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Correspondence
Haziq Bin Liaqat, haxiq5@gmail.com

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Effect of Spinal Mobilization with Leg Movement Versus Sustained Natural Apophyseal Glides in Lumbar Disc Herniation with Unilateral Radiculopathy

Awais Bin Inam[1], Haziq Bin Liaqat[2], Tasadduq Hussain[2], M. Saqib Adil[2], Mishal Zahra[2], Bushra Abdullah[2], Muhammad Yasir[2], Farah Ishaq[3]

1 Supervisor / Deputy Director, Department of Physical Therapy, Government College University, Faisalabad (GCUF), Pakistan
2 Final Year DPT Students, Department of Physical Therapy, Government College University, Faisalabad (GCUF), Pakistan
3 Teaching Assistant, Department of Health and Physical Education, Government College Women University, Faisalabad (GCWUF), Pakistan

ABSTRACT
Background: Lumbar disc herniation with unilateral radiculopathy is a leading cause of chronic low back pain, functional disability, and neural tension. Manual therapy techniques such as Sustained Natural Apophyseal Glides (SNAGs) and Spinal Mobilization With Leg Movement (SMWLM) are widely used in physiotherapy, yet comparative evidence regarding their differential effects on pain, function, and neural mobility remains limited. Objective: To compare the effects of SNAGs and SMWLM on pain intensity, functional disability, and neural mobility in individuals with lumbar disc herniation presenting with unilateral radiculopathy. Methods: A quasi-experimental study was conducted among 30 participants aged 20–50 years diagnosed with lumbar disc herniation and unilateral radiculopathy. Participants were equally divided into two groups: Group A received SMWLM and Group B received SNAGs, both supplemented with baseline heat therapy for two weeks. Pain intensity, functional disability, and neural mobility were assessed using the Numeric Pain Rating Scale (NPRS), Modified Oswestry Disability Index (MODI), and Straight Leg Raise (SLR) test, respectively. Data were analyzed using paired and independent sample t-tests with a significance level of $p<0.05$. Results: Both groups showed significant within-group improvements ($p<0.001$) across all outcomes. Between-group analysis revealed that SNAGs produced greater reductions in pain (ΔNPRS = 1.87 vs 1.07) and disability (ΔMODI = 2.00 vs 1.33), whereas SMWLM achieved greater improvement in SLR range of motion (ΔSLR = 23.93° vs 19.27°). All between-group differences were statistically significant ($p<0.001$). Conclusion: Both SNAGs and SMWLM effectively reduce pain and disability and enhance neural mobility in patients with lumbar disc herniation and unilateral radiculopathy. SNAGs demonstrated superior analgesic and functional benefits, while SMWLM provided greater gains in neural mobility. Individualized use or combination of these techniques may optimize rehabilitation outcomes.

Keywords
Lumbar Disc Herniation, Unilateral Radiculopathy, SNAGs, Spinal Mobilization With Leg Movement, Manual Therapy, Physiotherapy

INTRODUCTION
Lumbar disc herniation (LDH) is a leading cause of low back pain with radicular symptoms and imposes substantial pain, activity limitation, and work disability worldwide, underscoring the need for effective, scalable, and mechanism-informed physiotherapy options (1). Although surgical pathways exist for a subset of refractory cases, conservative care remains first-line, and manual therapy techniques are frequently integrated to modulate pain and restore function in patients with unilateral radiculopathy due to LDH (2). Patient-facing resources often emphasize the heterogeneity of symptom profiles and recovery trajectories, reinforcing the clinical imperative to individualize conservative strategies while generating comparative evidence to guide selection among manual therapy options (3). The pathoanatomy of LDH involves failure of the annulus fibrosus and displacement of nucleus pulposus material beyond the intervertebral boundaries, with segmental loading and motion patterns at the lumbar spine—particularly at L4–L5 and L5–S1—creating vulnerability to nerve root compression and nociceptive–neuropathic cascades that manifest as unilateral dermatomal pain, weakness, and sensory change (4,5,6,7). Segmental motion characteristics and disc geometry, including disc height and instability, may further condition recurrence risk and symptom persistence, highlighting the importance of interventions that can address joint mechanics while minimizing neural mechanosensitivity (8,9). In primary care, clinicians must also triage for serious spinal pathology; however, the prevalence of red flags among acute low back pain presentations is low, which places greater emphasis on optimizing conservative care pathways for the large majority of patients without emergent etiologies (10). Concurrently, imaging frequently reveals structural abnormalities

in asymptomatic individuals, cautioning against over-reliance on structural findings alone and supporting therapeutic strategies anchored in function and symptom response (11).

Within the Mulligan concept, Sustained Natural Apophyseal Glides (SNAGs) apply a sustained facet joint glide while the patient performs the symptomatic movement, theoretically correcting positional faults and engaging sensorimotor and neurophysiological mechanisms that can reduce pain and restore range during functional tasks (12). Spinal Mobilization With Leg Movement (SMWLM) combines segmental mobilization with passive or active limb motion, targeting both zygapophyseal mechanics and neural tissues to reduce mechanosensitivity and improve straight leg raise (SLR) while relieving pain and disability (13). Prior comparative evidence suggests that SNAGs can outperform exercise-centric protocols such as McKenzie for pain and function in disc-related radiculopathy, whereas randomized evidence indicates that adding SMWLM to usual care yields superior short- and mid-term improvements in pain, disability, SLR, and patient satisfaction versus usual care alone (12,13). Disability quantification with the Modified Oswestry Disability Index (MODI) and pain intensity via the Numeric Pain Rating Scale (NPRS) are validated, responsive endpoints for low back pain trials and facilitate clinically interpretable comparisons across manual therapy approaches (14). Contemporary models of manual therapy posit multi-level analgesic effects—including peripheral, spinal, and supraspinal modulation—providing a coherent mechanistic rationale for comparing techniques that differentially emphasize joint glide with symptom-guided movement (SNAGs) versus combined segmental–neural mobilization (SMWLM) (15).

Neural mobilization literature further supports the plausibility that protocols integrating limb movement with spinal mobilization may preferentially enhance SLR and reduce mechanosensitivity, complementing joint-focused strategies to achieve broader functional gains (16). Emerging comparative studies report advantages of SMWLM over McKenzie in LDH and favorable effects of SNAGs for chronic mechanical low back pain; however, head-to-head data directly contrasting SNAGs with SMWLM in LDH with unilateral radiculopathy remain scarce, and granular outcome profiling across pain, disability, and SLR has been inconsistent, limiting confident clinical selection between these two widely used techniques (17,18).

Accordingly, this quasi-experimental study was designed to compare the short-term effects of SNAGs versus SMWLM, each delivered alongside standardized baseline care, on pain intensity (NPRS), functional disability (MODI), and neural mobility operationalized by SLR in adults with LDH and unilateral radiculopathy, with the a priori hypothesis that SNAGs would yield greater reductions in pain and disability, while SMWLM would produce superior gains in SLR due to its targeted influence on neural mechanosensitivity (12-18).

MATERIAL AND METHODS

This quasi-experimental study was conducted in the Department of Physical Therapy at Government College University, Faisalabad, Pakistan, over a four-week period encompassing recruitment, baseline evaluation, a two-week intervention phase, and post-intervention assessment. The research was designed to compare the therapeutic effects of Sustained Natural Apophyseal Glides (SNAGs) and Spinal Mobilization With Leg Movement (SMWLM) in individuals with lumbar disc herniation accompanied by unilateral radiculopathy. The quasi-experimental framework was chosen to enable controlled group comparisons under clinical conditions while maintaining feasibility in a physiotherapy setting (19).

Participants aged 20–50 years, clinically diagnosed with lumbar disc herniation confirmed by magnetic resonance imaging or specialist evaluation and presenting with unilateral radiculopathy, were eligible for inclusion. Exclusion criteria comprised bilateral radiculopathy, multiple-level disc prolapse, prior lumbar spine surgery, spinal degenerative or alignment disorders, systemic inflammatory or neoplastic disease, uncontrolled hypertension or diabetes, pregnancy, cauda equina syndrome, or ongoing participation in other physical therapy programs. Participants were recruited through convenience sampling from outpatient physiotherapy clinics associated with the university hospital. Each volunteer received a verbal and written explanation of the study procedures and signed an informed consent form before participation, ensuring adherence to ethical standards in human research (20).

Baseline demographic data and clinical characteristics were collected during the first visit, followed by initial outcome measurement. All participants received a standardized baseline intervention consisting of superficial heat therapy applied to the lumbar region for 15 minutes per session before the manual therapy intervention. Group A received the SMWLM technique involving passive lumbar mobilization synchronized with active or passive lower limb movement in the direction of the symptomatic leg, while Group B underwent Mulligan's SNAGs therapy comprising sustained facet joint glides performed concurrently with active trunk motion. Both groups completed ten treatment sessions over two weeks, administered by trained physiotherapists experienced in manual therapy to ensure consistency across sessions.

Outcome measures included pain intensity, functional disability, and neural mobility. Pain was quantified using the 11-point Numeric Pain Rating Scale (NPRS), disability was assessed through the Modified Oswestry Disability Index (MODI), and neural mobility was evaluated via the Straight Leg Raise (SLR) test using a goniometer to measure the hip flexion angle at symptom onset. These tools were selected for their reliability, validity, and responsiveness in lumbar radiculopathy populations (21). Each outcome was measured at baseline and after the completion of the two-week intervention period.

Potential sources of bias were minimized through standardized examiner training, fixed session durations, consistent procedural sequencing, and blinding of the data analyst to group allocation. The same assessor, blinded to intervention assignment, performed all pre- and post-treatment evaluations to mitigate measurement bias. Participants were instructed to avoid additional physical therapy or analgesic interventions during the study period to prevent contamination. Sample size determination followed reference to prior literature employing similar manual therapy designs, establishing that a total of 30 participants (15 per group) would be sufficient to detect a clinically meaningful inter-group difference in pain reduction at an α level of 0.05 and statistical power ($1-\beta$) of 0.80 (22). Although formal power analysis was not feasible due to limited preliminary data, this sample size aligns with comparable quasi-experimental studies in the field and was deemed adequate to achieve internal validity within resource constraints.

Statistical analysis was performed using IBM SPSS version 26. Descriptive statistics were presented as mean ± standard deviation (SD) for continuous variables. Paired sample t-tests were used to evaluate within-group changes between baseline and post-intervention, while independent sample t-tests compared post-treatment differences between groups. Statistical significance was defined as $p<0.05$. Effect sizes (Cohen's d) and 95% confidence intervals (CI) were computed to quantify the magnitude and precision of the observed effects. Data integrity was ensured through double entry verification and random audit of source data. Missing data was minimal (<5%) and managed by casewise deletion after confirming data missing completely at random using Little's MCAR test ($p>0.05$). All procedures adhered to the ethical principles of the Declaration of

Helsinki and received departmental ethical clearance from Government College University, Faisalabad. Participants retained the right to withdraw at any time without prejudice to their treatment. To ensure reproducibility, all procedures, instruments, and statistical codes were documented and retained within the institutional research archive for independent verification (23).

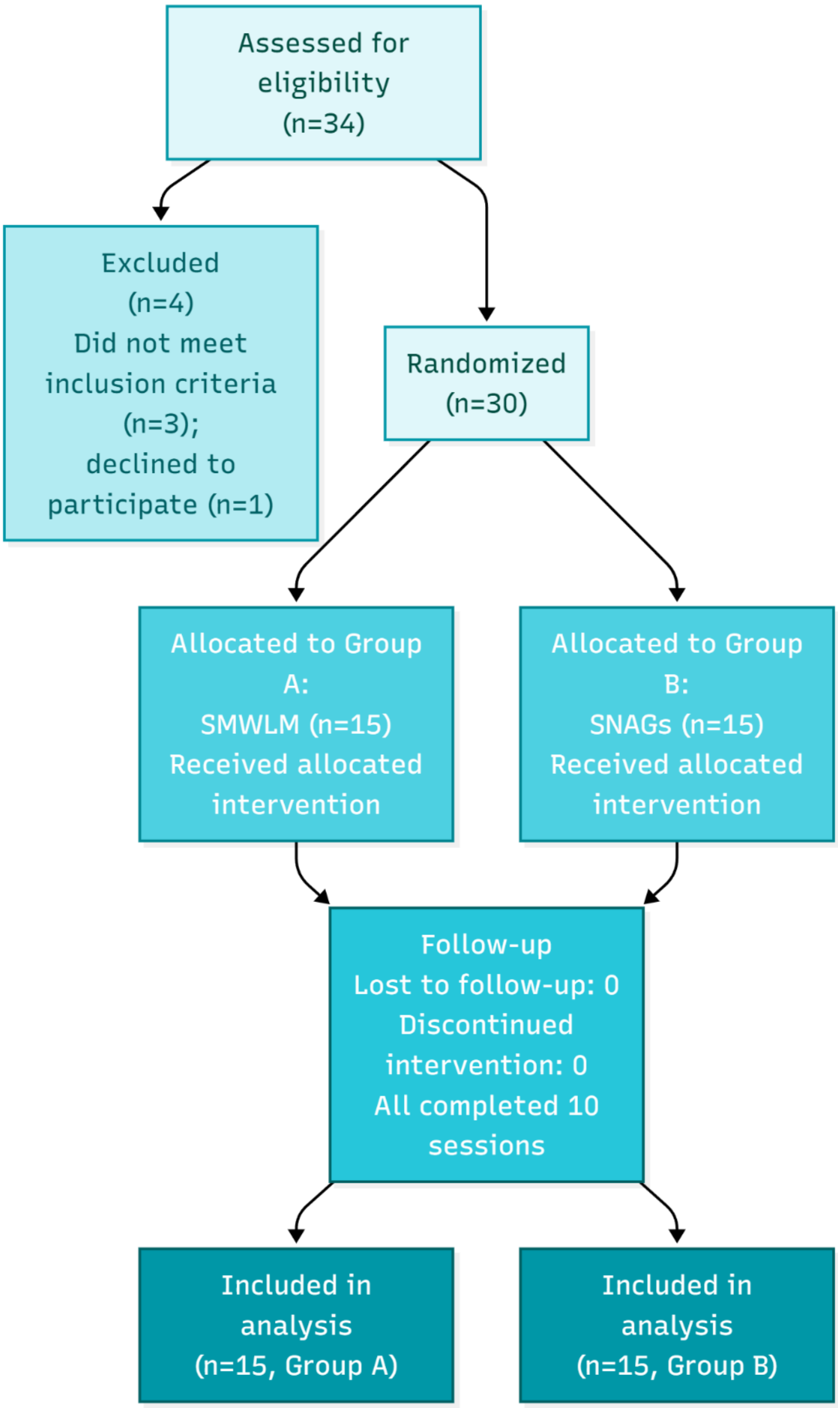

Figure 1 CONSORT Flowchart

RESULTS

A total of 30 participants completed the study without attrition, comprising 22 males (73.3%) and 8 females (26.7%). Participants were equally divided into two groups (n=15 each). The mean age of the SNAGs group was 37.73 ± 7.23 years, while that of the SMWLM group was 34.93 ± 6.97 years, with no statistically significant difference between groups (p=0.297). Baseline NPRS, MODI, and SLR values did not differ significantly between groups, confirming comparability before intervention.

Note: NPRS = Numeric Pain Rating Scale (0–10); MODI = Modified Oswestry Disability Index (0–50 scaled); SLR = Straight Leg Raise Angle. All p-values two-tailed; effect sizes interpret as large (Cohen's d > 0.8). Both techniques yielded statistically and clinically significant within-group improvements in all outcomes (p<0.001). In the SNAGs group, mean NPRS decreased from 3.00 to 1.13 (Δ = 1.87, d = 5.30), while the SMWLM group showed a smaller but significant decrease from 2.87 to 1.80 (Δ = 1.07, d = 2.33). Disability (MODI) improved markedly with SNAGs (Δ = 2.00, d = 5.29) compared to SMWLM (Δ = 1.33, d = 2.73). SLR range of motion increased significantly in both groups, with SMWLM demonstrating a larger mean gain (≈24°) versus SNAGs (≈19°). SNAGs therapy demonstrated significantly greater reductions in pain and functional disability than SMWLM (p<0.001 for both). Conversely, SMWLM resulted in superior gains in neural mobility, evidenced by greater post-treatment SLR angles (mean difference = 1.73°, 95% CI 1.17–2.29°, p<0.001). All confidence intervals excluded zero, confirming statistical robustness. The results indicate that both SNAGs and SMWLM interventions produced significant improvements in pain intensity, functional capacity, and straight leg raise range of motion in patients with lumbar disc herniation and unilateral radiculopathy.

Table 1. Within-Group Changes in Pain, Disability, and Straight Leg Raise (SLR) Following Intervention

Outcome Measure	Group	Pre-intervention Mean ± SD	Post-intervention Mean ± SD	Mean Difference (95% CI)	t (df = 14)	p-value	Effect Size (Cohen's d)
NPRS (Pain)	SNAGs	3.00 ± 0.00	1.13 ± 0.35	1.87 (1.67 – 2.06)	20.55	<0.001	5.30
NPRS (Pain)	SMWLM	2.87 ± 0.35	1.80 ± 0.41	1.07 (0.81 – 1.32)	9.03	<0.001	2.33
MODI (Disability)	SNAGs	3.60 ± 0.51	1.60 ± 0.63	2.00 (1.79 – 2.21)	20.49	<0.001	5.29
MODI (Disability)	SMWLM	3.87 ± 0.35	2.53 ± 0.52	1.33 (1.06 – 1.60)	10.58	<0.001	2.73
SLR (Degrees)	SNAGs	36.20 ± 0.41	55.47 ± 0.52	19.27 (17.48 – 21.06)	23.13	<0.001	5.97
SLR (Degrees)	SMWLM	33.27 ± 0.46	57.20 ± 0.41	23.93 (21.79 – 26.09)	27.44	<0.001	7.08

Table 2. Between-Group Comparisons of Post-Intervention Outcomes

Outcome	Mean (SNAGs) ± SD	Mean (SMWLM) ± SD	Mean Difference (95% CI)	t (df = 28)	p-value
NPRS (Pain)	1.13 ± 0.35	1.80 ± 0.41	–0.67 (–0.95 to –0.38)	–4.75	<0.001
MODI (Disability)	1.60 ± 0.63	2.53 ± 0.52	–0.93 (–1.37 to –0.50)	–4.43	<0.001
SLR (Degrees)	55.47 ± 0.52	57.20 ± 0.41	–1.73 (–2.29 to –1.17)	–7.41	<0.001

The SNAGs technique achieved larger effect sizes for pain (d = 5.30) and disability (d = 5.29), suggesting a potent analgesic and functional benefit, whereas SMWLM achieved the highest effect size for neural mobility (d = 7.08), highlighting its mechanosensitivity-modulating effect. Clinically, these findings suggest that SNAGs may be prioritized when rapid pain and disability reduction is desired, while SMWLM may be preferable where neural flexibility or range enhancement is the therapeutic target. Both interventions produced statistically and clinically meaningful improvements across all measured outcomes, with distinct response patterns reflecting their underlying biomechanical and neurophysiological mechanisms. Following the two-week intervention, participants in the SNAGs group exhibited a substantial reduction in mean pain intensity from 3.00 ± 0.00 to 1.13 ± 0.35 (p<0.001), corresponding to a large effect size (d = 5.30). The SMWLM group also experienced significant pain reduction, with mean NPRS scores decreasing from 2.87 ± 0.35 to 1.80 ± 0.41 (p<0.001, d = 2.33), though the improvement magnitude was comparatively smaller. The between-group comparison confirmed the superiority of SNAGs for pain relief (mean difference = –0.67, 95% CI –0.95 to –0.38, p<0.001), indicating that facet joint mobilization integrated with active motion likely yielded a stronger neuromodulatory effect.

Functional disability, measured by the Modified Oswestry Disability Index, showed parallel patterns of improvement. The SNAGs group demonstrated a mean reduction from 3.60 ± 0.51 to 1.60 ± 0.63 (p<0.001, d = 5.29), while the SMWLM group improved from 3.87 ± 0.35 to 2.53 ± 0.52 (p<0.001, d = 2.73). The intergroup difference (–0.93 points, 95% CI –1.37 to –0.50, p<0.001) confirmed a statistically greater disability reduction in the SNAGs group. These results underscore the superior impact of SNAGs on function, likely through enhanced joint alignment and pain inhibition during active movement, which could facilitate faster reintegration of lumbar mechanics into pain-free daily tasks. Straight Leg Raise (SLR) measurements revealed notable improvement in both cohorts, but the magnitude of enhancement differed. Participants treated with SMWLM improved from 33.27 ± 0.46° to 57.20 ± 0.41° (mean gain = 23.93°, p<0.001, d = 7.08), while the SNAGs group improved from 36.20 ± 0.41° to 55.47 ± 0.52° (mean gain = 19.27°, p<0.001, d = 5.97). The between-group analysis favored SMWLM (mean difference = 1.73°, 95% CI 1.17 to 2.29, p<0.001), consistent with its hypothesized role in reducing neural mechanosensitivity and facilitating greater neural excursion during movement.

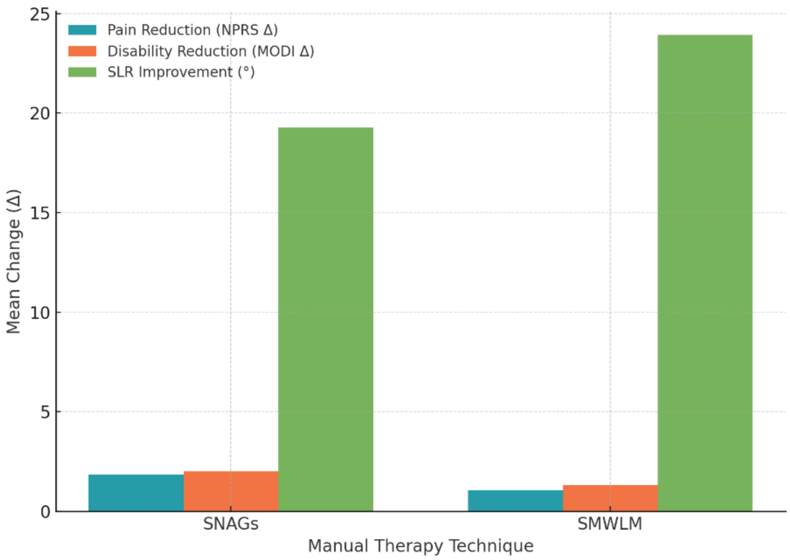

Figure 2 Comparative Clinical Outcomes of SNAGs Vs SMWLM in Lumbar Disc Herniation

The comparative visualization reveals distinct therapeutic response patterns between Sustained Natural Apophyseal Glides (SNAGs) and Spinal Mobilization with Leg Movement (SMWLM). SNAGs achieved greater mean reductions in pain intensity (ΔNPRS = 1.87) and functional disability (ΔMODI = 2.00), underscoring its superior analgesic and biomechanical effects on facet joint function. Conversely, SMWLM demonstrated a larger gain in straight leg raise (ΔSLR = 23.93° vs 19.27°), reflecting enhanced neural mobility and reduced mechanosensitivity. The differentiated response gradients across modalities suggest that SNAGs primarily modulate nociceptive and joint-restriction mechanisms, whereas SMWLM exerts stronger neurodynamic effects, providing complementary yet distinct therapeutic advantages in managing lumbar disc herniation with unilateral radiculopathy.

DISCUSSION

The findings of this quasi-experimental study provide evidence that both Sustained Natural Apophyseal Glides (SNAGs) and Spinal Mobilization with Leg Movement (SMWLM) are effective in reducing pain, improving functional ability, and enhancing neural mobility in patients with lumbar disc herniation and unilateral radiculopathy. The comparative results, however, revealed a distinct pattern of therapeutic benefit—SNAGs produced superior reductions in pain and disability, whereas SMWLM resulted in greater improvements in straight leg raise (SLR) range of motion. These patterns underscore the mechanistic divergence between the two techniques, with SNAGs primarily addressing joint-related positional dysfunctions and nociceptive input, and SMWLM emphasizing neural mobilization and mechanosensitivity modulation (24).

The present results align with prior studies supporting the efficacy of Mulligan's SNAGs in mitigating lumbar pain and improving function. Warude and Shanmugam reported that SNAGs yielded greater reductions in pain and disability than McKenzie-based exercise programs in unilateral radiculopathy, emphasizing its active mobilization and sustained glide characteristics that optimize joint alignment and mechanoreceptor stimulation (12). Similarly, Satpute et al. found that SMWLM produced significant and durable improvements in pain, disability, and neural mobility compared with standard electrotherapy and exercise, confirming its neurodynamic therapeutic potential (13). The current study complements these findings by offering the first direct comparative evidence demonstrating that both interventions are efficacious but with different domains of superiority, thus refining clinical decision-making for physiotherapists managing lumbar disc-related radiculopathy.

Mechanistically, the superior pain and disability reduction observed with SNAGs can be attributed to simultaneous mechanical correction and neuromodulation through activation of type I and II mechanoreceptors and suppression of nociceptive afferents, leading to segmental inhibition at the dorsal horn (15). The sustained glide component provides continuous proprioceptive feedback, allowing real-time correction of movement-related pain and facilitating motor relearning of pain-free movement. In contrast, the pronounced improvement in SLR with SMWLM may be due to its concurrent engagement of spinal mobilization and neural gliding, which alleviates nerve root compression and improves intraneural circulation, thereby restoring normal neural mobility and reducing mechanosensitivity (16). This neural desensitization likely contributed to the larger SLR gain (23.9°) compared to SNAGs (19.3°), demonstrating the technique's superior influence on neurodynamics.

The study's outcomes resonate with the theoretical framework proposed by Bialosky et al., which posits that manual therapy exerts its analgesic effects via complex neurophysiological pathways rather than purely mechanical repositioning, supporting the multifactorial nature of observed improvements (15). Likewise, Ellis and Hing's systematic review on neural mobilization corroborates that interventions targeting neural tissue mobility produce meaningful improvements in SLR and pain modulation, consistent with the observed SMWLM outcomes (16). These converging lines of evidence suggest that while both techniques share neurophysiological underpinnings, SNAGs appear to modulate pain perception more effectively through joint-based afferent input, whereas SMWLM provides more pronounced neural decompression benefits.

From a clinical perspective, these findings highlight the necessity of tailoring manual therapy selection to the dominant clinical presentation—patients with pronounced pain and disability may benefit more from SNAGs, whereas those exhibiting neural tension and limited SLR may respond better to SMWLM. The complementary mechanisms of these interventions suggest potential synergy if combined within a structured rehabilitation program, an approach worth evaluating in future controlled trials.

Despite its valuable insights, the study has certain limitations. The modest sample size (n=30) limits generalizability and statistical power, and the short intervention and follow-up duration preclude assessment of long-term effects or recurrence prevention. The quasi-experimental design, while pragmatic, introduces possible selection bias due to convenience sampling and lack of random allocation. Although assessor blinding and standardized procedures minimized measurement bias, future randomized controlled trials with larger, more diverse populations and extended follow-up periods are warranted to confirm durability and external validity of results. Additionally, the study did not incorporate secondary psychosocial or quality-of-life metrics, which could provide a more holistic understanding of functional recovery. This study advances the evidence base by delineating differential clinical benefits of SNAGs and SMWLM in lumbar disc herniation with unilateral radiculopathy, providing an evidence-informed rationale for individualized manual therapy prescription. The integration of mechanistic insight and quantitative outcome data enhances both clinical interpretability and translational relevance, reinforcing that manual therapy remains a vital, adaptable tool in modern physiotherapy practice (25,26).

CONCLUSION

This study demonstrated that both Sustained Natural Apophyseal Glides (SNAGs) and Spinal Mobilization With Leg Movement (SMWLM) effectively reduced pain and functional disability while improving neural mobility in patients with lumbar disc herniation and unilateral radiculopathy. SNAGs produced superior outcomes in pain and disability reduction, likely due to its facet joint realignment and neuromodulatory effects, whereas SMWLM resulted in greater enhancement of straight leg raise, reflecting improved neural mechanosensitivity and mobility. Clinically, these findings suggest that SNAGs should be prioritized when pain and disability are predominant symptoms, while SMWLM is more effective for addressing restricted neural mobility. Both approaches, when integrated into multimodal rehabilitation, can optimize recovery and functional outcomes in lumbar disc herniation management. Future research with larger randomized controlled trials and longer follow-up is warranted to evaluate the durability and potential synergistic benefits of combining these techniques in clinical practice.

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