

Effects of Precision Rehabilitation Based on Selective Functional Movement Assessment on Pain, Multifidus Thickness, and Recurrence Rate in Patients with Chronic Non-Specific Low Back Pain: A Prospective Randomized Controlled Trial

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Abstract: This trial examined how an individualized rehabilitation program based on the Selective Functional Movement Assessment (SFMA) affected pain, functional disability, multifidus morphology, and recurrence in patients with chronic non-specific low back pain (CNLBP). Sixty CNLBP patients were enrolled in a prospective randomized controlled trial and randomly assigned to a control group or an observation group. The control group received routine rehabilitation only. The observation group received routine rehabilitation plus SFMA screening, after which individualized intervention was delivered according to the abnormal movement patterns identified. At baseline, the two groups were pretty comparable—nothing much to separate them. Four weeks in, though, the observation group looked better on pain and function: VAS dropped 67.9%, and RMDQ dropped 74.2%. Both reductions were larger than in the control group ($P < 0.05$), and the effect seemed to get stronger as treatment went on. Ultrasound findings pointed in the same direction. L4-5 multifidus thickness increased by 38.2% in the observation group, versus 27.3% in controls ($P < 0.05$)—more or less a sign that the spinal stabilizer muscles were remodeling. At the three-month follow-up, recurrence was 6.67% in the observation group and 23.33% in controls ($P < 0.05$), which works out to roughly a 71.4% lower recurrence risk. So SFMA-guided rehab can help spot and fix movement-pattern deficits. It gives fairly quick pain relief, improves function, and helps the multifidus thicken. Down the road, it may also lower the chance of recurrence.

Keywords: Non-specific Low Back Pain; Pain; Multifidus Thickness; Prospective; Randomized Controlled Trial.

1. Introduction

Chronic non-specific low back pain, or CNLBP, is a chronic musculoskeletal condition where the main symptom is low back pain. Usually there's no clear specific pathology behind it—no infection, tumor, or fracture—and symptoms tend to last more than three months [1]. It gets in the way of daily life and lowers quality of life. It also comes with a hefty socioeconomic burden: ongoing pain, functional loss, frequent healthcare visits, direct medical costs, lost work productivity, and disability compensation [2]. Epidemiologically, roughly 65–80% of people worldwide are affected by CNLBP, with women more affected than men and a noticeable peak among young and middle-aged adults [2-3].

Standard clinical care usually involves medication, physical therapy, and exercise therapy. But responses vary a lot from person to person, recurrence is common, and some patients just don't benefit enough from what's available [4]. More importantly, conventional rehabilitation often uses a uniform protocol and doesn't precisely evaluate each patient's functional deficits. That makes it hard to target the mechanisms that drive pain chronicity and repeated episodes, so symptoms often stick around [5]. Clearly, there's an urgent clinical need for more precise and effective rehabilitation assessment and intervention pathways—ones that improve function and reduce recurrence.

The Selective Functional Movement Assessment (SFMA) is a movement-pattern-based systematic evaluation tool. It breaks down top-level movements to reveal flexibility and stability problems linked to pain and dysfunction [6]. Research has shown that SFMA has good inter-rater and intra-

rater reliability. It can expose functional deficits in both athletes and the general population, and it offers objective benchmarks for building individualized exercise rehabilitation plans [6-7]. In CNLBP patients, atrophy of deep lumbar muscles like the multifidus, decreased core stability, and aberrant movement patterns are commonly seen as key mechanisms behind persistent pain and recurrence [8]. By systematically decomposing functional movements, SFMA can precisely identify these potential impairment sources. That helps it overcome the limits of traditional static examination and gives a scientific foundation for targeted rehabilitation strategies [8]. Initial case reports suggest that exercise interventions based on SFMA findings can alleviate pain and dysfunction in CNLBP and increase deep core muscle thickness [8]. Still, randomized controlled trial evidence for SFMA-guided rehabilitation in CNLBP remains scarce, and its superiority over standard rehabilitation hasn't been robustly validated by high-quality evidence.

To fill this gap, the present study used a prospective randomized controlled trial design. CNLBP patients were randomly assigned to a control group (conventional rehabilitation) or an observation group (conventional rehabilitation plus SFMA assessment and targeted intervention). What makes SFMA useful is its dynamic, systematic evaluation. It goes beyond static examination, detects compensatory patterns and functional deficits during daily activities, and informs an individualized “reset–strengthen–reload” rehabilitation sequence [8]. Depending on the assessed impairments—flexibility problems (e.g., reduced soft tissue extensibility or restricted joint motion) and stability problems (e.g., poor motor control or inadequate core

stability)—tailored treatments were applied. These included myofascial techniques, Mulligan techniques, core stability training, and breathing training.

This study had three specific aims: 1) to compare the two protocols' effects on pain intensity, functional disability, and lumbar multifidus thickness in CNLBP patients; 2) to assess the short-term effectiveness of SFMA-guided rehabilitation in lowering recurrence; and 3) to provide high-quality evidence for promoting SFMA-based precision rehabilitation strategies in clinical practice.

2. Materials and Methods

2.1. Study Population

Sixty patients with chronic non-specific low back pain (CNLBP) who attended the Department of Rehabilitation Medicine/Pain Management at Zigong Fourth People's Hospital between September 2023 and October 2025 were enrolled. Diagnosis was based on the Chinese Expert Consensus on the Diagnosis and Treatment of Acute/Chronic Non-specific Low Back Pain (2016) [9]. Inclusion criteria were: (1) meeting the diagnostic criteria for CNLBP; (2) clear consciousness, ability to cooperate with examination and treatment, and no severe cognitive impairment; (3) awareness of the study and voluntary signing of informed consent; and (4) normal mental status and good compliance. Exclusion criteria were: (1) severe osteoarticular dysfunction or severe osteoporosis; (2) a history of epilepsy, severe failure of vital organs such as the heart, lungs, kidneys, or liver, or neurological disease; and (3) inability to cooperate, including severe cognitive problems, agitation, communication difficulties, or emotional disorders.

The enrolled patients were randomized into a control group (Group A, n=30) and an observation group (Group B, n=30).

2.2. Interventions

Group A received conventional rehabilitation: medium-frequency pulsed electrotherapy (once daily, six times weekly, for 4 weeks) and lower back muscle relaxation plus lumbar back muscle training (once daily, six times weekly, for 4 weeks).

Group B received the same conventional rehabilitation plus SFMA. The SFMA began with seven top-level screens: cervical movement pattern, upper extremity movement pattern, multi-segmental flexion, multi-segmental extension, multi-segmental rotation, single-leg stance, and overhead deep squat. If a top-level screen was not passed, the corresponding breakout tests were performed. Targeted reset, strengthen, and reload treatments were then provided for the identified dysfunctions. SFMA-identified dysfunctions fell into two main types: mobility problems and stability problems. Mobility problems included soft tissue extensibility and joint mobility issues, while stability problems involved stability and/or motor control deficits.

Soft tissue extensibility problems were managed with fascial techniques, muscle energy technique, DMS, and dynamic stretching; joint mobility problems with traction and Mulligan techniques; and stability and/or motor control problems with core stability training, breathing training, 4 × 4 training, and kinesio taping. All treatments were administered once daily, six times weekly, for 4 weeks.

2.3. Outcome Measures

Baseline data collected at enrollment included demographic characteristics, medical history, pain status, and degree of functional disability. Patients in the observation group also underwent SFMA. All efficacy outcomes were assessed before treatment and at 2 and 4 weeks of treatment.

Efficacy measures:

1) VAS: A 10-cm visual rating scale was used, with “0” indicating no pain and “10” indicating the worst pain imaginable. Participants marked a point according to their pain intensity, and the distance measured with a ruler gave the corresponding pain score; higher scores indicated greater pain.

2) RMDQ: Disability was assessed using 24 items, each scored 0 or 1. Higher total scores indicated more severe disability.

3) Multifidus thickness on the weaker side at the L4-5 level: A musculoskeletal ultrasound diagnostic device was used to measure the resting thickness of the weaker-side multifidus at L4-5.

Recurrence rate: Three months after treatment completion, patients in both groups were followed up by WeChat or telephone for recurrence. Recurrence was defined as another episode of low back pain within 3 months, with a VAS score ≥ 3 and pain duration ≥ 24 h.

2.4. Statistical Analysis

SPSS 22.0 was used for data analysis. Continuous measurements are presented as mean $\pm$ standard deviation ($\bar{x} \pm SD$). Baseline between-group comparisons used independent-samples t-tests for continuous data and chi-square tests for categorical data. Repeated-measures ANOVA was used to compare efficacy outcomes within the same group across different time points. All statistical tests were two-sided, and $P < 0.05$ was considered statistically significant.

3. Results

3.1. Comparative Analysis of Baseline Data Between the Two Groups

Comparative analysis was conducted on baseline data such as gender and age between the two groups. The results showed no statistically significant differences between the groups (all $P > 0.05$), as shown in Table 1.

Table 1. Baseline characteristics between two groups

Project	Control group (n=30)	Experimental group (n=30)	X ² /F-value	P-value
Women	18 (60%)	17 (56.667%)	0.069	0.793
Age	42.033 $\pm$ 9.242	45.600 $\pm$ 9.383	0.003	0.143

3.2. Comparative Analysis of VAS Scores and RMDQ Scores between the Two Groups

Compared with before treatment, the VAS scores and RMDQ scores of both groups were significantly decreased at

2 weeks and 4 weeks after treatment (all $P < 0.05$), and the VAS scores and RMDQ scores of the experimental group at 2 weeks and 4 weeks after treatment were significantly lower than those of the control group (all $P < 0.05$), as shown in Tables 2 and 3.

Table 2. Comparison of VAS scores between two groups of patients at different time periods

Project	Time period	Control group (n=30)	Experimental group (n=30)	F-value	P-value
VAS	Before treatment	5.510±0.309	5.513±0.324	0.061	0.968
	2 weeks after treatment	4.110±0.449	3.407±0.413	0.028	0.000
	4 weeks after treatment	2.697±0.476	1.770±0.443	0.060	0.000
F-value		4.320 ^a /5.401 ^b	3.644 ^a /3.989 ^b		
P-value		0.000 ^a /0.000 ^b	0.000 ^a /0.000 ^b		

Note: ^a represents the F value and P value for comparison between 2 weeks after treatment and before treatment, ^b represents the F value and P value for comparison between 4 weeks after treatment and before treatment

Table 3. Comparison of RMDQ scores between two groups of patients at different time periods

Project	Time period	Control group (n=30)	Experimental group (n=30)	F-value	P-value
RMDQ	Before treatment	15.500±2.374	15.267±2.559	0.069	0.716
	2 weeks after treatment	10.167±1.931	8.067±1.701	1.152	0.000
	4 weeks after treatment	6.900±1.517	3.933±1.363	0.573	0.000
F-value		1.001 ^a /4.755 ^b	4.385 ^a /8.167 ^b		
P-value		0.000 ^a /0.000 ^b	0.000 ^a /0.000 ^b		

Note: ^a represents the F value and P value for comparison between 2 weeks after treatment and before treatment, ^b represents the F value and P value for comparison between 4 weeks after treatment and before treatment

3.3. Comparative Analysis of L4-5 Segment Multifidus Muscle Thickness Between the Two Groups

Table 4. Comparison of L4-5 segment multifidus thickness scores between two groups of patients at different time periods

Project	Time period	Control group (n=30)	Experimental group (n=30)	F-value	P-value
L4-5 segment multifidus muscle thickness	Before treatment	17.183±1.311	17.220±1.554	1.205	0.922
	2 weeks after treatment	19.300±1.432	20.323±1.825	2.101	0.019
	4 weeks after treatment	21.867±1.680	23.803±1.685	0.440	0.000
F-value		0.060 ^a /2.920 ^b	0.593 ^a /0.025 ^b		
P-value		0.000 ^a /0.000 ^b	0.000 ^a /0.000 ^b		

Note: ^a represents the F value and P value for comparison between 2 weeks after treatment and before treatment, ^b represents the F value and P value for comparison between 4 weeks after treatment and before treatment

Compared with before treatment, the L4-5 segment multifidus muscle thickness of both groups was significantly

increased at 2 weeks and 4 weeks after treatment (all $P < 0.05$), and the L4-5 segment multifidus muscle thickness of the experimental group at 2 weeks and 4 weeks after treatment was significantly greater than that of the control group (all $P < 0.05$), as shown in Table 4.

3.4. Recurrence Rate

At the 3-month follow-up after treatment, recurrence occurred in 2 cases (6.667%) in the experimental group and 7 cases (23.333%) in the control group. The recurrence rate of the experimental group was significantly lower than that of the control group ($P < 0.005$).

4. Discussion

CNLBP is a long-term musculoskeletal disorder where low back pain dominates, but clinically you usually can't find a definite cause like infection, neoplasm, or fracture. It occurs often and relapses often, so it puts a heavy strain on patients' well-being and on socioeconomic systems [1]. Physiotherapy, medication, exercise-based treatments can give partial relief, but patient variability and poor targeting limit overall effectiveness, and recurrence remains a major concern [4]. That's why finding more accurate, effective rehab approaches—ones that improve function and prevent relapse—has become a clinical priority.

This study adds something original by incorporating SFMA into CNLBP rehab. After systematic screening for each patient's flexibility and stability deficits, the rehab plan is individually tailored [8]. That's more precisely targeted than standard rehab. Main findings? SFMA-guided rehab produced clear pain reduction, better function, and greater L4-5 multifidus thickness; at 3-month follow-up, fewer recurrences in observation than control. So SFMA-based precision rehab may offer advantages for both immediate symptom management and longer-term relapse prevention—a fresh avenue for CNLBP care.

It also helps close a gap: conventional rehab assessment often can't determine where functional impairment originates. Earlier research shows CNLBP patients commonly have deep stabilizer dysfunction—lumbar multifidus atrophy, diminished core stability—and these biomechanical changes are strongly linked to persistent pain and repeated flare-ups [8,10]. Conventional rehab usually follows a fixed protocol and seldom adapts treatment to whether the problem is flexibility- or stability-related. SFMA uses a whole-part-whole movement breakdown, which can reveal compensatory strategies from distant areas like the hip and thoracic spine; that helps set treatment priorities [6,8]. Our trial supports this: relative to conventional rehab, the SFMA group had a 34.4% decrease in VAS and 43.0% decrease in RMDQ at 4 weeks, while weaker-side L4-5 multifidus thickness rose 38.2%, exceeding the 27.3% gain in controls. These observations match Huang et al.'s case report, where 8 weeks of SFMA-guided exercise increased multifidus thickness and relieved pain [8]. The distinction is that this is the first prospective randomized controlled design with a larger sample to systematically confirm the dual value of SFMA-guided rehab for short-term symptom relief and long-term recurrence prevention, contributing relatively strong evidence for precision rehab in CNLBP.

Clinically, these results carry considerable relevance. By week 2, SFMA-guided rehab already outperformed conventional treatment: VAS was 3.407 ± 0.413 and RMDQ 8.067 ± 1.701 in observation, lower than 4.110 ± 0.449 and

10.167 ± 1.931 in controls—and this between-group difference kept widening. Such an early, accumulating response suggests accurate assessment can help avoid ineffective care, letting interventions address the underlying dysfunction more directly and shorten time to benefit [8]. In practice, SFMA may serve as routine initial evaluation for CNLBP, enabling prompt classification of flexibility versus stability deficits and informing an individualized reset-strengthen-reload sequence. Furthermore, at 3 months, recurrence was 6.667% in observation vs 23.333% in controls, roughly 71.4% lower recurrence risk—clear health-economic implications. Repeated CNLBP episodes often cause repeated consultations, greater resource use, and prolonged disability [11-12]. SFMA adds some initial time and expense, yes, but it corrects aberrant movement patterns and improves neuromuscular control, targeting the biomechanical underpinnings of recurrence. That can reduce later relapses and downstream costs from outpatient visits, imaging, and work absence, yielding favorable long-term cost-effectiveness. SFMA should therefore be viewed as a supplementary assessment within CNLBP rehab pathways, particularly for patients with recurrent symptoms or unsatisfactory responses to conventional care.

Moreover, musculoskeletal ultrasound measurement of weaker-side multifidus thickness at L4-5 supplied objective imaging support for SFMA-guided rehab. The multifidus is a key deep stabilizer of lumbar segments, and its atrophy and fatty infiltration are closely related to CNLBP chronification [10,13]. In observation, multifidus thickness increased by 38.2% from baseline after 4 weeks; this structural change paralleled pain reduction (VAS down 67.9%) and functional gains (RMDQ down 74.2%), indicating multifidus hypertrophy may be an important biological pathway behind the clinical benefits of SFMA rehab. James et al.'s animal work similarly reported that targeted multifidus activation attenuated fibrosis following disc injury [13]. From a translational standpoint, musculoskeletal ultrasound is non-invasive, real-time, and repeatable, making it well suited to rehab monitoring and potentially reducing reliance on costly MRI for dynamic evaluation during treatment [14]. Taken together, this study offers relatively robust evidence for adopting SFMA-based precision rehab. Future multicenter trials with larger samples and longer follow-up could compare efficacy across CNLBP subtypes and integrate SFMA with musculoskeletal ultrasound monitoring, creating a closed-loop assessment-intervention-reassessment model that may help standardize and refine CNLBP rehab pathways.

Several limitations should be acknowledged. First, single-center setting and limited sample size (30 per group) may reduce statistical power and restrict generalizability; larger multicenter studies are needed. Second, because of the intervention's nature, neither therapists nor participants could be fully blinded. Assessor blinding was applied to minimize measurement bias, but performance bias cannot be entirely excluded. Third, a 3-month follow-up can't fully capture long-term recurrence patterns of chronic low back pain, and this study examined only multifidus thickness as a morphological measure, without dynamically assessing contractile function, endurance, or activation. Fourth, quality-of-life instruments and psychosocial variables weren't included, so assessment of overall health benefit remains narrow. Future research should adopt a multidimensional evaluation framework.

In conclusion, this randomized controlled trial shows that

individualized rehab guided by SFMA outperforms conventional therapy in improving clinical outcomes among CNLBP patients. By detecting flexibility and stability deficits, the protocol can rapidly ease pain, substantially reduce functional disability, and encourage morphological rebuilding of the lumbar stabilizer (multifidus), which in turn lowers recurrence risk. The assessment–reset–strengthen closed-loop framework central to SFMA provides compelling evidence for surpassing the symptom-focused limitations of conventional rehab. Despite the limitations above, results support incorporating SFMA into routine clinical care as a valuable instrument for precision management of low back pain. Future studies should lengthen follow-up and explore mechanisms more deeply to further develop a standardized rehab paradigm grounded in biomechanical characteristics.

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