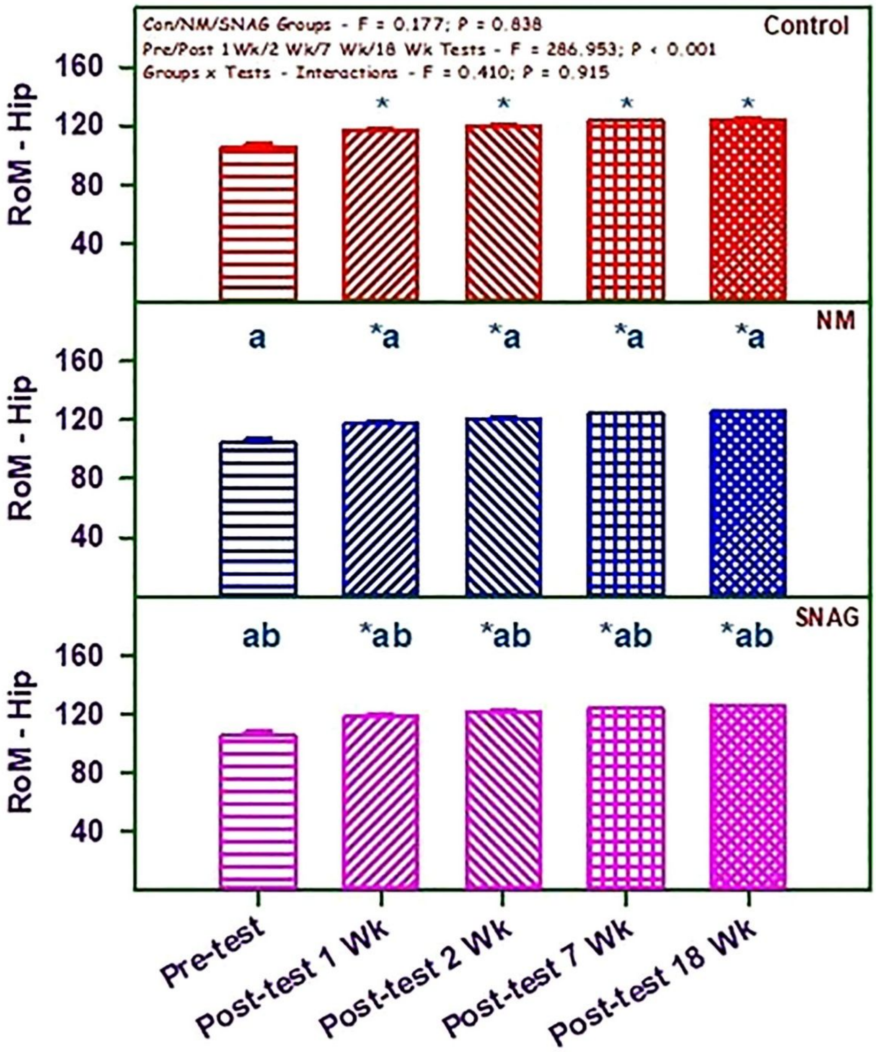

Fig 8: Graph of N-SNAG (Pink bars), NM (Blue bars), and Control group (Red bars) effects on Hip ROM [ROM-Hip= ROM of hip flexion, WK=Week]

[Illustration: Pre-test score comparison between groups showed p= 0.838 and F= 0.177, which shows homogeneity of the data. Within group analysis of Pre/Post 1st WK/ 2nd WK/ 7th WK/ 18th WK value analysis shows p<0.001 and F= 286.953, which shows Hip flexion ROM has improved in all three groups. Intergroup week-wise progression comparison shows p= 0.915 and F= 0.410, which shows no significant difference in hop flexion ROM improvement between the groups.]

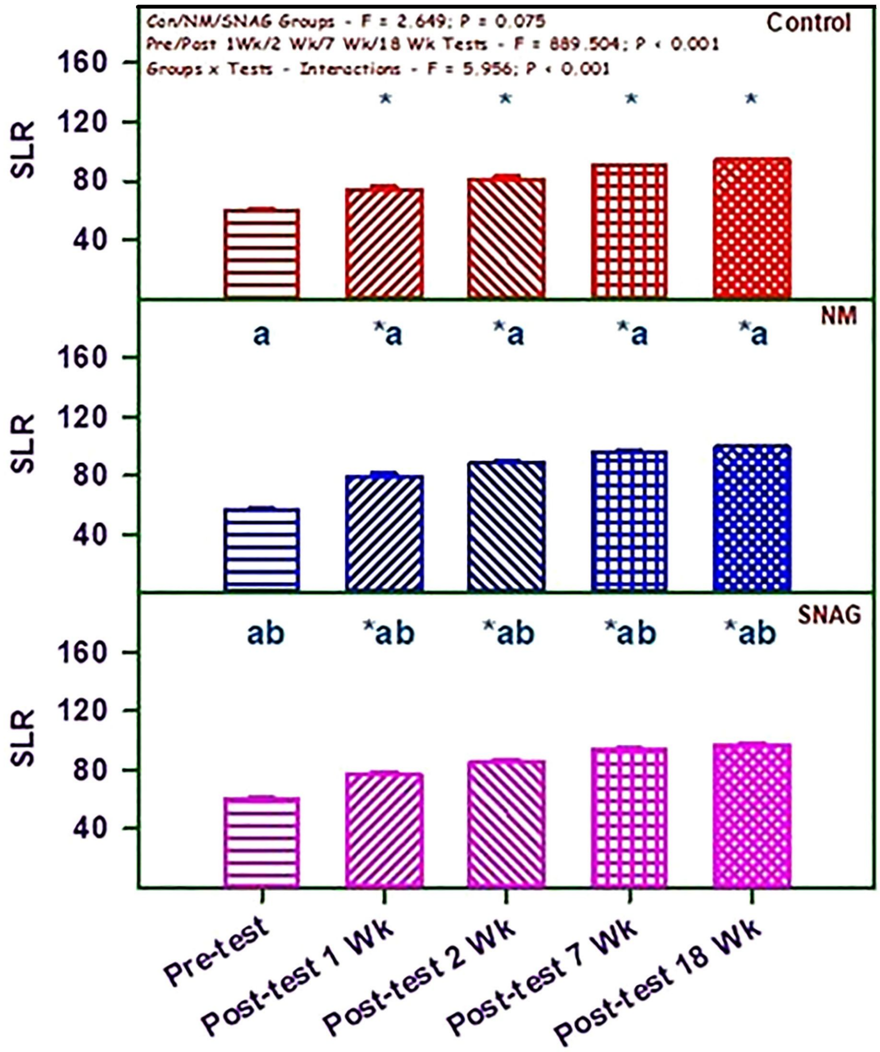

Fig 9: Graph of analysis of N-SNAG (Pink bars), NM (Blue bars), and Control group (Red bars) effects on Active SLR. [WK=Week]

[**Illustration:** Pre-test score comparison between groups showed p= 0.075 and F= 2.649, which shows homogeneity of the data. Within group analysis of Pre/Post 1st WK/ 2nd WK/ 7th WK/ 18th WK value analysis shows p<0.001 and F= 889.504, which shows SLR has improved in all three groups. Intergroup week-wise progression comparison shows p<0.001 and F= 5.956, which shows NM Was better than the control and N-SNAG is better than NM and control group in improving SLR]

4.2. Analysis of N-SNAG, NM, and general exercise effects on Disability and HRQL

The analysis of disability by RMDQ-L score and HRQL by Patient-specific questionnaire showed a significant (p<0.05) reduction in disability and improvement in HRQL within groups. The pre-intervention analysis didn't show homogeneity for HRQL, suggesting that lumbosacral radiculopathy does not directly affect the HRQL of patients. However, still, the improvement in values suggests HRQL has improved. Whereas individually, N-SNAG, NM, and general exercise improve disability. Between-group analysis showed N-SNAG and NM significantly (p<0.05) better than general exercise, and N-SNAG is significantly (p<0.05) better than NM in reducing disability (Figure 10) and improving HRQL (Figure 11).

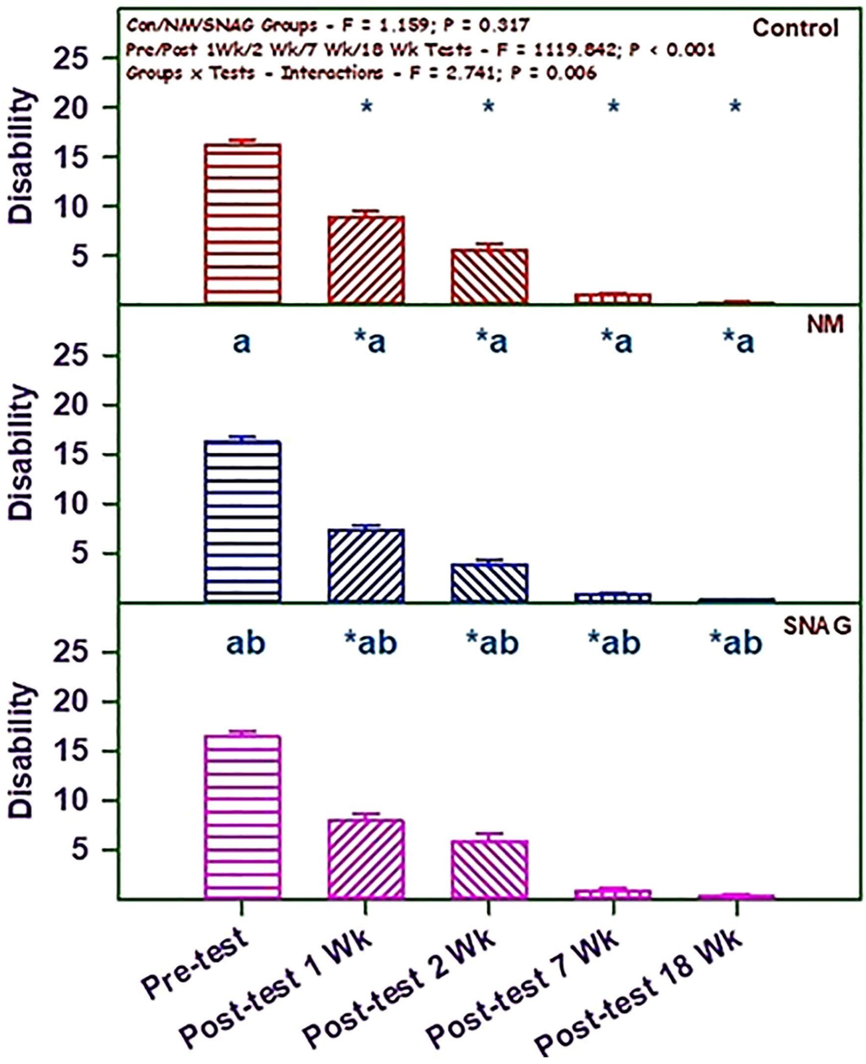

Fig 10: Graph of N-SNAG (Pink bars), NM (Blue bars), and Control group (Red bars) effects on Disability [Disability= RMDQ-L value to evaluate Disability due to lumbosacral radiculopathy, WK=Week]

[**Illustrations:** Pre-test score comparison between groups showed p= 0.317 and F= 1.159, which shows homogeneity of the data. Within group analysis of Pre/Post 1st WK/ 2nd WK/ 7th WK/ 18th WK value analysis shows p<0.001 and F= 1119.842, which shows disability has reduced in all three groups. Intergroup week-wise progression comparison shows p= 0.006 and F= 2.741, which shows NM was better than the control and N-SNAG is better than NM and the control group in reducing disability.]

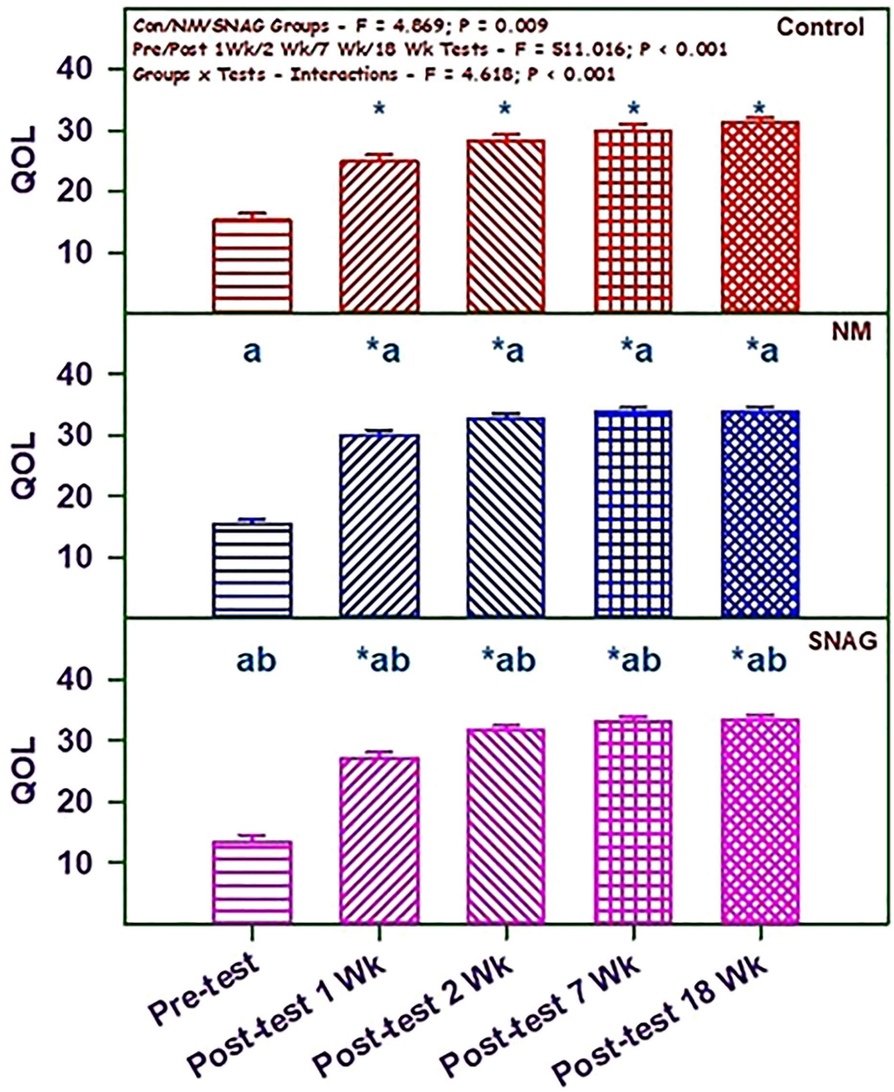

Fig 11: Graph of N-SNAG (Pink bars), NM (Blue bars), and Control group (Red bars) effects on HRQL [QOL= Patient-specific questionnaire value for HRQL evaluation, WK=Week]

[**Illustration**: Pre-test score comparison between groups showed p= 0.009 and F= 4.869, which shows no difference in the data. Within group analysis of Pre/Post 1st WK/ 2nd WK/ 7th WK/ 18th WK value analysis shows p<0.001 and F= 511.016, which shows HRQL improved in all three groups. Intergroup week-wise progression comparison shows p<0.001 and F= 4.618, which shows NM was better than the control and N-SNAG is better than NM and the control group in reducing disability]

4.3. *Analysis of N-SNAG, NM, and general exercise effects on Biceps femoris and Gastrocnemius muscle activation*

Analysis of biceps femoris muscle activation using surface EMG showed significant (p<0.05) improvement by general exercise, NM, and N-SNAG in both peak and average values within groups, which means individually, N-SNAG, NM, and general exercise improve biceps femoris muscle activation (Figure 12). Between-group analysis showed N-SNAG and NM significantly (p<0.05) better than general exercise, and N-SNAG is significantly (p<0.05) better than NM in improving average muscle activation. In contrast, peak value analysis showed insignificant (p>0.05) differences between groups (Figure 12). Analysis of gastrocnemius muscle activation using surface EMG showed significant (p<0.05) improvement by general exercise, NM, and N-SNAG in both peak and average values within groups, which means individually, N-SNAG, NM, and general exercise improve gastrocnemius muscle activation (Figure 13). Between-group analysis showed N-SNAG and NM significantly (p<0.05) better than general exercise, and N-SNAG is significantly (p<0.05) better than NM in improving peak muscle activation. In contrast, average value analysis showed insignificant (p>0.05) differences between groups (Figure 13).

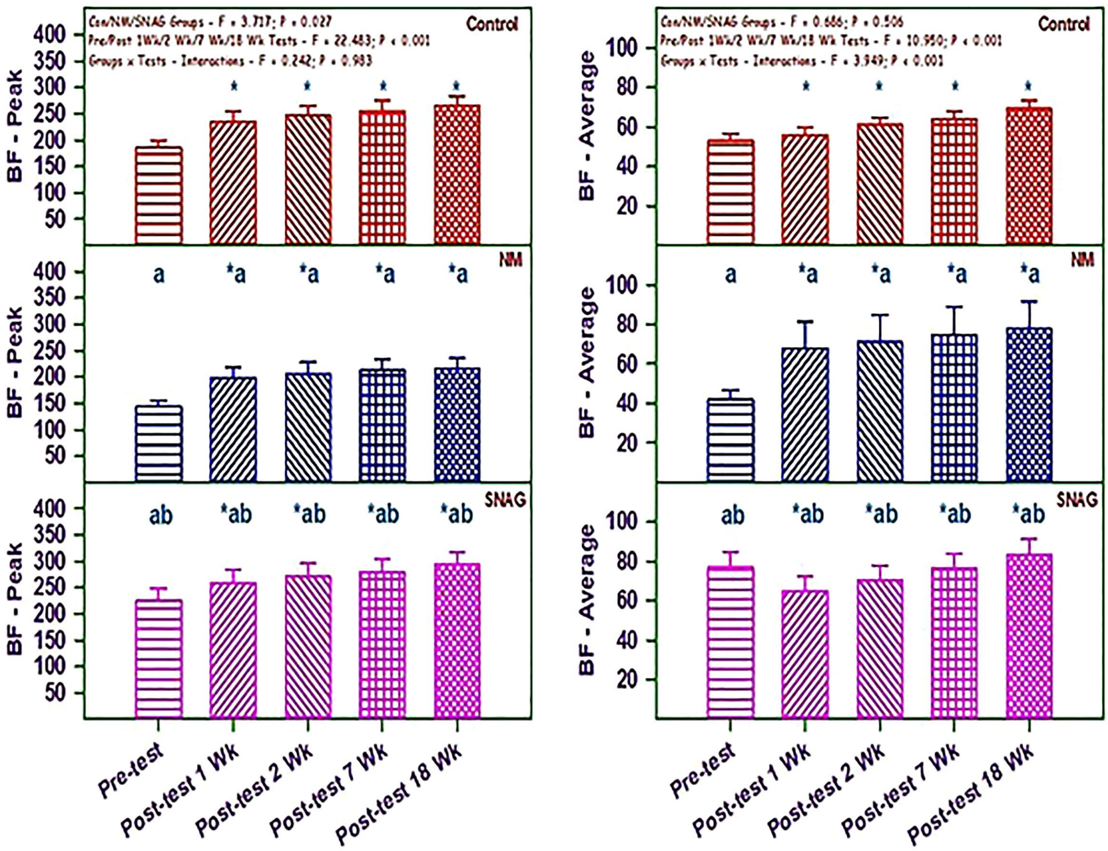

Fig 12: Graph of N-SNAG (Pink bars), NM (Blue bars), and Control group (Red bars) effects on Biceps femoris muscle activation. [BF Peak= Peak muscle activation of Biceps femoris by surface EMG, BF Average = Average muscle activation of Biceps femoris by surface EMG, WK=Week]

[Illustration: ***BF Peak***

Pre-test score comparison between groups showed p= 0.027 and F= 3.717, which shows a difference between groups. Within group analysis of Pre/Post 1st WK/ 2nd WK/ 7th WK/ 18th WK value analysis shows p<0.001 and F= 22.483, which shows biceps femoris peak muscle activation has improved in all three groups. Intergroup week-wise progression comparison shows p= 0.983 and F= 0.242, which shows no significant difference between the groups.

BF Average

Pre-test score comparison between groups showed p= 0.506 and F= 0.686, which shows the homogeneity of the data. Within group analysis of Pre/Post 1st WK/ 2nd WK/ 7th WK/ 18th WK value analysis shows p<0.001 and F= 10.950, which shows that the average biceps femoris muscle activation has improved in all three groups. Intergroup week-wise progression comparison shows p<0.001 and F= 3.949, which shows NM was better than the control and N-SNAG is better than NM and control group in improving biceps femoris muscle activation.]

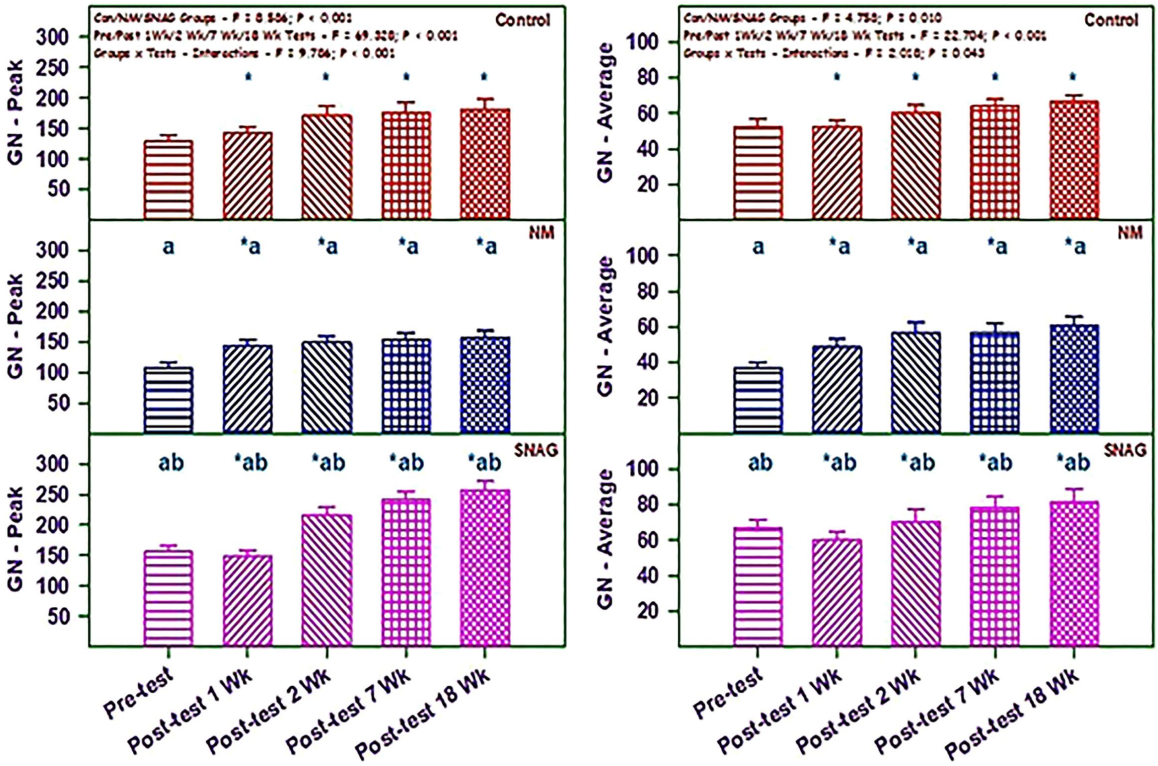

Fig 13: Graph of N-SNAG (Pink bars), NM (Blue bars), and Control group (Red bars) effects on Gastrocnemius muscle activation. [GN Peak= Peak muscle activation of Gastrocnemius by surface EMG, GN Average = Average muscle activation of Gastrocnemius by surface EMG, WK=Week]

[Illustration: ***GN Peak***

Pre-test score comparison between groups showed p< 0.001 and F= 8.586, which shows a difference between groups. Within group analysis of Pre/Post 1^{st} WK/ 2^{nd} WK/ 7^{th} WK/ 18^{th} WK value analysis shows p<0.001 and F= 69.328, showing that gastrocnemius' peak muscle activation has improved in all three groups. Intergroup week-wise progression comparison shows p<0.001 and F= 9.786, which shows NM was better than the control. N-SNAG is better than NM and the control group in improving gastrocnemius muscle activation.

GN Average

Pre-test score comparison between groups showed p= 0.010 and F= 4.758, which shows a difference between groups. Within group analysis of Pre/Post 1^{st} WK/ 2^{nd} WK/ 7^{th} WK/ 18^{th} WK value analysis shows p<0.001 and F= 22.704, which shows average muscle activation of gastrocnemius has improved in all three groups. Intergroup week-wise progression comparison shows p= 0.043 and F= 2.018, which shows no significant difference between the groups]

5. DISCUSSION

All three interventions effectively reduce LBP and lumbosacral radiculopathy pain; better scores have resulted in the N-SNAG group than the NM and control groups. NM reduces neurogenic pain by altering the mechanical properties of peripheral nerves. [16,17] This alteration of mechanical properties leads to a direct effect on nerve physiology. [18,19] The pain relief by N-SNAG is possibly due to corrections of the mispositioned spine that cause pain to sensitive structures and nerve roots traversing closely. [20,21] It also causes modulation and inhibition of the incoming nociceptive information in combination with sympathoexcitation of the affected structures showing a non-opioid hypoalgesic effect.[22-,24] As N-SNAG is a combination manual therapy technique, the improvement of hypomobility of the facet joint during SNAG while trying to glide the nerve might release the sciatic nerve tension due to impingement, hence reducing the radiculopathy pain due to nerve tension. When rotational torque is applied to the lumbar segment during SNAG, the collagenous structures, particularly the alternate layers of the annulus, are stretched, which reduces the mechanical deformation of injured annular collagen fibers and their associated nociceptive endings. It improved pain and mobility of the lumbar spine. [12] Increased lumbar flexion ROM and hip flexion ROM are equal in all three intervention groups but slightly higher in the N-SNAG group. In contrast, active SLR is increased in the third group compared to the two other groups. It is possibly due to either stretching exercises which usually restore the impaired flexibility, or NM, which restores the normal mobility, length-tension relationship, blood flow, and axonal transport in impaired neurons. [25,26]. NM is also capable of breaking the adhesions and bringing out mobility [26]. But the N-SNAG technique might help reduce the nerve root compression and improve microcirculation by diminishing intra-neural edema and adhesions and consequently recover nerve mechano-sensitivity after stretching of the sciatic nerve. [16] This explanation helps us to understand the improvement of active SLR by N-SNAG rather than NM and general exercise. HRQL had improved in almost all patients who participated. However, based on the reduction of pain and improved mobility of the hip and low back and facilitation of active SLR, the application of N-SNAG improves HRQL better than NM than general exercise in current social and personal scenarios. Surface EMG demonstrates an improved muscle activation of biceps femoris and gastrocnemius muscles following the application of NM and N-SNAG, confirming the given technique's neurophysiological effects. The peak muscle activation of biceps femoris showed similar improvement in all three groups. The average activation shows a better result with N-SNAG as it facilitated the active SLR and radiculopathy pain better than NM and general exercise. In the case of the gastrocnemius muscle, the average value showed similar activation. Peak value showed better results in N-SNAG than NM in general exercise, respectively. The gastrocnemius always maintains an average activation of the muscle to maintain posture. Due to that, when muscle activation was tested in an open kinematic chain, the peak value showed better results than the average value, and we received better peak muscle activation in N-SNAG than in NM. However, the neurophysiological effects of N-SNAG, NM, and general exercise cannot be clearly explained.

6. CONCLUSION

N-SNAG, NM, and general exercises are effective physiotherapy treatments for lumbosacral radiculopathy with low back pain. However, N-SNAG showed better results in improving low back pain, radicular pain, lumbar ROM, hip ROM, and active SLR than NM and general exercise. Hence, the disabilities patients suffer due to lumbosacral radiculopathy reduces better by applying N-SNAG. Though improvements were seen in HRQL and muscle activation by N-SNAG, the effects were almost similar to NM and general exercises. So it shows that the major symptoms of lumbosacral radiculopathy can be treated by N-SNAG more efficiently than other physiotherapeutic manipulations, and therefore reduces the disability and improves overall HRQL.

7. AUTHORS CONTRIBUTION STATEMENT

Anwesh Pradhan conceptualized, gathered data for this work, did statistics, and wrote the manuscript. Dr. Muthukumaran Jothilingam and Dr. Shabnam Agarwal helped to conceptualize the research work and supervised the whole research work.

8. CONFLICT OF INTEREST

Conflict of interest declared none.

9. REFERENCES

1. Alexander CE, Varacallo M. Lumbosacral radiculopathy. Stat. 2021.
2. Lee-Robinson A, Lee AT. Clinical and diagnostic findings in patients with lumbar radiculopathy and polyneuropathy. Am J Clin Med. 2010;7:80-5.
3. Paraseth TK, Gajendran M, James D. Approach to chronic low back pain in a Rural Mission Hospital: an audit report. CHRISMED J Health Res. 2018;5(1):43. doi: 10.4103/CJHR.CJHR_40_17.
4. Bogduk N. On the definitions and physiology of back pain, referred pain, and radicular pain. Pain. 2009;147(1-3):17-9. doi: 10.1016/j.pain.2009.08.020, PMID 19762151.
5. Hahne AJ, Ford JJ, Mcmeeken JM. Conservative management of lumbar disc herniation with associated radiculopathy: a systematic review. Spine (Phila Pa 1976). 2010;35(11):E488-504. doi: 10.1097/BRS.0b013e3181cc3f56, PMID 20421859.
6. Boyles R, Toy P, Mellon J, Hayes M, Hammer B. Effectiveness of manual physical therapy in the treatment of cervical radiculopathy: A systematic review. J Man Manip Ther. 2011;19(3):135-42. doi: 10.1179/2042618611Y.0000000011, PMID 22851876.
7. Pradhan A, Jothilingam M, Agarwal S, RayChaudhuri G. Exercise and manual therapy for treatment of low back pain with or without lumbosacral radiculopathy: A narrative review. Ann Rom Soc Cell Biol. 2021;25:9627-37.
8. Shacklock M. Neurodynamics. Physiotherapy. 1995;81(1):9-16. doi: 10.1016/S0031-9406(05)67024-1.
9. Bonser RJ, Hancock CL, Hansberger BL, Loutsch RA, Stanford EK, Zeigel AK, et al. Changes in hamstring range of motion after neurodynamic sciatic sliders: A critically appraised topic. J Sport Rehabil. 2017;26(4):311-5. doi: 10.1123/jsr.2015-0166, PMID 27632844.
10. Hussien HM, Abdel-Raoof NA, Kattabei OM, Ahmed HH. Effect of mulligan concept lumbar SNAG on chronic nonspecific low back pain. J Chiropr Med. 2017;16(2):94-102. doi: 10.1016/J.JCM.2017.01.003, PMID 28559749.
11. Fiaad MN, Elsayed WH, Kamal M, Takla N, El ZAM. Mulligan mobilization vs. spinal manipulation effect on low back pain. J Adv Pharm Educ Res. 2020;10:70-5.
12. Hearn A, Rivett DA. Cervical SNAGs: A biomechanical analysis. Man Ther. 2002;7(2):71-9. doi: 10.1054/math.2002.0440, PMID 12151243.
13. Pradeep S, Heggannavar A, Metgud S. Effect of sciatic nerve neurodynamic sustained natural apophyseal glides on individuals with pelvic crossed syndrome: A randomized controlled trial. Indian J Phys Ther Res. 2020;2(1):35-40. doi: 10.4103/ijptr.ijptr_40_19.
14. Kumar D. Manual of mulligan concept. International ed. New Delhi: Create Space Independent Publishing Platform; 2014. p. 237-9.
15. Pradhan A, Jothilingam M, Agarwal S, Manikumar M. Effects of neurodynamic sustained natural apophyseal glides versus conventional physiotherapy exercises in the treatment of lumbosacral radiculopathy. Chin J Med Genet. 2022;32(3):472-7.
16. Mahmoud ELDesoky MT. Efficacy of neural mobilization on low back pain with s1 radiculopathy. Int J Physiother. 2016;3(3):362-70. doi: 10.15621/IJPHY/2016/V3I3/100847.
17. Ellis RF, Hing WA, McNair PJ. Comparison of longitudinal sciatic nerve movement with different mobilization exercises: an in vivo study utilizing ultrasound imaging. J Orthop Sports Phys Ther. 2012;42(8):667-75. doi: 10.2519/jospt.2012.3854, PMID 22711174.
18. Kumar V, Goyal M, Rajendran N. Effect of neural mobilization on monosynaptic reflex – a pretest posttest experimental design. Int J Physiother Res. 2013;3:58-62.
19. Santos FM, Silva JT, Giardini AC, Rocha PA, Achermann APP, Alves AS et al. Neural mobilization reverses behavioral and cellular changes that characterize neuropathic pain in rats. Mol Pain. 2012;8:57. doi: 10.1186/1744-8069-8-57, PMID 22839415.
20. Vicenzino B, Paungmali A, Teys P. Mulligan's mobilization-with-movement, positional faults and pain

relief: current concepts from a critical review of literature. Man Ther. 2007;12(2):98-108. doi: 10.1016/j.math.2006.07.012, PMID 16959529.
21. Thakur A, Mahapatra AK. Effect of mulligan spinal mobilization with leg movement and Shacklock neural tissue mobilization in lumbar radiculopathy: A randomized controlled trial. J Med Thesis. 2015;2:27-30.
22. Yadav S, Arora Nijhawan M, Panda P. Effectiveness of spinal mobilization with leg movement (smwlm) in patients with lumbar radiculopathy (L5 / S1 nerve root) in lumbar disc herniation. Int J Physiother Res. 2014;2:712-30.
23. Moulson A, Watson T. A preliminary investigation into the relationship between cervical snags and sympathetic nervous system activity in the upper limbs of an asymptomatic population. Man Ther. 2006;11(3):214-24. doi: 10.1016/J.MATH.2006.04.003, PMID 16820316.
24. Hearn A, Rivett DA. Cervical SNAGs: a biomechanical analysis. Man Ther. 2002;7(2):71-9. doi: 10.1054/MATH.2002.0440, PMID 12151243.
25. Rainville J, Hartigan C, Martinez E, Limke J, Jouve C, Finno M. Exercise as a treatment for chronic low back pain. Spine J. 2004;4(1):106-15. doi: 10.1016/S1529-9430(03)00174-8, PMID 14749199.
26. Sarkari E, Multani N. Efficacy of neural mobilization in sciatica. J Exerc Sci Physiother. 2007;3:136-41.