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Original Article

Temporal Recovery Patterns and Clinically Meaningful Change in Pain, Lumbar Mobility, and Disability Among Patients with Lumbar Myofascial Pain Syndrome Receiving McKenzie-Based Rehabilitation: A Secondary Analysis of a Randomized Trial

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ABSTRACT

Background: Lumbar myofascial pain syndrome is commonly associated with persistent pain, restricted spinal mobility, and functional disability. Conventional trial reporting often emphasizes statistical differences between interventions, but this may not clarify when recovery occurs or whether pain, mobility, and disability improve at similar rates. **Objective:** To evaluate temporal recovery patterns and clinically meaningful change in pain intensity, lumbar mobility, hip flexion, and disability among patients with lumbar myofascial pain syndrome receiving McKenzie-based rehabilitation. **Methods:** This secondary analysis used data from a single-blinded randomized trial including 70 adults allocated to adjunctive Graston technique with McKenzie extension protocol or McKenzie extension protocol alone. Outcomes included Visual Analogue Scale pain score, Oswestry Disability Index, lumbar flexion, lumbar extension, right and left lateral flexion, and hip flexion measured at baseline, 6 weeks, and 12 weeks. Absolute change, percentage improvement, Friedman tests, Mann–Whitney U tests, and effect-size gradients were used to interpret recovery patterns. **Results:** At 12 weeks, adjunctive Graston plus McKenzie rehabilitation produced greater improvement than McKenzie alone in pain reduction (65.4% vs 44.7%), ODI reduction (59.7% vs 50.5%), lumbar flexion (32.4% vs 16.8%), lumbar extension (93.0% vs 71.1%), right lateral flexion (65.4% vs 33.9%), left lateral flexion (128.8% vs 110.2%), and hip flexion (9.2% vs 4.5%). Mobility outcomes showed the largest between-group effect sizes, while disability recovery was delayed relative to pain and range-of-motion gains. **Conclusion:** Recovery following McKenzie-based rehabilitation was clinically multidimensional and time-dependent. Adjunctive Graston technique appeared to enhance pain and mobility recovery, whereas disability improvement emerged more gradually over 12 weeks. **Keywords:** Lumbar myofascial pain syndrome; McKenzie extension protocol; Graston technique; recovery trajectory; Oswestry Disability Index; range of motion; secondary analysis.

INTRODUCTION

Low back pain remains one of the most disabling musculoskeletal conditions worldwide and contributes substantially to limitations in mobility, work participation, self-care, and health-related quality of life. Although the clinical presentation of low back pain is heterogeneous, a considerable proportion of patients demonstrate soft-tissue involvement, altered lumbar movement, localized tenderness, and pain arising from myofascial trigger points. Lumbar myofascial pain syndrome is therefore clinically relevant not only as a pain condition but also as a functional disorder in which nociceptive sensitization, restricted lumbar mobility, impaired muscular performance, and activity limitation may interact over time. In patients with chronic lumbar symptoms, the therapeutic goal is not limited to statistical reduction in pain intensity; rather, meaningful rehabilitation requires restoration of movement, reduction in disability, and sustained improvement across clinically interpretable follow-up intervals (1).

Myofascial trigger points are commonly described as hyperirritable areas within taut bands of skeletal muscle that may produce local pain, referred pain, motor dysfunction, and autonomic features. In the lumbar region, trigger points involving muscles such as the quadratus lumborum, iliocostalis lumborum, longissimus thoracis, multifidus, gluteus medius, and associated hip musculature may contribute to pain persistence and reduced spinal mobility. The proposed mechanisms include localized ischemia, increased metabolic demand, impaired adenosine triphosphate availability, excessive acetylcholine release at the motor endplate, sustained sarcomere contraction, and accumulation of nociceptive and inflammatory mediators. These mechanisms provide a plausible biological explanation for why patients with lumbar myofascial pain syndrome may show simultaneous impairments in pain intensity, lumbar range of motion, hip mobility, and functional ability (2).

Conservative rehabilitation remains the preferred first-line management approach for most patients with non-specific and myofascial low back pain because it targets modifiable mechanical, neuromuscular, and behavioral contributors without exposing patients to the risks of invasive management. Among exercise-based approaches, the McKenzie extension protocol has been widely used in lumbar disorders because it emphasizes directional preference, repeated movement testing, symptom centralization, posture correction, and restoration of lumbar extension tolerance. These features are clinically relevant in patients whose symptoms are aggravated by sustained flexion postures, impaired lumbar mechanics, or derangement-like movement patterns. Previous investigations have reported that McKenzie-based interventions may reduce pain and improve functional outcomes in selected patients with low back pain, although the magnitude and timing of recovery may vary across individuals and outcome domains (3).

Instrument-assisted soft tissue mobilization, including the Graston technique, is also used in musculoskeletal rehabilitation to address soft-tissue restriction, fascial adhesions, local tissue irritability, and movement limitation. The technique applies controlled mechanical loading through specialized instruments and is commonly combined with active exercise to reinforce newly available movement, improve tissue tolerance, and support functional restoration. Existing evidence suggests that instrument-assisted soft tissue mobilization may improve pain and flexibility in spinal pain populations, but findings regarding disability and superiority over other interventions remain inconsistent. This inconsistency indicates that evaluating only between-group statistical significance may be insufficient; a more clinically useful approach is to examine how individual outcomes change over time and whether observed improvements reach thresholds that are meaningful for patient recovery (4).

Most rehabilitation trials in low back pain report baseline-to-post-treatment differences and p-values, but such reporting does not fully explain the clinical course of recovery. Pain may improve earlier than disability, mobility may recover gradually after symptom reduction, and functional change may depend on cumulative improvements in both pain modulation and movement capacity. A patient may show statistically significant improvement in visual analogue scale scores without achieving meaningful

functional recovery, while another may demonstrate modest pain reduction with substantial improvement in activity tolerance. Therefore, a temporal analysis of recovery patterns can provide information beyond conventional intervention comparisons by identifying whether the main therapeutic gains occur during the early treatment phase, continue during later follow-up, or differ across pain, mobility, and disability outcomes (5).

The distinction between statistical significance and clinically meaningful change is particularly important in rehabilitation research. Statistical tests indicate whether observed differences are unlikely to be due to chance, but they do not necessarily indicate whether the change is large enough to matter to patients, clinicians, or service planners. In conditions such as lumbar myofascial pain syndrome, clinically meaningful interpretation should consider absolute change, percentage improvement, direction and consistency of change, and the relationship between pain reduction, range-of-motion gains, and disability improvement. Such an approach can strengthen the translational value of trial findings by helping clinicians understand not merely whether a protocol works, but which outcomes respond first, which outcomes require longer rehabilitation exposure, and which clinical domains remain partially unresolved (6).

The available randomized trial dataset provides an opportunity to examine this issue because patients with lumbar myofascial pain syndrome were assessed repeatedly at baseline, 6 weeks, and 12 weeks using pain intensity, lumbar range of motion, hip flexion, and Oswestry Disability Index outcomes. This repeated-measures structure allows recovery to be conceptualized as a trajectory rather than a single pre-post contrast. By reanalyzing the dataset through change scores, percentage improvement, clinically meaningful response patterns, and associations among pain, mobility, and disability domains, the present secondary analysis can generate a distinct and clinically useful interpretation without duplicating the primary treatment-effectiveness manuscript (7).

The research problem addressed in this manuscript is that current reporting of McKenzie-based rehabilitation outcomes in lumbar myofascial pain syndrome remains primarily focused on intervention superiority, while less attention has been given to the timing, magnitude, and clinical interpretability of recovery across different outcome domains. The knowledge gap lies in understanding whether pain, lumbar mobility, hip flexion, and disability improve in parallel or follow different recovery patterns during rehabilitation. Therefore, this secondary analysis aimed to evaluate temporal recovery patterns and clinically meaningful change in pain intensity, lumbar mobility, hip flexion, and disability among patients with lumbar myofascial pain syndrome receiving McKenzie-based rehabilitation. The study was guided by the research question: among adults with lumbar myofascial pain syndrome, how do pain intensity, lumbar range of motion, hip flexion, and functional disability change from baseline to 6 weeks and 12 weeks during McKenzie-based rehabilitation, and do these changes indicate clinically meaningful recovery across outcome domains?

MATERIAL AND METHODS

This study was designed as a secondary analysis of prospectively collected data from a single-blinded, two-arm randomized clinical trial conducted among adults with lumbar myofascial pain syndrome. The parent trial compared McKenzie-based rehabilitation delivered with adjunctive instrument-assisted soft tissue mobilization against McKenzie-based rehabilitation alone; however, the present analysis was not planned to restate the primary between-group effectiveness question. Instead, it was developed to examine temporal recovery patterns, magnitude of change, and clinically interpretable improvement across pain intensity, lumbar mobility, hip flexion, and functional disability. The analytic framework was aligned with the repeated-measures structure of the trial and focused on recovery from baseline to 6 weeks and from baseline to 12 weeks, allowing the rehabilitation response to be interpreted as a clinical trajectory rather than as a single end-point comparison.

The trial was conducted at Johar Pain Relief Center, Johar Town, Lahore, after approval of the research synopsis and ethical clearance from the relevant institutional review process. The study procedures were completed over a 9-month period. Participants were recruited from patients presenting with chronic low back pain attributable to lumbar myofascial pain syndrome. Eligibility was determined through clinical screening before enrollment. Adults aged 18 to 55 years of either sex were considered eligible if they had chronic low back pain for more than 6 months, clinical features consistent with lumbar myofascial pain, and identifiable myofascial trigger points in corresponding lumbar-region musculature, including muscles such as the quadratus lumborum. Participants were also required to demonstrate local or referred pain during mechanical stimulation of the trigger point, with the pain pattern considered distinct from symptoms attributable primarily to nerve root compression. Patients were excluded if they had serious fracture, spinal or systemic tumor, ankylosing spondylitis, nerve root compromise, severe or unstable cardiopulmonary disease, predominant cervical or thoracic pain rather than lumbar pain, sickle cell disease, history of previous back surgery, severe osteoporosis, spinal instability, or pregnancy.

A total of 70 participants were enrolled using purposive sampling and then allocated into two equal groups of 35 participants each by lottery-based randomization. Written informed consent was obtained before participation, and all participants were informed about the voluntary nature of enrollment, confidentiality of their data, and their right to withdraw at any stage without penalty. Allocation created two rehabilitation exposure groups for the parent trial. Group A received Graston technique in addition to the McKenzie extension protocol, whereas Group B received the McKenzie extension protocol alone. The outcome assessor was kept unaware of group allocation to reduce measurement bias. Although complete participant and therapist blinding was not feasible because of the physical nature of the interventions, assessor blinding, standardized outcome timing, predefined eligibility criteria, and uniform measurement tools were used to strengthen internal validity.

Both groups received McKenzie-based rehabilitation over the treatment period. The McKenzie extension protocol emphasized repeated lumbar extension, symptom centralization, postural correction, avoidance of repeated flexion stress, and maintenance of lumbar lordosis during daily activities. The protocol included prone lying, prone lying in extension, extension in lying, extension in lying with belt fixation where required, extension in standing, posture correction, and modification of lying posture. Participants were instructed in repeated extension-based exercises and postural strategies, with progression guided by symptom response and clinical tolerance. The home and supervised components were intended to support repeated exposure to directional preference exercises and to promote improvement in pain, spinal movement, and function.

Participants in Group A additionally received Graston technique applied to lumbar and associated soft-tissue regions. A lubricating medium was used before instrument-assisted mobilization to permit controlled gliding over the treated tissues. The technique was applied to superficial and deep fascia of the erector spinae and related musculature, including gluteus maximus, gluteus medius, and hamstrings, using a large Graston instrument appropriate for broad soft-tissue regions. Application was performed at approximately 45 degrees parallel to the muscle fibers and then perpendicular to the fibers, with brief controlled treatment exposure for each muscle region. Participants were informed that transient discomfort, bruising, or petechial responses could occur after instrument-assisted mobilization, and local cold application was advised when post-treatment soreness was excessive. The adjunctive technique was delivered in combination with the same McKenzie-based exercise framework used in the comparison group.

The primary variables for this secondary analysis were pain intensity, lumbar mobility, hip flexion, and functional disability. Pain intensity was measured using the Visual Analogue Scale, with higher scores indicating greater pain intensity. Lumbar range of motion was assessed using goniometry and included lumbar flexion, lumbar extension, right lateral flexion, and left lateral flexion. Hip flexion was also measured using goniometry because hip mobility may influence lumbar movement strategies and

functional performance in patients with chronic lumbar symptoms. Functional disability was assessed using the Oswestry Disability Index, where higher scores reflected greater disability related to low back pain. Outcomes were recorded at baseline, at the 6th week, and at the 12th week. For the present secondary analysis, these three time points were used to construct early recovery intervals, late recovery intervals, and total follow-up change.

The principal exposure variable was rehabilitation group, categorized as adjunctive Graston technique with McKenzie extension protocol versus McKenzie extension protocol alone. The principal time variable was assessment point, categorized as baseline, 6 weeks, and 12 weeks.

The primary derived variables were absolute change and percentage change in each outcome from baseline to 6 weeks and from baseline to 12 weeks. For pain and disability, improvement was defined by reduction in score, whereas for range-of-motion variables, improvement was defined by increased measured mobility. Percentage improvement for pain and disability was calculated as baseline value minus follow-up value divided by baseline value and multiplied by 100. Percentage improvement for mobility outcomes was calculated as follow-up value minus baseline value divided by baseline value and multiplied by 100. These derived variables allowed the analysis to focus on magnitude and timing of recovery rather than only on statistical significance at isolated follow-up points.

The sample size was inherited from the parent randomized trial. The parent study calculated the required sample size using OpenEpi software with the Oswestry Disability Index as the reference outcome, a 95% confidence level, 80% statistical power, expected mean differences based on previous literature, and an additional allowance for anticipated dropout.

The final sample comprised 35 participants per group, resulting in a total of 70 participants. Because the present manuscript used the same trial dataset for secondary analysis, no separate sample size calculation was performed. The available sample was considered appropriate for exploratory evaluation of temporal change patterns and clinically interpretable recovery trends across repeated outcome measurements.

Data were entered and analyzed using SPSS version 21. Continuous variables were summarized using mean and standard deviation when reporting central tendency and dispersion, while median and interquartile range were used where non-normal distribution was relevant to inferential testing. Categorical variables were summarized using frequencies and percentages.

Distributional assumptions were examined using Kolmogorov–Smirnov and Shapiro–Wilk tests. Because baseline outcome variables did not satisfy normality assumptions, non-parametric approaches were used for the primary inferential analyses. Within-group change across baseline, 6-week, and 12-week assessments was evaluated using the Friedman test. Between-group comparisons at corresponding time points were evaluated using the Mann–Whitney U test. Statistical significance was set at $p \leq 0.05$.

For the secondary recovery-pattern analysis, absolute change scores and percentage change scores were calculated for each outcome across two clinically relevant intervals: baseline to 6 weeks and baseline to 12 weeks. Early recovery was interpreted using baseline-to-6-week change, while total observed recovery was interpreted using baseline-to-12-week change.

Where participant-level data were available, associations between pain reduction, mobility gain, and disability improvement were planned using Spearman rank correlation coefficients because of the non-normal distribution of the primary outcomes. The analysis was intended to determine whether reduction in pain paralleled improvement in functional disability and whether gains in lumbar or hip mobility were clinically aligned with disability reduction. No imputation was planned for missing outcome values; available complete observations at the relevant time points were used for each analysis. To minimize risk of overinterpretation from multiple outcome testing, results were interpreted through

consistency of direction, magnitude of change, and clinical coherence across outcomes rather than through p-values alone.

Bias and confounding were addressed at both design and analysis levels. Random allocation in the parent trial reduced baseline selection bias between treatment arms, while assessor blinding reduced detection bias during outcome measurement.

The use of standardized instruments, fixed measurement time points, and predefined eligibility criteria supported measurement consistency. Age and sex were summarized to evaluate baseline comparability because demographic imbalance may influence rehabilitation response. The secondary analysis emphasized within-person change over time, which reduces between-participant variability when evaluating recovery trajectories. However, the interpretation of temporal recovery was kept clinically cautious because the parent trial was not originally powered for extensive subgroup modeling or prediction analysis.

Ethical conduct followed the principles of voluntary participation, informed consent, confidentiality, and anonymized reporting. Participants provided written consent before enrollment, and identifying information was not used in the analysis or reporting of results. Data were handled in aggregate form to protect participant privacy.

Data integrity was supported by consistent outcome definitions, repeated assessment at prespecified time points, and analysis based on the same measurement framework across both groups. The reporting of this secondary analysis was structured to preserve transparency by explicitly distinguishing the current recovery-pattern objective from the primary intervention-comparison objective of the parent randomized trial.

RESULTS

Seventy participants with lumbar myofascial pain syndrome were included in the analysis, with 35 participants in the adjunctive Graston plus McKenzie rehabilitation group and 35 participants in the McKenzie-only rehabilitation group. The two groups were comparable in age distribution at baseline. The mean age was 50.31 ± 5.80 years in the adjunctive Graston plus McKenzie group and 49.26 ± 5.38 years in the McKenzie-only group. Male participants represented 51.4% of the adjunctive treatment group and 62.9% of the McKenzie-only group. The baseline comparability of the outcome variables supported interpretation of subsequent recovery patterns as follow-up changes rather than pre-existing between-group differences.

Table 1. Baseline Demographic Profile of Participants

Variable	Adjunctive Graston + McKenzie Group (n = 35)	McKenzie-Only Group (n = 35)
Age, years, mean ± SD	50.31 ± 5.80	49.26 ± 5.38
Age range, years	29–59	29–58
Male, n (%)	18 (51.4%)	22 (62.9%)
Female, n (%)	17 (48.6%)	13 (37.1%)

Pain intensity showed a progressive reduction across follow-up in both rehabilitation groups, but the magnitude and timing of recovery differed clinically. In the adjunctive Graston plus McKenzie group, mean VAS decreased from 7.43 ± 1.85 at baseline to 4.31 ± 2.05 at 6 weeks and 2.57 ± 0.70 at 12 weeks. This represented an absolute reduction of 3.12 points by 6 weeks and 4.86 points by 12 weeks, corresponding to 42.0% and 65.4% improvement from baseline, respectively. In the McKenzie-only group, VAS decreased from 7.23 ± 1.65 at baseline to 5.51 ± 2.84 at 6 weeks and 4.00 ± 1.94 at 12 weeks, representing 23.8% improvement by 6 weeks and 44.7% improvement by 12 weeks.

Functional disability followed a different temporal pattern. In the adjunctive group, ODI decreased only modestly by 6 weeks but showed a marked reduction by 12 weeks, falling from 25.66 ± 9.78 at baseline to 10.34 ± 5.31 at 12 weeks, equivalent to 59.7% improvement. In the McKenzie-only group, ODI increased

from 26.69 ± 9.27 to 29.60 ± 8.56 at 6 weeks before decreasing to 13.20 ± 6.19 at 12 weeks, indicating that functional recovery was more delayed than pain recovery in this group.

Table 2. Temporal Change in Pain Intensity and Functional Disability

Outcome	Group	Baseline Mean ± SD	6 Weeks Mean ± SD	12 Weeks Mean ± SD	Change Baseline to 6 Weeks	% Change Baseline to 6 Weeks	Change Baseline to 12 Weeks	% Change Baseline to 12 Weeks	Friedman χ^2	p-value	Kendall's W
VAS pain	Adjunctive Graston + McKenzie	7.43 ± 1.85	4.31 ± 2.05	2.57 ± 0.70	−3.12	42.0% improvement	−4.86	65.4% improvement	68.057	<0.001	0.972
VAS pain	McKenzie-only	7.23 ± 1.65	5.51 ± 2.84	4.00 ± 1.94	−1.72	23.8% improvement	−3.23	44.7% improvement	37.724	<0.001	0.539
ODI	Adjunctive Graston + McKenzie	25.66 ± 9.78	23.80 ± 10.36	10.34 ± 5.31	−1.86	7.2% improvement	−15.32	59.7% improvement	66.427	<0.001	0.949
ODI	McKenzie-only	26.69 ± 9.27	29.60 ± 8.56	13.20 ± 6.19	+2.91	10.9% worsening	−13.49	50.5% improvement	67.778	<0.001	0.968

Lumbar mobility outcomes improved across the 12-week period in both groups, although the adjunctive Graston plus McKenzie group demonstrated greater early and total recovery in most movement domains. Lumbar flexion increased from 29.77 ± 2.35 to 39.43 ± 2.05 in the adjunctive group, yielding a 9.66-degree total gain and 32.4% improvement from baseline. In the McKenzie-only group, lumbar flexion improved from 29.29 ± 2.36 to 34.20 ± 2.62, with a smaller total gain of 4.91 degrees and 16.8% improvement. Lumbar extension demonstrated the largest proportional gain among sagittal-plane measures, increasing by 20.34 degrees in the adjunctive group and 15.80 degrees in the McKenzie-only group by 12 weeks. Right lateral flexion improved by 9.66 degrees in the adjunctive group compared with 4.86 degrees in the McKenzie-only group. Left lateral flexion showed a large proportional increase in both groups, but the absolute 12-week gain remained higher in the adjunctive group. Hip flexion improved by 10.00 degrees in the adjunctive group and 4.91 degrees in the McKenzie-only group, indicating that hip mobility recovery was present but less proportionally dramatic than lumbar extension and lateral flexion recovery.

Table 3. Temporal Change in Lumbar Mobility and Hip Flexion

Outcome	Group	Baseline Mean ± SD	6 Weeks Mean ± SD	12 Weeks Mean ± SD	Change Baseline to 6 Weeks	% Change Baseline to 6 Weeks	Change Baseline to 12 Weeks	% Change Baseline to 12 Weeks	Friedman χ^2	p-value	Kendall's W
Lumbar flexion	Adjunctive Graston + McKenzie	29.77 ± 2.35	36.03 ± 2.28	39.43 ± 2.05	+6.26	21.0% improvement	+9.66	32.4% improvement	70.000	<0.001	1.000
Lumbar flexion	McKenzie-only	29.29 ± 2.36	30.06 ± 2.27	34.20 ± 2.62	+0.77	2.6% improvement	+4.91	16.8% improvement	65.415	<0.001	0.935
Lumbar extension	Adjunctive Graston + McKenzie	21.86 ± 5.58	28.80 ± 1.86	42.20 ± 2.13	+6.94	31.7% improvement	+20.34	93.0% improvement	70.000	<0.001	1.000
Lumbar extension	McKenzie-only	22.23 ± 7.87	26.29 ± 1.98	38.03 ± 1.85	+4.06	18.3% improvement	+15.80	71.1% improvement	60.743	<0.001	0.868
Right lateral flexion	Adjunctive Graston + McKenzie	14.77 ± 2.35	21.03 ± 2.28	24.43 ± 2.05	+6.26	42.4% improvement	+9.66	65.4% improvement	70.000	<0.001	1.000
Right lateral flexion	McKenzie-only	14.34 ± 2.25	15.06 ± 2.27	19.20 ± 2.62	+0.72	5.0% improvement	+4.86	33.9% improvement	63.754	<0.001	0.911
Left lateral flexion	Adjunctive Graston + McKenzie	11.89 ± 2.45	13.80 ± 1.86	27.20 ± 2.13	+1.91	16.1% improvement	+15.31	128.8% improvement	58.380	<0.001	0.834
Left lateral flexion	McKenzie-only	10.71 ± 1.99	11.29 ± 1.98	22.51 ± 1.93	+0.58	5.4% improvement	+11.80	110.2% improvement	55.014	<0.001	0.786
Hip flexion	Adjunctive Graston + McKenzie	109.14 ± 2.35	115.97 ± 2.18	119.14 ± 1.83	+6.83	6.3% improvement	+10.00	9.2% improvement	70.000	<0.001	1.000

Outcome	Group	Baseline Mean ± SD	6 Weeks Mean ± SD	12 Weeks Mean ± SD	Change Baseline to 6 Weeks	% Change Baseline to 6 Weeks	Change Baseline to 12 Weeks	% Change Baseline to 12 Weeks	Friedman χ^2	p-value	Kendall's W
Hip flexion	McKenzie-only	109.29 ± 2.36	110.06 ± 2.27	114.20 ± 2.62	+0.77	0.7% improvement	+4.91	4.5% improvement	65.415	<0.001	0.935

Between-group comparisons confirmed that the two groups did not differ significantly at baseline for pain, mobility, or disability outcomes. At 6 weeks, the strongest between-group effects were observed for lumbar flexion, right lateral flexion, and hip flexion, each showing large effect sizes favoring adjunctive Graston plus McKenzie rehabilitation. Pain also differed significantly at 6 weeks, although the effect size was moderate. By 12 weeks, significant between-group differences were retained for all outcomes, with the largest effects observed for lumbar flexion, right lateral flexion, hip flexion, left lateral flexion, and lumbar extension. The smallest between-group effects were observed for ODI at 6 and 12 weeks, despite statistically significant differences, suggesting that disability improvement occurred in both groups and that functional recovery may be influenced by broader factors beyond isolated pain and mobility changes.

Table 4. Between-Group Differences at Follow-Up with Effect Size Estimates

Outcome	Time Point	Adjunctive Graston + McKenzie Median (IQR)	McKenzie-Only Median (IQR)	Mann–Whitney Z	p-value	Effect Size r	Interpretation
VAS pain	Baseline	8 (3)	7 (2)	−0.572	0.568	0.068	Trivial
VAS pain	6 weeks	8 (3)	6 (5)	−2.653	0.008	0.317	Moderate
VAS pain	12 weeks	3 (1)	3 (2)	−3.637	<0.001	0.435	Moderate
Lumbar flexion	Baseline	29 (4)	29 (2)	−0.707	0.479	0.085	Trivial
Lumbar flexion	6 weeks	35 (3)	30 (2)	−6.688	<0.001	0.799	Large
Lumbar flexion	12 weeks	39 (2)	35 (2)	−6.756	<0.001	0.808	Large
Lumbar extension	Baseline	24 (3)	23 (3)	−0.018	0.986	0.002	Trivial
Lumbar extension	6 weeks	28 (2)	26 (3)	−4.543	<0.001	0.543	Large
Lumbar extension	12 weeks	42 (4)	38 (2)	−6.210	<0.001	0.742	Large
Right lateral flexion	Baseline	14 (4)	14 (2)	−0.701	0.483	0.084	Trivial
Right lateral flexion	6 weeks	20 (3)	15 (2)	−6.688	<0.001	0.799	Large
Right lateral flexion	12 weeks	24 (2)	20 (2)	−6.756	<0.001	0.808	Large
Left lateral flexion	Baseline	11 (4)	11 (2)	−1.486	0.137	0.178	Small
Left lateral flexion	6 weeks	13 (2)	11 (3)	−4.543	<0.001	0.543	Large
Left lateral flexion	12 weeks	27 (4)	23 (2)	−6.456	<0.001	0.772	Large
Hip flexion	Baseline	109 (2)	109 (2)	−0.404	0.686	0.048	Trivial
Hip flexion	6 weeks	116 (2)	110 (2)	−6.693	<0.001	0.800	Large
Hip flexion	12 weeks	119 (2)	115 (2)	−6.675	<0.001	0.798	Large
ODI	Baseline	21 (16)	25 (15)	−1.495	0.135	0.179	Small
ODI	6 weeks	23 (15)	27 (13)	−2.076	0.038	0.248	Small
ODI	12 weeks	10 (9)	13 (8)	−2.139	0.032	0.256	Small

The recovery-gradient analysis demonstrated that pain improved earlier than disability, while mobility variables showed domain-specific response patterns. By 6 weeks, the adjunctive Graston plus McKenzie group had already achieved 42.0% pain reduction, 31.7% lumbar extension improvement, 42.4% right lateral flexion improvement, and 21.0% lumbar flexion improvement. However, ODI improvement at the same time point was only 7.2%, indicating that pain and mobility gains did not immediately translate into proportional functional recovery. By 12 weeks, the same group showed a more integrated recovery pattern, with 65.4% pain reduction, 93.0% lumbar extension improvement, 65.4% right lateral flexion improvement, 128.8% left lateral flexion improvement, and 59.7% ODI improvement. In the McKenzie-only group, early recovery was more limited for pain and mobility, and ODI worsened at 6 weeks before

improving substantially by 12 weeks. This pattern suggests that clinically meaningful disability improvement may lag behind symptom relief and movement recovery, particularly when rehabilitation is delivered without adjunctive soft-tissue mobilization.

Table 5. Recovery Gradient Across Clinical Domains

Clinical Domain	Outcome Indicator	Adjunctive Graston + McKenzie: % Improvement at 6 Weeks	Adjunctive Graston + McKenzie: % Improvement at 12 Weeks	McKenzie-Only: % Improvement at 6 Weeks	McKenzie-Only: % Improvement at 12 Weeks
Pain	VAS reduction	42.0%	65.4%	23.8%	44.7%
Functional disability	ODI reduction	7.2%	59.7%	−10.9%	50.5%
Sagittal lumbar mobility	Lumbar flexion gain	21.0%	32.4%	2.6%	16.8%
Sagittal lumbar mobility	Lumbar extension gain	31.7%	93.0%	18.3%	71.1%
Frontal-plane mobility	Right lateral flexion gain	42.4%	65.4%	5.0%	33.9%
Frontal-plane mobility	Left lateral flexion gain	16.1%	128.8%	5.4%	110.2%
Hip mobility	Hip flexion gain	6.3%	9.2%	0.7%	4.5%

Overall, the secondary analysis showed that recovery after McKenzie-based rehabilitation was not uniform across clinical domains. Pain intensity improved progressively in both groups, with a larger and earlier reduction in the adjunctive Graston plus McKenzie group. Lumbar mobility improved significantly across all measured planes, particularly lumbar extension and lateral flexion, while functional disability demonstrated a delayed pattern, especially in the McKenzie-only group. The largest between-group effect sizes were observed for mobility outcomes rather than ODI, indicating that adjunctive soft-tissue mobilization may exert its strongest measurable influence on movement restoration, while disability recovery appears to require longer follow-up and may reflect broader functional adaptation.

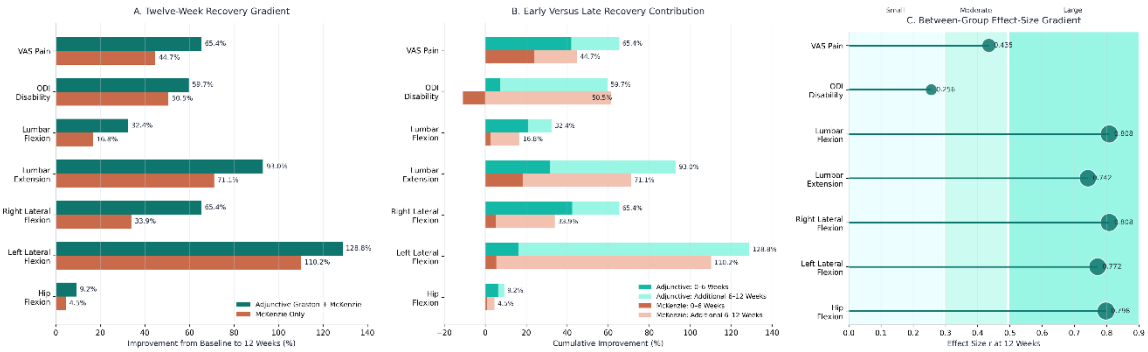

Figure 1. Temporal Recovery Pattern and Clinical Effect Gradient Across Pain, Mobility, and Disability Outcomes.

The panelled figure demonstrates a non-uniform recovery profile across clinical domains. At 12 weeks, the adjunctive Graston plus McKenzie group showed greater percentage improvement than McKenzie-only rehabilitation for VAS pain reduction (65.4% vs 44.7%), ODI disability reduction (59.7% vs 50.5%), lumbar flexion gain (32.4% vs 16.8%), lumbar extension gain (93.0% vs 71.1%), right lateral flexion gain (65.4% vs 33.9%), left lateral flexion gain (128.8% vs 110.2%), and hip flexion gain (9.2% vs 4.5%). The early-to-late recovery pattern showed that pain reduction occurred earlier than disability improvement, while ODI recovery was most prominent between 6 and 12 weeks, particularly after minimal early improvement in the adjunctive group and transient worsening in the McKenzie-only group. Between-group effect-size gradients at 12 weeks were largest for lumbar flexion, right lateral flexion, hip flexion, left lateral flexion, and lumbar extension (r = 0.742–0.808), whereas disability showed a smaller but statistically significant effect (r = 0.256), indicating that adjunctive soft-tissue mobilization was most

strongly associated with mobility recovery, while functional improvement appeared more delayed and multidimensional.

DISCUSSION

The present secondary analysis provides a clinically oriented interpretation of recovery among patients with lumbar myofascial pain syndrome receiving McKenzie-based rehabilitation, with or without adjunctive Graston technique. Unlike the primary treatment-effectiveness analysis, which focused on whether one intervention arm produced superior post-treatment outcomes, this manuscript examined how recovery unfolded over time across pain intensity, lumbar mobility, hip flexion, and functional disability. The findings indicate that recovery was not uniform across domains. Pain intensity improved progressively in both groups, but the adjunctive Graston plus McKenzie group achieved a larger and earlier reduction, with VAS improving by 42.0% at 6 weeks and 65.4% at 12 weeks compared with 23.8% and 44.7% in the McKenzie-only group. This pattern suggests that the addition of instrument-assisted soft tissue mobilization may accelerate symptom modulation during the earlier phase of rehabilitation while also supporting continued improvement by the end of follow-up.

The temporal pattern of functional disability was clinically different from the pain trajectory. In the adjunctive group, ODI improved only modestly at 6 weeks but showed substantial improvement by 12 weeks, decreasing by 59.7% from baseline. In the McKenzie-only group, ODI worsened by 10.9% at 6 weeks before improving by 50.5% at 12 weeks. This delayed disability response is important because it shows that reduction in pain does not necessarily translate immediately into functional recovery. Disability in chronic low back pain is influenced not only by nociceptive intensity but also by movement confidence, activity tolerance, fear of symptom recurrence, deconditioning, postural habits, and behavioral adaptation. Therefore, a treatment may produce early analgesic benefit while functional independence and daily activity performance require longer exposure to repeated movement, postural retraining, and progressive restoration of mobility. This distinction supports the need to interpret rehabilitation outcomes using both symptom-based and function-based endpoints rather than relying on pain scores alone.

The mobility outcomes demonstrated a stronger and more immediate between-group gradient than disability. At 12 weeks, large between-group effect sizes were observed for lumbar flexion, lumbar extension, right lateral flexion, left lateral flexion, and hip flexion, whereas the between-group effect for ODI remained small despite statistical significance. This suggests that adjunctive Graston technique may exert its clearest measurable effect on movement restoration rather than directly on disability. Mechanistically, instrument-assisted soft tissue mobilization may reduce soft-tissue irritability, improve local tissue extensibility, influence fascial glide, and increase tolerance to movement, thereby enhancing the effectiveness of repeated McKenzie extension exercises. When soft-tissue restriction and trigger-point-related guarding are reduced, patients may be more able to perform extension-based and posture-correction exercises with less protective limitation. This interpretation is consistent with the proposed clinical role of instrument-assisted soft tissue mobilization as an adjunct rather than as a stand-alone replacement for active rehabilitation (4,5).

The recovery-gradient analysis further showed that different movement planes recovered at different rates. Lumbar extension demonstrated large improvement in both groups, increasing by 93.0% in the adjunctive group and 71.1% in the McKenzie-only group by 12 weeks. This finding is clinically coherent because the McKenzie protocol used in the parent trial was extension-oriented and specifically intended to restore extension tolerance, reduce posterior derangement-like symptoms, and improve spinal mechanics. Right lateral flexion and lumbar flexion improved more strongly in the adjunctive group, whereas left lateral flexion showed particularly large late-phase improvement in both groups. These findings may indicate that movement restoration in lumbar myofascial pain syndrome is not limited to the direction directly emphasized by the exercise protocol; instead, improvement in soft-tissue

compliance, pain inhibition, and spinal confidence may produce broader multidirectional mobility gains over time.

Hip flexion improved modestly in both groups, with a 9.2% increase in the adjunctive group and a 4.5% increase in the McKenzie-only group by 12 weeks. Although this percentage gain was smaller than the proportional improvement in lumbar extension or lateral flexion, it remains clinically relevant because hip mobility can influence lumbar loading strategies, pelvic mechanics, and compensatory spinal movement during functional tasks. The smaller proportional gain may partly reflect the higher baseline hip flexion values, leaving less room for measurable improvement compared with more restricted lumbar movements. This highlights the importance of considering baseline range, measurement ceiling effects, and anatomical specificity when interpreting percentage change across different mobility outcomes.

The findings also reinforce the limitation of relying solely on p-values in rehabilitation trials. In the parent dataset, most within-group changes reached statistical significance, but the secondary analysis revealed meaningful differences in timing and magnitude that are not apparent from significance testing alone. For example, ODI change was statistically significant over time in both groups, yet the early-phase pattern differed substantially: small improvement in the adjunctive group and temporary worsening in the McKenzie-only group. Similarly, the largest between-group effect sizes were concentrated in mobility variables rather than disability, suggesting that statistical significance alone may obscure clinically important differences in the type of recovery achieved. Reporting absolute change, percentage improvement, and effect-size gradients therefore provides a more interpretable framework for clinicians who need to estimate when patients may experience pain relief, when movement restoration may occur, and when functional gains are likely to become visible.

These results align with previous evidence suggesting that McKenzie-based rehabilitation can reduce pain and improve function in low back pain populations, while also extending the interpretation by showing that recovery trajectories are domain-specific rather than simultaneous (3,8). The findings also partly support evidence on instrument-assisted soft tissue mobilization and Graston technique, where improvements in pain and mobility have been reported, but the effect on disability has been less consistent across studies (4,5). The current analysis helps reconcile this inconsistency by showing that mobility outcomes may respond more strongly and earlier than disability outcomes. Therefore, studies assessing only final disability scores may underestimate the clinical contribution of adjunctive soft-tissue techniques when they are used to facilitate movement restoration within an active rehabilitation program.

The delayed functional response observed in this analysis has practical implications for physiotherapy planning. Patients with lumbar myofascial pain syndrome may require counseling that pain reduction is an early but incomplete marker of recovery. Clinicians should continue monitoring disability, movement confidence, posture tolerance, and activity participation beyond the point at which pain begins to improve. The 12-week findings suggest that meaningful disability reduction may require sustained exposure to rehabilitation, particularly in chronic presentations where protective movement patterns and functional limitations have become established. This has implications for follow-up scheduling, home-exercise adherence, and outcome selection in future trials.

Several limitations should be considered while interpreting this secondary analysis. First, the analysis was based on an existing randomized trial dataset, and the parent study was powered for the primary outcome rather than for detailed subgroup, responder, or predictive modeling. Second, only aggregated values were available for the present manuscript development, which limited the ability to calculate participant-level minimal clinically important difference rates, confidence intervals for change scores, or correlations between pain reduction, mobility gain, and disability improvement. Third, adherence to home-based exercise could not be fully controlled, and variation in exercise performance may have influenced the timing of recovery. Fourth, psychological and behavioral factors such as fear-avoidance,

catastrophizing, self-efficacy, sleep quality, and mood were not included, although these may strongly influence the relationship between pain relief and disability reduction in chronic low back pain. Finally, the trial was conducted in a single clinical setting, which may limit generalizability to other rehabilitation contexts, patient populations, and service models.

Despite these limitations, the present secondary analysis adds clinical value by reframing the parent trial data around recovery timing and clinically meaningful interpretation. The findings suggest that McKenzie-based rehabilitation produces progressive improvement in pain, mobility, and disability among patients with lumbar myofascial pain syndrome, but the sequence of recovery differs across domains. Adjunctive Graston technique appears to enhance early and total improvement in pain and mobility, while functional disability demonstrates a slower pattern of recovery that becomes more apparent by 12 weeks. Future studies should prospectively define recovery trajectories, include participant-level responder analyses, assess psychosocial moderators, and report confidence intervals and minimal clinically important difference thresholds to strengthen the clinical interpretability of rehabilitation outcomes.

CONCLUSION

The present secondary analysis demonstrated that patients with lumbar myofascial pain syndrome receiving McKenzie-based rehabilitation improved across pain, lumbar mobility, hip flexion, and disability outcomes over 12 weeks, but recovery occurred at different rates across clinical domains. Adjunctive Graston technique combined with McKenzie rehabilitation was associated with greater early and total improvement in pain and mobility outcomes, with the largest between-group effects observed for lumbar and hip movement measures. Functional disability improved more slowly than pain and mobility, indicating that symptom reduction may precede meaningful functional restoration. These findings support the clinical value of evaluating rehabilitation success through temporal recovery patterns, percentage improvement, and effect-size gradients rather than relying only on statistical significance at isolated follow-up points.

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