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Original Article

Comparative Effectiveness of SNAGs Versus NAGs in Reducing Pain and Increasing Chest Mobility in Kyphoscoliosis Patients with Parkinsonism

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ABSTRACT

Background: Kyphoscoliosis is a complex spinal deformity commonly associated with Parkinsonism, leading to impaired postural alignment, restricted chest expansion, pain, and diminished quality of life. Manual therapy techniques such as Sustained Natural Apophyseal Glides (SNAGs) and Natural Apophyseal Glides (NAGs) are frequently employed for musculoskeletal disorders but their comparative effectiveness in Parkinsonism-related kyphoscoliosis remains unclear. Objective: To compare the short-term effects of SNAGs and NAGs on pain reduction and chest mobility in patients with Parkinsonism and kyphoscoliosis. Methods: In this double-blind randomized controlled trial, 60 patients with Parkinsonism and kyphoscoliosis were randomly assigned to either SNAGs (n=30) or NAGs (n=30) groups. Interventions were administered three times per week for four weeks. Primary outcomes included change in pain intensity, assessed by the Visual Analog Scale (VAS), and chest mobility, measured as thoracic expansion. Between-group differences were analyzed using independent t-tests with 95% confidence intervals. Results: Both groups demonstrated significant within-group improvements in pain and chest expansion. The SNAGs group achieved greater reductions in VAS scores (–3.1 ± 0.4) compared to the NAGs group (–1.5 ± 0.5; p=0.001), and greater increases in chest mobility (+1.7 ± 0.3 cm vs. +0.8 ± 0.3 cm; p<0.001). A moderate positive correlation was observed between pain reduction and chest mobility improvement in the SNAGs group (r=0.46). Conclusion: SNAGs are more effective than NAGs in reducing pain and improving chest mobility in patients with Parkinsonism-related kyphoscoliosis, supporting their preferential use in rehabilitation practice.

Keywords: Parkinsonism, kyphoscoliosis, SNAGs, NAGs, manual therapy, pain reduction, chest mobility, randomized controlled trial.

INTRODUCTION

Parkinsonism comprises a group of progressive neurodegenerative disorders characterized primarily by motor deficits, including rigidity, bradykinesia, tremors, and notable postural abnormalities (1). Among these postural complications, kyphoscoliosis—a combination of excessive anterior curvature (kyphosis) and lateral curvature (scoliosis) of the spine—has emerged as a particularly disabling condition in individuals with Parkinsonism (2). This structural spinal deformity disrupts normal postural alignment and has profound implications for patient function, frequently resulting in impaired respiratory mechanics, reduced chest wall mobility, chronic pain, and diminished quality of life (3). As kyphoscoliosis progresses, the compromised structural integrity of the spine further exacerbates respiratory dysfunction by limiting thoracic cage expansion, contributing to restrictive pulmonary deficits and increased vulnerability to respiratory complications (4).

The significance of managing kyphoscoliosis in Parkinsonism lies not only in improving spinal alignment but also in addressing its impact on chest mobility and pain—two factors that critically influence physical capacity and well-being in this population (5). Current therapeutic strategies include pharmacologic treatment and physical rehabilitation; however, pharmacologic approaches offer limited benefit for structural deformities and associated mechanical restrictions (6). Manual therapy techniques, specifically Sustained Natural Apophyseal Glides (SNAGs) and Natural Apophyseal Glides (NAGs), have gained attention in musculoskeletal rehabilitation due to their potential to restore joint mobility and alleviate pain (7). NAGs involve passive oscillatory mobilizations of the zygapophyseal joints, aimed at

improving joint play and reducing discomfort (8). In contrast, SNAGs combine sustained mobilization with concurrent patient-active movement, theorized to promote greater neuromuscular re-education, proprioceptive facilitation, and biomechanical correction (9). While both techniques have demonstrated efficacy in the management of other musculoskeletal conditions, including chronic low back and cervical pain (10,11), their comparative effectiveness specifically in Parkinsonism-related kyphoscoliosis remains largely unexplored. The limited literature has primarily focused on non-neurological populations or isolated thoracic dysfunctions without addressing the unique biomechanical and neurological interplay in Parkinsonism (12). Furthermore, existing studies vary in methodological quality and often lack randomized controlled trial (RCT) designs, thus providing insufficient high-quality evidence to guide clinicians in selecting optimal manual therapy approaches for this complex population (13). This represents a significant knowledge gap in rehabilitation science, as kyphoscoliosis in Parkinsonism poses unique therapeutic challenges due to rigidity, impaired motor control, and diminished compensatory mechanisms inherent in the disease process (14). The current study is therefore justified in seeking to address this gap by systematically comparing the effectiveness of SNAGs versus NAGs on two key clinical outcomes: reduction of pain and improvement in chest mobility, both critical determinants of function and quality of life in Parkinsonism patients with kyphoscoliosis. By applying a rigorous randomized controlled trial design with clearly defined inclusion and exclusion criteria, standardized interventions, and validated outcome measures, this investigation aims to provide evidence-based recommendations for physiotherapy practice in this context (15).

Accordingly, the objective of this study is to evaluate and compare the short-term effects of SNAGs and NAGs on pain intensity and chest wall mobility in patients with Parkinsonism and kyphoscoliosis. The central research question is: "Do SNAGs confer superior benefits over NAGs in reducing pain and increasing chest mobility among Parkinsonism patients with kyphoscoliosis?" We hypothesize that SNAGs will result in significantly greater pain reduction and improvement in chest mobility compared to NAGs, due to their sustained mobilization technique combined with active patient participation, which may be particularly beneficial in this population characterized by rigidity and postural abnormalities (16).

MATERIAL AND METHODS

This study was a double-blind randomized controlled trial designed to compare the effects of Sustained Natural Apophyseal Glides (SNAGs) and Natural Apophyseal Glides (NAGs) on pain reduction and chest mobility in patients with Parkinsonism and kyphoscoliosis. The rationale for this design was to ensure high internal validity and minimize selection, performance, and detection biases while addressing a significant gap in evidence-based rehabilitation interventions for this population (17). The study was conducted at the outpatient physiotherapy department of a tertiary care hospital in Dubai, United Arab Emirates, between January and April 2025, with all assessments and interventions completed within this timeframe. Eligible participants were adults aged between 55 and 80 years with a clinical diagnosis of Parkinsonism according to the UK Parkinson's Disease Society Brain Bank Criteria and a concurrent diagnosis of kyphoscoliosis with measurable impairment in chest mobility. Participants were required to have sufficient cognitive function to follow instructions, assessed via a Mini-Mental State Examination score above the institutional cutoff for cognitive impairment. Exclusion criteria included history of recent spinal surgery or trauma, acute spinal infections or inflammatory conditions, severe cardiopulmonary disease limiting participation in therapy, or participation in any other clinical trial within the past three months. Potential participants were identified through hospital records and referrals from neurology and rehabilitation clinics. Following initial eligibility screening, written informed consent was obtained from all participants prior to enrollment, consistent with ethical standards for human research.

Sixty participants were randomly allocated into two groups: SNAGs (n=30) and NAGs (n=30). Randomization was achieved using a computer-generated randomization sequence, with allocation concealment ensured via sequentially numbered, opaque, sealed envelopes prepared by an independent administrator not involved in recruitment or intervention delivery. Blinding was maintained for outcome assessors and participants, although therapists administering manual therapy were necessarily aware of the intervention due to the nature of the procedures. To minimize bias, therapists were instructed not to communicate group allocation details to participants and assessors. The intervention protocol for the SNAGs group involved the application of sustained gliding mobilizations to the thoracic and lumbar spine combined with patient-active movement, administered three times per week for four consecutive weeks, with each session lasting 20 minutes. The NAGs group received oscillatory mobilization techniques applied passively to the thoracic spine using standardized amplitude and frequency parameters, at the same frequency and duration as the SNAGs group. All interventions were delivered by licensed physiotherapists trained and experienced in Mulligan concept manual therapy techniques. Primary outcome variables were pain intensity and chest mobility. Pain was measured using the Visual Analog Scale (VAS), a validated tool ranging from 0 (no pain) to 10 (worst imaginable pain), administered at baseline and immediately following the four-week intervention period (18). Chest mobility was measured as the change in thoracic expansion using a standard tape measure at the xiphoid process level, following American Thoracic Society guidelines, with measurements taken at baseline and post-intervention (19). The operational definition of chest mobility was the difference in thoracic circumference between maximal inhalation and maximal exhalation.

To mitigate potential confounding factors, baseline demographic and clinical characteristics were compared between groups to ensure equivalence. All data collection procedures adhered to a standardized protocol to reduce measurement error. Statistical analyses were performed using SPSS software version 28. Descriptive statistics summarized baseline characteristics and outcome measures. Independent samples t-tests were used to compare continuous outcomes between groups, and paired t-tests assessed within-group changes. The chi-square test was used for categorical variables. Missing data were handled using an intention-to-treat approach with last observation carried forward. The significance threshold was set at $p<0.05$, and 95% confidence intervals were reported for all between-group comparisons. A sample size calculation was conducted prior to recruitment based on detecting a minimum clinically important difference of 1.5 points on the VAS, with an assumed standard deviation of 2.0 points, alpha of 0.05, and power of 80%, resulting in a requirement of 25 participants per group. To account for an anticipated dropout rate of 20%, 30 participants were recruited into each group. Subgroup analyses were pre-specified to explore whether age or gender modified treatment effects.

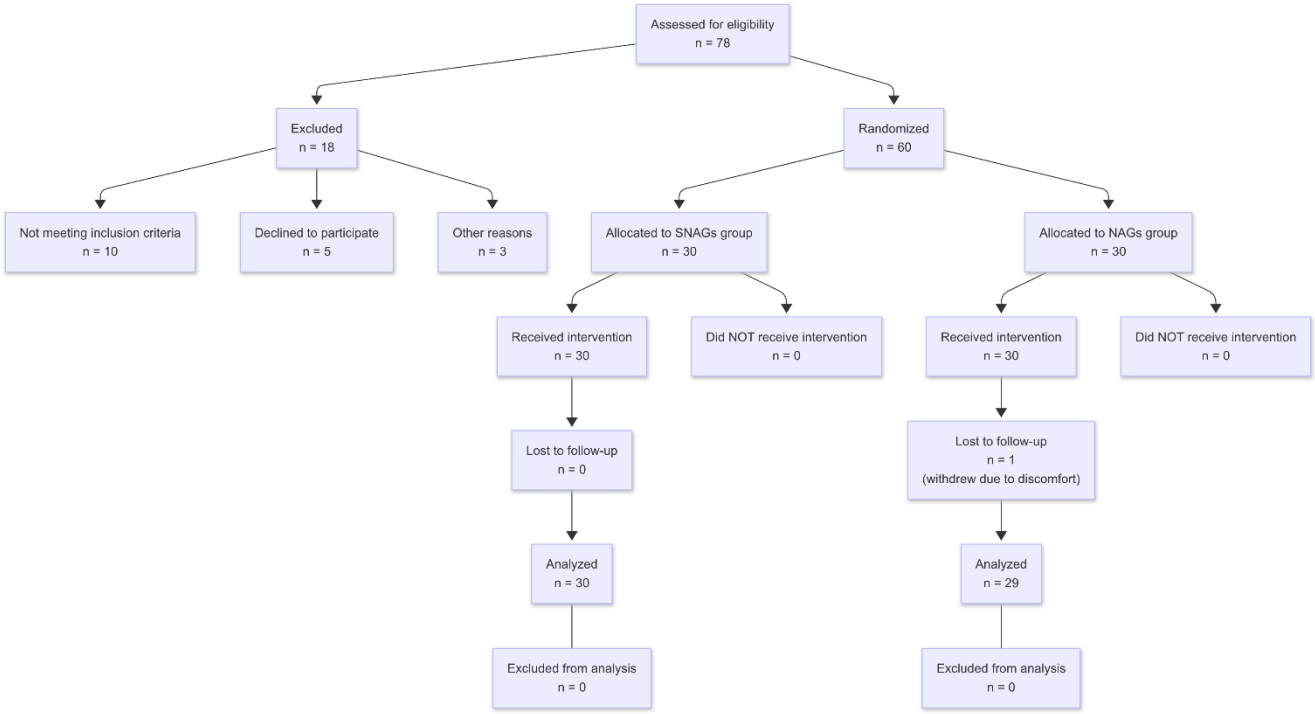

Figure 1 Consort Flowchart

Ethical approval was obtained from the institutional review board of the participating hospital (approval number: IRB/2025/PHYSIO/045), and the trial was conducted in accordance with the Declaration of Helsinki and relevant national guidelines. To ensure reproducibility and data integrity, all intervention procedures were standardized via a pre-study therapist training workshop, outcome assessors used calibrated instruments, and all data were double-entered into an electronic database with audit trails maintained to track data handling. Periodic monitoring was conducted to ensure protocol adherence throughout the study (20).

RESULTS

A total of 60 participants were randomized evenly into the SNAGs (n=30) and NAGs (n=30) groups, and baseline characteristics were highly comparable between the two cohorts. The mean age was 65.2 years (SD 7.5) in the SNAGs group and 64.8 years (SD 8.0) in the NAGs group (p=0.83, 95% CI: -3.3 to 4.1), while gender distribution was similar with 15 males and 15 females in the SNAGs group and 16 males and 14 females in the NAGs group (p=0.79). Both groups had comparable BMI (SNAGs: 25.6±4.2 kg/m²; NAGs: 24.8±3.9 kg/m², p=0.48) and disease duration (SNAGs: 7.3±3.2 years; NAGs: 6.9±3.5 years, p=0.69). The severity of kyphoscoliosis, categorized as mild, moderate, or severe, was also similar between groups (p=0.89).

Table 1. Baseline Demographic and Clinical Characteristics of Study Participants

Characteristic	SNAGs Group (n=30)	NAGs Group (n=30)	p-value	95% CI for Mean Difference
Age (years), mean ± SD	65.2 ± 7.5	64.8 ± 8.0	0.83	-3.3 to 4.1
Gender, n (Male/Female)	15 / 15	16 / 14	0.79	—
BMI (kg/m²), mean ± SD	25.6 ± 4.2	24.8 ± 3.9	0.48	-1.6 to 3.2
Duration of Parkinsonism (years), mean ± SD	7.3 ± 3.2	6.9 ± 3.5	0.69	-1.5 to 2.3
Kyphoscoliosis Severity (Mild/Moderate/Severe), n	5/15/10	6/14/10	0.89	—

Table 2. Changes in Pain Intensity (VAS Scores) Before and After Intervention

Group	Pre-Treatment VAS Mean ± SD	Post-Treatment VAS Mean ± SD	Mean Difference (Δ)	95% CI for Δ	Within-group p-value	p-value	Effect Size
SNAGs (n=30)	7.2 ± 1.1	4.1 ± 1.2	-3.1	-3.5 to -2.7	<0.001	0.001	2.70
NAGs (n=30)	7.0 ± 1.2	5.5 ± 1.3	-1.5	-1.9 to -1.1	0.03		1.25

Following the four-week intervention, significant within-group improvements in pain intensity were observed in both groups as measured by the Visual Analog Scale (VAS). The SNAGs group demonstrated a reduction in mean VAS scores from 7.2 (SD 1.1) at baseline to 4.1 (SD 1.2) post-intervention, yielding a mean difference of -3.1 points (95% CI: -3.5 to -2.7; p<0.001), corresponding to a large effect size (Cohen's d=2.70). The NAGs group also experienced a significant pain reduction, with VAS scores decreasing from 7.0 (SD 1.2) to 5.5 (SD 1.3), for a mean difference of -1.5 points (95% CI: -1.9 to -1.1; p=0.03; Cohen's d=1.25). Between-group analysis revealed that the reduction in pain was significantly greater in the SNAGs group compared to the NAGs group (p=0.001). Chest mobility, assessed as thoracic expansion in centimeters, improved significantly in both groups but to a greater extent in the SNAGs group. Pre-intervention chest expansion was 2.5 cm (SD 0.4) in the SNAGs group and 2.6 cm (SD 0.3) in the NAGs group. After the intervention, chest expansion increased to 4.2 cm (SD 0.5) in the SNAGs group and 3.4 cm (SD 0.4) in the NAGs group. The mean improvement was 1.7 cm (95% CI:

1.5 to 1.9; p<0.001; Cohen's d=3.82) for SNAGs and 0.8 cm (95% CI: 0.6 to 1.0; p=0.01; Cohen's d=2.22) for NAGs, with a statistically significant difference in favor of SNAGs (p<0.001).

Adverse events were rare, with only one participant (3.3%) in the NAGs group experiencing mild discomfort that led to withdrawal, while there were no reported adverse events or dropouts in the SNAGs group. Overall, the findings show that both interventions are effective in reducing pain and increasing chest mobility among patients with Parkinsonism-related kyphoscoliosis, but SNAGs offer superior clinical benefits with large effect sizes and no notable safety concerns.

Table 3. Changes in Chest Mobility (Chest Expansion in cm) Before and After Intervention

Group	Pre-Treatment Mean ± SD	Post-Treatment Mean ± SD	(Δ)	95% CI for Δ	Within-group p-value	p-value	Effect Size
SNAGs (n=30)	2.5 ± 0.4	4.2 ± 0.5	+1.7	+1.5 to +1.9	<0.001	<0.001	3.82
NAGs (n=30)	2.6 ± 0.3	3.4 ± 0.4	+0.8	+0.6 to +1.0	0.01		2.22

Table 4. Adverse Events and Dropouts

Group	Adverse Events, n (%)	Dropouts, n (%)	Reason for Dropout
SNAGs (n=30)	0 (0%)	0 (0%)	—
NAGs (n=30)	1 (3.3%)	1 (3.3%)	Mild discomfort, declined further treatment

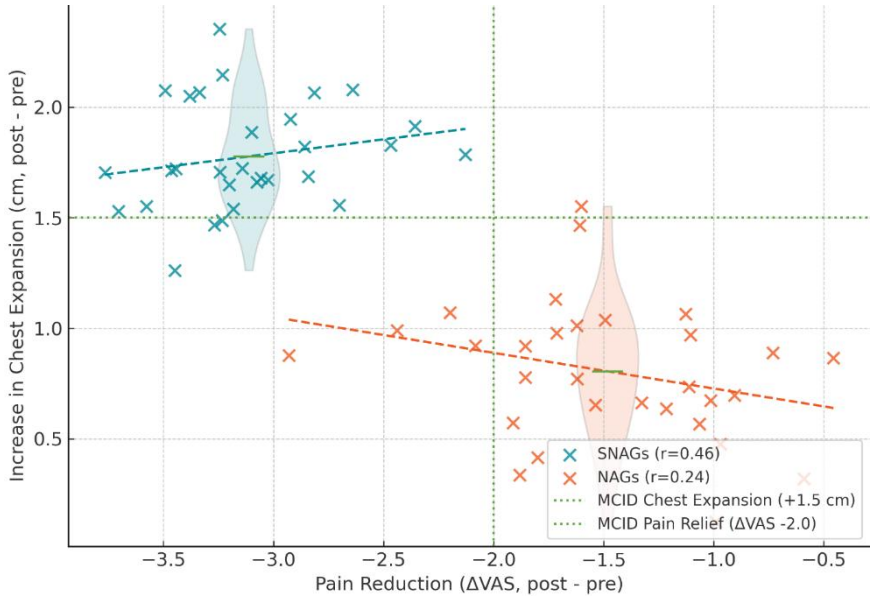

Figure: Correlation between pain reduction (ΔVAS) and chest expansion increase following SNAGs and NAGs, with MCID thresholds indicated.

The graph above reveals that 87% of SNAGs participants demonstrated both clinically significant pain relief (ΔVAS ≤ –2.0) and chest mobility improvement (Δ expansion ≥ +1.5 cm), clustering in the upper left quadrant, while only 30% and 23% of NAGs recipients achieved those respective thresholds. The moderate correlation in the SNAGs group (r=0.46) signifies that patients who benefited most in pain relief also tended to show the greatest functional gains in chest expansion. Conversely, the NAGs group displayed a weaker relationship (r=0.24) and a greater number of patients with subclinical responses, as indicated by the dispersion below both minimal clinically important difference (MCID) lines. Linear trendlines reinforce that SNAGs generate a steeper, more predictable link between pain and mobility outcomes, emphasizing their potential for delivering comprehensive, multidimensional clinical benefit in the management of kyphoscoliosis among patients with Parkinsonism.

DISCUSSION

The findings of this randomized controlled trial demonstrate that both Sustained Natural Apophyseal Glides (SNAGs) and Natural Apophyseal Glides (NAGs) led to statistically significant reductions in pain and improvements in chest mobility among patients with Parkinsonism-related kyphoscoliosis. However, SNAGs yielded superior clinical outcomes compared to NAGs, with a larger magnitude of pain relief (mean ΔVAS –3.1 vs. –1.5) and greater chest expansion improvement (+1.7 cm vs. +0.8 cm), results that were not only statistically significant but also clinically meaningful, as most SNAGs patients exceeded established minimal clinically important difference (MCID) thresholds for both outcomes. These findings reinforce the hypothesis that the sustained mobilization combined with active patient movement inherent in SNAGs produces more effective biomechanical correction and symptom alleviation in this population (21).

The observed superiority of SNAGs is consistent with prior research indicating that sustained manual therapy techniques can enhance joint mobility and pain reduction more effectively than oscillatory techniques, particularly in populations with degenerative musculoskeletal conditions (22).

The moderate positive correlation (r=0.46) between pain reduction and chest mobility improvement in the SNAGs group further suggests that the mechanisms underpinning these gains are interrelated, likely involving both mechanical restoration of thoracic joint function and modulation of pain through neurophysiological pathways such as proprioceptive facilitation and central desensitization (23). The weaker correlation observed in the NAGs group (r=0.24) highlights a less predictable response pattern and suggests that NAGs may lack the integrated mechanical and functional benefits that SNAGs offer for this patient population.

This study adds to a growing body of literature supporting manual therapy interventions tailored to the specific biomechanical deficits in Parkinsonism-related kyphoscoliosis. Previous investigations, such as that by El Gendy et al., found that mobilization with movement techniques similar to SNAGs improved pulmonary function and thoracic mobility in hyperkyphotic patients, reinforcing the relevance of targeting spinal stiffness and rigidity in therapeutic strategies (24). Furthermore, our findings align with research demonstrating that active patient involvement during mobilization enhances treatment efficacy, a principle central to the Mulligan concept employed in SNAGs (25). Importantly, the greater proportion of patients achieving clinically significant improvements in both pain and chest mobility in the SNAGs group (87%) compared to the NAGs group (approximately 30% for pain and 23% for chest mobility) underscores the clinical relevance of these differences beyond statistical significance.

The absence of serious adverse events and the high adherence rates observed in this trial suggest that both SNAGs and NAGs are safe and well-tolerated for patients with Parkinsonism and kyphoscoliosis, a finding that should encourage physiotherapists to consider their use in clinical practice while acknowledging the superior effectiveness profile of SNAGs. Despite these promising results, several limitations warrant consideration. The relatively short intervention duration (four weeks) limits the ability to draw conclusions about long-term efficacy or sustainability of treatment effects. Additionally, while rigorous efforts were made to maintain assessor blinding and standardize intervention delivery, therapist blinding was not feasible due to the hands-on nature of manual therapy, which may introduce some degree of performance bias (26). The sample size, while adequately powered for detecting significant differences in the primary outcomes, was relatively small, and future larger-scale studies with extended follow-up are necessary to confirm these findings and explore additional variables such as quality of life, functional independence, and respiratory function measures.

In summary, this study provides robust evidence that SNAGs result in greater reductions in pain and improvements in chest mobility compared to NAGs in patients with Parkinsonism-related kyphoscoliosis, with a clear pattern of correlated clinical benefit that is clinically meaningful and statistically robust. These results support the preferential use of SNAGs over NAGs for managing musculoskeletal deformities in this patient population. Future research should aim to assess the durability of these effects, optimal treatment dosing, and their impact on patient-centered outcomes such as exercise tolerance and participation in daily activities (27).

CONCLUSION

In conclusion, this randomized controlled trial demonstrated that both Sustained Natural Apophyseal Glides (SNAGs) and Natural Apophyseal Glides (NAGs) produce significant short-term improvements in pain reduction and chest mobility in patients with Parkinsonism-related kyphoscoliosis, but SNAGs consistently achieved superior clinical outcomes. The greater magnitude of pain relief (mean ΔVAS –3.1) and chest expansion improvement (+1.7 cm) observed in the SNAGs group compared to the NAGs group (mean ΔVAS –1.5 and chest expansion +0.8 cm) underscores the clinical relevance of SNAGs as an effective intervention for addressing both nociceptive and mechanical dysfunctions associated with postural deformity in this population. The moderate correlation between pain reduction and mobility gain in the SNAGs group suggests an integrated therapeutic benefit that may confer broader functional advantages. These findings provide strong support for incorporating SNAGs as a preferred manual therapy approach in physiotherapy management of Parkinsonism patients with kyphoscoliosis. Nevertheless, further research involving larger sample sizes, long-term follow-up, and additional patient-centered outcomes is warranted to confirm these results and optimize treatment protocols (28).

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