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Integrating Fascial Manipulation and Postural Exercises in Chronic Low Back Pain: A Prospective Controlled Clinical Study

Klejda Tani [1], Vjollca Shpata [1], Aisel Oseku [2], Surven Metolli [3], Daniela Matei [4]* and Odrih Koperaj [5]

1 Department of Rehabilitation, Sport University of Tirana, Albania;
2 Department of Biomedical Sciences, Sport University of Tirana, Albania;
3 Department of Movement and Health, Sport University of Tirana, Albania;
4 Department of Medical Rehabilitation, University of Medicine and Pharmacy of Craiova, Romania;
5 Department of Rehabilitation, Treka FIZIO Professional Physiotherapy Center in Tirana, Albania

* Correspondence: daniela.matei@umfcv.ro

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Abstract: Non-specific low back pain (NSLBP) is a leading cause of disability, often requiring multimodal rehabilitation approaches. The combined effect of Fascial Manipulation (FM) and Dynamic Neuromuscular Stabilization (DNS) remains insufficiently explored. This prospective controlled study included 78 patients with chronic NSLBP, allocated to either FM alone (FMTh group; n = 39) or FM combined with DNS (CTh group; n = 39). Both groups received weekly sessions over 8 weeks, while the CTh group also performed daily home-based exercises. Functional disability was assessed using the Oswestry Disability Index (ODI) at baseline and post-treatment. Both groups showed significant improvements in ODI scores. However, the CTh group demonstrated significantly greater reduction in disability compared to FMTh group (10.74 ± 5.53 vs. 14.97 ± 5.84; $p = 0.001$; Cohen's $d = 0.74$). A higher proportion of patients in the CTh group achieved minimal disability (58.97% vs. 23.08%, $p = 0.005$). Pain intensity decreased in both groups, with no significant between-group differences ($p = 0.36$). The addition of DNS to FM enhances functional recovery in chronic NSLBP, supporting integrated rehabilitation strategies that combine manual therapy with motor control training.

Keywords: Fascial Manipulation, Dynamic Neuromuscular Stabilization (DNS), Chronic Low Back Pain (CLBP), Functional Disability, Oswestry Disability Index (ODI)

1. Introduction

Low back pain (LBP) remains the leading cause of disability worldwide, generating substantial socioeconomic burden and placing persistent pressure on healthcare systems [1]. The majority of cases are classified as non-specific low back pain (NSLBP), defined by the absence of a clearly identifiable structural pathology [2]. This diagnostic ambiguity contributes to variability in treatment strategies and highlights the need for more targeted, mechanism-based therapeutic approaches [3–5]. Recent evidence has emphasized the role of the fascial system, particularly the thoracolumbar fascia (TLF), in the pathophysiology of chronic LBP. Rather than acting as a passive structure, the TLF is now recognized as an active component involved in load transfer, proprioception, and motor coordination [6,7]. Imaging studies have demonstrated structural alterations in patients with NSLBP, including increased thickness and reduced shear strain, suggesting impaired fascial mobility and a state of densification [8,9]. Histological findings further support the nociceptive potential of fascial tissues, showing a high density of nociceptors and proprioceptors, particularly in pathological conditions [10,11]. These findings support the concept of the myofascial unit, highlighting the functional interdependence between fascia and muscle in maintaining spinal stability [6,7]. In parallel, impaired neuromuscular control is a well-established feature of chronic LBP, characterized by altered activation patterns of deep stabilizing muscles and deficient postural control [12,13]. Therapeutic strategies targeting these deficits, such as core stabilization exercises and Dynamic Neuromuscular Stabilization (DNS), have demonstrated effectiveness in improving motor control and functional outcomes [14–16]. Similar benefits of non-pharmacological interventions targeting functional status and quality of life have also been reported in patients with other chronic pain conditions, such as fibromyalgia [17]. DNS, based on principles of developmental kinesiology, facilitates coordinated activation of the diaphragm, abdominal wall, and spinal stabilizers, contributing to improved intra-abdominal pressure regulation and postural stability [12,18]. Recent studies have also explored its potential influence on structural parameters, including lumbar muscle morphology and fascial properties [19,20]. Fascial Manipulation (FM), developed by Stecco [11], represents a targeted manual therapy approach focused on restoring normal fascial tension and gliding by treating specific points of densification within myofascial sequences. Clinical evidence supports its effectiveness in reducing pain and improving function in patients with chronic LBP [3,4,21]. However, while FM addresses structural dysfunction at the tissue level, it does not directly target neuromuscular control deficits, which are critical for functional recovery.

Current evidence supports the effectiveness of both FM and exercise-based interventions in the management of chronic low back pain [16,22]. However, most studies have investigated these approaches separately, focusing either on structural tissue-oriented treatments or on neuromuscular rehabilitation strategies. Despite the growing recognition that chronic low back pain is a multifactorial condition involving both myofascial dysfunction and impaired motor control, there is limited evidence regarding the potential synergistic effects of combining these therapeutic approaches within a single rehabilitation program. In particular, it remains unclear whether the integration of FM with DNS can provide superior functional outcomes compared with FM alone. Therefore, the aim of this prospective controlled study was to evaluate the effects of combining FM with DNS in patients with chronic NSLBP. Specifically, we compared a FM-only protocol with a combined FM and DNS intervention, using the Oswestry Disability Index (ODI) as the primary outcome measure of functional disability. We hypothesized that: (1) the combined therapy would result in significantly greater improvements in functional disability compared to FM alone; (2) the integrated approach would demonstrate a clinically meaningful advantage, reflecting the synergistic interaction between structural and neuromuscular mechanisms.

2. Materials and Methods

This prospective parallel-group controlled study was designed to investigate the effects of adding DNS postural exercises to a FM protocol in patients with NSLBP. The study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the Ethics Committee of the Sports University of Tirana, Albania (protocol code No. 3000/2; approval date: 17 December 2025). The study was conducted with the institutional agreement of the TREKA FIZIO clinic, where patient recruitment and data collection took place. All participants were informed about the study procedures and provided written informed consent prior to enrollment. The study was not prospectively registered due to institutional limitations; however, the study design, conduct, and reporting followed internationally accepted methodological standards.

2.1 Participants

A total of 78 patients with chronic NSLBP were recruited from the Treka Fizio Clinic and assessed for eligibility according to predefined criteria.

Inclusion criteria were: (1) age between 45 and 59 years; diagnosis of NSLBP with a duration longer than 8 weeks (persistent condition requiring structured rehabilitation intervention); (2) a baseline Oswestry Disability Index (ODI) score greater than 30%, ensuring a functionally relevant level of disability. This threshold was selected to reduce the risk of floor effects and to ensure sufficient sensitivity for detecting clinically meaningful changes.

The selected age range was intended to minimize variability related to degenerative changes in older populations and high functional variability in younger individuals, thus improving sample homogeneity.

Exclusion criteria included: (1) history of spinal surgery; (2) presence of specific spinal pathology, such as fracture, tumor, infection, radiculopathy, or neurological deficits associated with lumbar pathology; (3) pregnancy; (4) systemic inflammatory diseases; (5) uncontrolled use of analgesic or anti-inflammatory medication during the study period; (6) current participation in other physiotherapy programs; (7) inability to comply with the study protocol or home exercise program.

Sample size was determined using a priori power analysis with G*Power software (version 3.1.9.7). Assuming a moderate to large effect size (Cohen's d = 0.65–0.70), an alpha level of 0.05, and a desired statistical power for independent samples t-test, a minimum of 37 participants per group was required (N = 74). To account for potential dropouts, 78 participants were enrolled (39 per group). All enrolled participants completed the study and were included in the final analysis.

2.2 Allocation and Blinding

Participants (N = 78) were assigned to either the FM therapy group (FMTh; n = 39) or the combined FM and DNS therapy group (CTh; n = 39). Participants were recruited consecutively and assigned according to a predefined allocation schedule established before study initiation. Due to the nature of the interventions (manual therapy and postural exercises), blinding of participants and treating physiotherapists was not feasible. However, outcome assessment and statistical analysis were performed by an investigator blinded to group allocation in order to reduce potential detection bias (Figure 1).

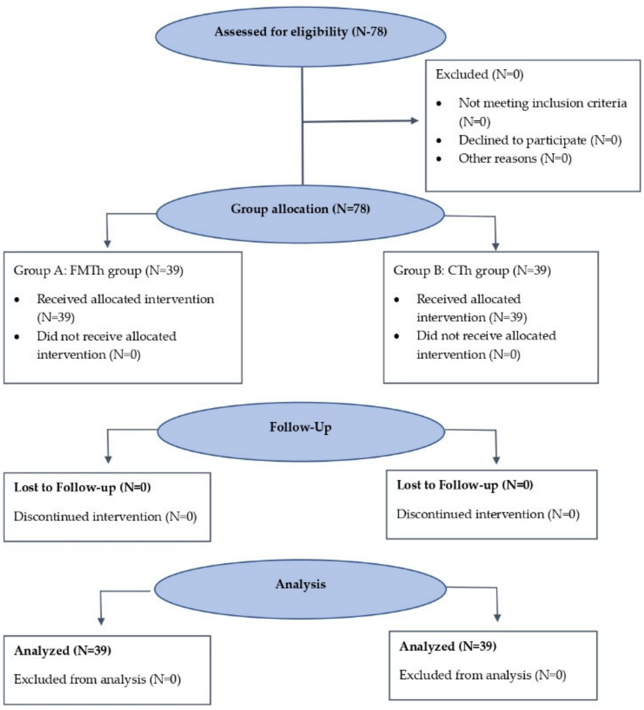


Figure 1. Participant flow diagram showing the progression of participants through the study phases, comparing FMTh group versus CTh group.

2.3 Intervention Protocols

The intervention period lasted eight weeks. Both groups received one weekly treatment session, totaling eight sessions.

- FM Therapy Protocol (FMTh group): The patients received a 30-minute session of FM once per week for eight weeks, performed by a certified Stecco FM practitioner. Treatment was individualized based on the Fascial Clinical Examination, including movement and palpatory assessment to identify densified areas within myofascial sequences. Intervention targeted primarily the lumbopelvic region and related segments when clinically indicated. Deep manual pressure was applied to specific Centers of Coordination (CCs) and Centers of Fusion (CFs) until a reduction in local pain and restoration of tissue gliding were achieved. Participants were instructed to maintain their usual daily activities and not to initiate any additional structured exercise programs during the study period.
- FM and DNS Therapy Protocol (CTh group): The patients received the same 30-minute FM session, followed by 30 minutes of DNS training during each weekly session. Four DNS exercises, based on developmental kinesiology principles, were selected to promote coordinated activation of the diaphragm and deep stabilizing muscles: Bear Position (quadruped progression); Low Lateral Oblique Sit; Supine "3-month position" (90/90); DNS Squat. Exercises were performed using a standardized respiratory-isometric protocol. Each position was maintained for 6 sets of 10 diaphragmatic breathing cycles, with a 30-second rest between sets. Participants were instructed to achieve full expansion of the lower rib cage and abdominal wall during inhalation and maintain controlled activation during exhalation [23,24]. The protocol aimed to activate the Integrated Stabilizing System of the Spine (ISSS) through coordinated diaphragm, pelvic floor, and trunk muscle engagement, with emphasis on neutral spinal alignment and joint centration [25]. Incorrect execution or loss of breathing pattern resulted in immediate correction. Participants performed the same four DNS exercises daily at home (30 minutes/session) during the entire 8-week intervention period. Adherence was monitored weekly using a self-reported log.

2.4 Outcome Measures

The outcome measure was assessed at baseline and at the end of the 8-week intervention period. Functional disability was evaluated using the Oswestry Disability Index (ODI), version 2.0, a validated instrument widely used for assessing disability in patients with low back pain [26-29]. The ODI consists of ten sections covering different aspects of daily functioning, each scored on a 0–5 scale. The total score is expressed as a percentage, with higher values indicating greater disability.

Pain intensity was assessed as part of the ODI (Section 1), using a 6-point Likert scale ranging from 0 (no pain) to 5 (maximum pain intensity).

2.5 Data Analysis

Statistical analysis was performed using SPSS software (version 26.0; IBM Corp., Armonk, NY, USA). A two-way repeated measures analysis of variance (ANOVA) was used to evaluate the effects of Group (FMTh vs. CTh) and Time (pre- vs. post-treatment), as well as the interaction between these factors on ODI scores. Statistical significance was set at $p < 0.05$.

3. Results

3.1 Study Population and Baseline Characteristics

A total of 78 patients with chronic NSLBP, defined by a pain duration exceeding 8 weeks, completed the 8-week intervention and were included in the final analysis. Participants were equally distributed between the FMTh and the CTh groups.

The mean age of the cohort was 50.98 ± 3.98 years (range: 45–59 years), with 52.6% (n = 41) female participants. Figure 2 provides a histogram illustrating the age distribution of the study participants.

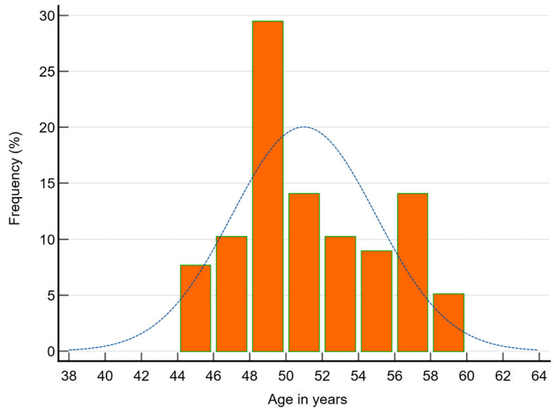


Figure 2. Histogram illustrating the age distribution of participants included in the study.

Baseline characteristics were generally comparable between groups (Table 1). No statistically significant differences were observed for demographic variables or most baseline clinical parameters, including total ODI score, pain intensity, personal care, lifting, and other functional domains. However, the Walking score was significantly higher in the FMTh group compared with the CTh group at baseline ($p < 0.05$), indicating a slight imbalance in walking-related functional limitation between groups at study entry.

Table 1. Baseline characteristics of all study participants and according to the therapy group.

Characteristic	CTh group	FMTh group	All patients	p-value
Gender (F/M; %)	51.28/48.72	53.85/46.15	52.56/47.44	na
Age in years*	50.71±4.15	51.26±3.84	50.99±3.98	0.54
Total Score score*	28.08±9.58	29.28±8.43	28.68±8.98	0.55
Pain intensity score*	3.36±1.33	3.44±1.14	3.40±1.23	0.77
Traveling score*	3.08±1.26	3.10±0.99	3.09±1.13	0.93
Personal care score*	2.59±1.18	2.46±1.17	2.53±1.17	0.62
Lifting score*	3.02±1.27	3.15±1.20	3.09±1.23	0.64
Walking score*	2.61±0.99	3.10±1.02	2.86±1.03	0.03
Sitting score*	2.90±1.07	2.97±1.01	2.94±1.04	0.76
Standing score*	3.33±0.95	3.54±0.99	3.44±0.97	0.34
Sleeping score*	1.92±1.06	2.15±1.04	2.04±1.05	0.33
Sex life score*	2.18±1.37	2.26±1.31	2.22±1.33	0.79
Social life score*	3.00±1.12	3.10±1.05	3.05±1.08	0.68

*Values are expressed as mean ± SD. Between-group comparisons were performed using the independent samples t-test. Statistical significance was set at $p < 0.05$.

3.1 Primary Outcome: Functional Disability

Both groups demonstrated significant improvements in functional disability from baseline to the end of the 8-week intervention. Baseline ODI scores were comparable between groups ($p > 0.05$). At post-treatment, the CTh group showed a significantly greater reduction in disability compared to the FMTh group. The mean ODI score decreased to 10.74 ± 5.53 in the CTh group, compared to 14.97 ± 5.84 in the FMTh group, with a statistically significant between-group difference ($p = 0.001$).

Detailed pre- and post-treatment ODI values are presented in Table 2.

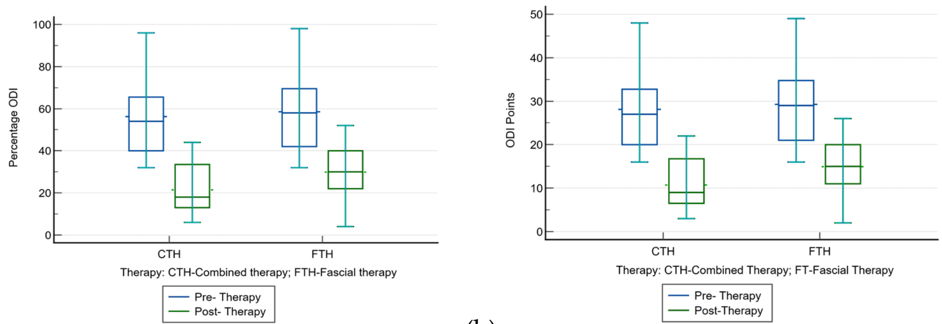
Table 2. Comparison of mean ODI values before and after therapy according to intervention group.

ODI score	CTh group	FMTh group	P value
PRE-Therapy (Mean ± SD)	28.07±9.57	29.28±8.43	0.55
POST-Therapy (Mean ± SD)	10.74±5.53	14.97±5.84	0.00

Values are expressed as mean ± SD. Between-group comparisons were performed using the independent samples t-test. Statistical significance was set at $p < 0.05$.

Figure 3 illustrates the changes in ODI values, confirming that although baseline scores were similar, the combined therapy group achieved greater improvements at the end of the intervention.

The between-group effect size at post-treatment was moderate to large (Cohen's $d = 0.74$).



(a) (b)

Figure 3. Boxplot representation of pre-therapy and post-therapy scores (ODI (%) (a) and points (b)) in the two study groups; CTH = Combined Therapy (CTh); FTH = Fascial Manipulation Therapy (FMTh).

3.2 Disability Category Analysis

The distribution of disability categories before and after treatment is presented in Table 3.

Table 3. Data on patients by therapy and level of disability before and after therapy.

Disability category	Pre-Therapy CTh group n (%)	Pre-Therapy FMTh group n (%)	Pre-therapy p-value	Post-Therapy CTh group n (%)	Post-Therapy FMTh group n (%)	Post-therapy p-value
Exaggerated symptoms (81–100%)	6 (15.38%)	4 (10.26%)	0.73	0 (0%)	0 (0%)	1.00
Crippled (61–80%)	6 (15.38%)	13 (33.33%)	0.11	0 (0%)	0 (0%)	1.00
Severe disability (41–60%)	14 (35.89%)	17 (43.59%)	0.64	1 (4.35%)	9 (23.08%)	0.01
Moderate disability (21–40%)	13 (33.33%)	5 (12.82%)	0.05	15 (38.46%)	21 (53.84%)	0.25
Minimal disability (0–20%)	0 (0%)	0 (0%)	1.00	23 (58.97%)	9 (23.08%)	0.00

Values are expressed as n (%). Between-group comparisons were performed using Fisher's exact test. Statistical significance was set at $p < 0.05$.

No statistically significant differences were observed between groups in disability category distribution at baseline. Following therapy, significant between-group differences were identified for severe disability ($p = 0.014$) and minimal disability ($p = 0.003$), with a higher proportion of patients achieving minimal disability status in the CTh group.

3.3 Pain Intensity Results

Both groups demonstrated reductions in pain intensity from baseline to post-treatment.

Baseline pain intensity scores were comparable between groups (p = 0.77). At the end of the intervention, pain intensity decreased to 1.64 ± 0.96 in the CTh group and to 1.82 ± 0.76 in the FMTh group, with no statistically significant between-group difference (p = 0.36).

Figure 4 illustrates the distribution of pain intensity scores before and after treatment in the two study groups. A reduction in pain scores can be observed in both groups, with considerable overlap in post-treatment values.

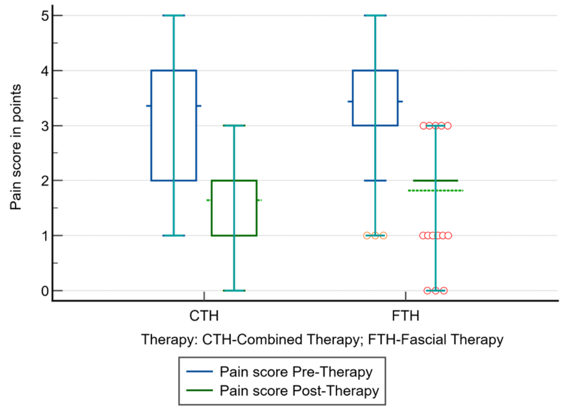


Figure 4. Boxplot representation of pre-therapy and post-therapy scores (pain intensity) in the two study groups; CTH = Combined Therapy (CTh); FTH = Fascial Manipulation Therapy (FMTh).

Table 4 presents the mean pain intensity scores before and after treatment in both study groups. Baseline values were comparable between groups (p = 0.77). Both groups showed a decrease in pain intensity at post-treatment; however, the difference between groups was not statistically significant (p = 0.36).

Table 4. Comparison of mean pain level before and after therapy depending on the type of therapy

Pain Intensity	CTh group	FMTh group	P value
PRE-Therapy (Mean ± SD)	3.35±1.33	3.43±1.14	0.77
POST-Therapy (Mean ± SD)	1.64±0.96	1.82±0.76	0.36

Values are expressed as mean ± SD. Between-group comparisons were performed using the independent samples t-test. Statistical significance was set at p < 0.05.

Although pain reduction was observed in both groups, the between-group effect size at post-treatment was small (Cohen's d = 0.21), consistent with the absence of statistically significant differences.

4. Discussion

The principal finding of this study is that the integration of DNS with FM resulted in significantly greater improvements in functional disability compared to FM alone in patients with chronic NSLBP. Although both groups demonstrated improvements over time, the between-group effect size indicates a moderate-to-large advantage of the combined intervention.

These findings are consistent with current recommendations for chronic low back pain, which support non-surgical, active, and function-oriented rehabilitation strategies rather than isolated passive approaches [30]. They also align with recent evidence showing that exercise therapy and manual therapy may both be useful in chronic low back pain, with exercise therapy showing small long-term advantages for disability in some analyses [31]. In this context, the present findings suggest that FM may provide a useful structural/manual component, while DNS may add a functional motor-control component.

An important finding of this study is the dissociation between pain reduction and functional improvement. While both groups showed comparable reductions in pain intensity, the combinet therapy group achieved significantly greater improvements in functional disability. This pattern is supported by recent evidence indicating that many non-surgical treatments for low back pain provide only small analgesic effects, while functional outcomes may require more complex, active rehabilitation strategies [32]. Similar observations have also been reported in other chronic pain populations, where functional status and quality of life may improve independently of pain intensity reduction [33].

The superior ODI improvement observed in the combined therapy group is also compatible with evidence from exercise-based rehabilitation. A network meta-analysis reported that several active exercise approaches can reduce pain intensity and functional limitations in chronic low back pain, although no single exercise type is universally superior for all patients [34]. Moreover, stabilization exercise evidence suggests benefits for pain and disability compared with some alternatives, but not necessarily superiority over all active exercise approaches [35]. Therefore, the present results should not be interpreted as proving that DNS is superior to all exercise methods, but rather as supporting the value of adding a structured motor-control component to FM.

The observed effects may be explained by the complementary mechanisms of the two interventions. FM primarily targets peripheral tissue dysfunction by restoring fascial gliding and reducing nociceptive input, while DNS addresses deficits in motor control and postural stabilization. This interpretation is supported by recent DNS-specific evidence showing that DNS training can improve core muscle contractility, diaphragm function, and standing postural control in patients with chronic low back pain [18]. Together, these mechanisms support a dual-phase recovery process, in which structural normalization facilitates movement, and neuromuscular re-education helps integrate this mobility into functional activity.

The higher proportion of patients achieving minimal disability in the combined therapy group compared to the FM-only group further supports the functional relevance of the combined approach. Recent systematic evidence also suggests that combining manual therapy with exercise may improve short-term pain, function, and disability outcomes compared with exercise alone [36]. Although the direction of comparison differs from the present study, both findings support the broader concept that multimodal rehabilitation may be more effective than relying on a single therapeutic component.

The inclusion of a daily home-based DNS program may represent a difference in intervention dose between groups. However, this approach reflects standard rehabilitation practice, as motor control re-education requires frequent and repeated practice to achieve neuromuscular adaptation. Recent evidence on home exercise in NSLBP suggests that home programs can contribute to pain and disability reduction, but also highlights the importance of supervision and professional follow-up [37]. In the present study, the home program was not unsupervised in isolation, but was linked to weekly supervised DNS correction and adherence monitoring. Therefore, the home-based component should be considered an integral part of the intervention rather than an isolated additional treatment.

From a clinical perspective, the results suggest that while FM alone may be effective for pain reduction, the addition of DNS is more relevant for optimizing functional recovery. This supports the implementation of integrated rehabilitation protocols combining manual, neuromuscular, and active self-management strategies. Similar function-oriented benefits of structured rehabilitation have also been reported in other populations with musculoskeletal or metabolic vulnerability, including obesity-related functional impairment [38].

Several limitations should be considered when interpreting these results. First, blinding of participants and treating therapists was not feasible due to the nature of the interventions; however, outcome assessors were blinded to reduce detection bias. Second, the combined intervention group received a higher overall therapeutic dose, including both supervised sessions and a daily home exercise program. Therefore, it cannot be excluded that part of the observed benefit was related to the greater treatment exposure rather than exclusively to the specific effects of DNS. Although this approach reflects real-world clinical practice and motor control training typically requires frequent repetition to induce neuromuscular adaptations, the difference in treatment dose should be considered a potential confounding factor when interpreting the superiority of the combined intervention. Third, the study evaluated only short-term outcomes immediately after the 8-week intervention. Therefore, the long-term sustainability of the observed improvements remains uncertain and should be investigated in future studies with extended follow-up periods. In addition, the use of a single outcome measure (ODI) limits the comprehensive assessment of treatment effects. Future research should incorporate additional functional and patient-reported outcomes, including quality of life, objective functional performance tests, and long-term follow-up assessments, to better characterize the clinical benefits of combined FM and DNS interventions.

Despite these limitations, the present study provides clinically relevant evidence supporting the integration of Fascial Manipulation and Dynamic Neuromuscular Stabilization in the management of chronic low back pain.

Regarding internal validity, several methodological aspects support the robustness of the present study. The use of predefined inclusion and exclusion criteria ensured a relatively homogeneous study population with chronic NSLBP. All participants underwent standardized evaluation using the same outcome measure (ODI), and assessments were conducted by a blinded evaluator, limiting detection bias. Furthermore, the consistency of intervention delivery by trained practitioners and the absence of dropouts contributed to the internal consistency of the results.

The external validity of this study is supported by the inclusion of both male and female participants within a clinically relevant age range and by the use of widely accepted diagnostic criteria for NSLBP. The interventions reflect real-world rehabilitation practice, combining manual therapy with structured exercise and home-based components. Additionally, the pragmatic design, including patients recruited from a clinical setting and adherence to a typical rehabilitation schedule, enhances the generalizability of the findings to routine clinical populations with chronic NSLBP.

5. Conclusions

The combined FM and DNS approach results in greater improvements in functional disability compared to FM alone in patients with chronic NSLBP, with a higher proportion of patients achieving minimal disability. These findings support a synergistic approach addressing both structural and neuromuscular components of dysfunction and highlight the value of integrating motor control training with manual therapy within structured, patient-active rehabilitation strategies.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of the Sports University of Tirana, Albania (protocol code No. 3000/2 and date 17/12/2025) for studies involving humans.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patient(s) to publish this paper.

Data Availability Statement: The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Bonaldi L, Pirri C, Giordani F, Fontanella CG, Stecco C, Uccheddu F. Segmentation of the thoracolumbar fascia in ultrasound imaging: a deep learning approach. BMC Med Imaging. 2025; 15;25(1):164. doi: 10.1186/s12880-025-01720-2. PMID: 40375198; PMCID: PMC12083131.
2. Bonaldi L, Berardo A, Stecco A, Stecco C, Fontanella CG. Assessment of the Fascial System Thickness in Patients with and Without Low Back Pain: A Narrative Review. Diagnostics (Basel). 2025 16;15(16):2059. doi: 10.3390/diagnostics15162059. PMID: 40870911; PMCID: PMC12385576.
3. Bertoldo D, Pirri C, Roviaro B, Stecco L, Day JA, Fede C, Guidolin D, Stecco C. Pilot Study of Sacroiliac Joint Dysfunction Treated with a Single Session of Fascial Manipulation® Method: Clinical Implications for Effective Pain Reduction. Medicina (Kaunas). 2021 6;57(7):691. doi: 10.3390/medicina57070691. PMID: 34356973; PMCID: PMC8306333.
4. Branchini M, Lopopolo F, Andreoli E, Loreti I, Marchand AM, Stecco A. Fascial Manipulation® for chronic aspecific low back pain: a single blinded randomized controlled trial. F1000Res. 2015; 4:1208. doi: 10.12688/f1000research.6890.2. PMID: 26834998; PMCID: PMC4706049.
5. Sannasi R, Dakshinamurthy A, Dommerholt J, Desai V, Kumar A, Sugavanam T. Diaphragm and core stabilization exercises in low back pain: A narrative review. J Bodyw Mov Ther. 2023; 36:221-227. doi: 10.1016/j.jbmt.2023.07.008. Epub 2023 Jul 13. PMID: 37949564.
6. Sikdar S, Srbely J, Shah J, Assefa Y, Stecco A, DeStefano S, Imamura M, Gerber LH. A model for personalized diagnostics for non-specific low back pain: the role of the myofascial unit. Front Pain Res (Lausanne). 2023; 4:1237802. doi: 10.3389/fpain.2023.1237802. PMID: 37901614; PMCID: PMC10606250.
7. Casato G, Stecco C, Busin R. Role of fasciae in nonspecific low back pain. Eur J Transl Myol. 2019; 29(3):8330. doi: 10.4081/ejtm.2019.8330. PMID: 31579477; PMCID: PMC6767839.
8. Pirri C, Pirri N, Guidolin D, Macchi V, Porzionato A, De Caro R, Stecco C. Ultrasound Imaging of Thoracolumbar Fascia Thickness: Chronic Non-Specific Lower Back Pain versus Healthy Subjects; A Sign of a "Frozen Back"? Diagnostics (Basel). 2023; 13(8):1436. doi: 10.3390/diagnostics13081436. PMID: 37189537; PMCID: PMC10137552.
9. Wilke J, Schleip R, Klingler W, Stecco C. The Lumbodorsal Fascia as a Potential Source of Low Back Pain: A Narrative Review. Biomed Res Int. 2017; 2017:5349620. doi: 10.1155/2017/5349620. Epub 2017 May 11. PMID: 28584816; PMCID: PMC5444000.
10. Mika A, Oleksy Ł, Fede C, Pirri C, Stecco C. Editorial: Fascia as a multi-purpose structure of connective tissue - dysfunction, diagnostics and treatment. Front Med (Lausanne). 2024; 11:1472116. doi: 10.3389/fmed.2024.1472116. PMID: 39206164; PMCID: PMC11349619.
11. Stecco A, Giordani F, Fede C, Pirri C, De Caro R, Stecco C. From Muscle to the Myofascial Unit: Current Evidence and Future Perspectives. Int J Mol Sci. 2023; 24(5):4527. doi: 10.3390/ijms24054527. PMID: 36901958; PMCID: PMC10002604.
12. Harper B, Steinbeck L, Aron A. Fascial manipulation vs. standard physical therapy practice for low back pain diagnoses: A pragmatic study. J Bodyw Mov Ther. 2019; 23(1):115-121. doi: 10.1016/j.jbmt.2018.10.007. Epub 2018 Nov 3. PMID: 30691738.
13. Zhang L, Cui S, Xi X, Bi H, Pu Y, Huang B. Efficacy and safety of dynamic neuromuscular stabilisation in treating chronic non-specific low back pain: a systematic review and meta-analysis protocol. BMJ Open. 2025; 15(4): e087036. doi: 10.1136/bmjopen-2024-087036. PMID: 40180364; PMCID: PMC11969597.
14. Moreno Catalá M, Schroll A, Laube G, Arampatzis A. Muscle Strength and Neuromuscular Control in Low-Back Pain: Elite Athletes Versus General Population. Front Neurosci. 2018; 12:436. doi: 10.3389/fnins.2018.00436. PMID: 30018531; PMCID: PMC6037821.
15. Kim B, Yim J. Core Stability and Hip Exercises Improve Physical Function and Activity in Patients with Non-Specific Low Back Pain: A Randomized Controlled Trial. Tohoku J Exp Med. 2020; 251(3):193-206. doi: 10.1620/tjem.251.193. PMID: 32669487.
16. Ulger O, Demirel A, Oz M, Tamer S. The effect of manual therapy and exercise in patients with chronic low back pain: Double blind randomized controlled trial. J Back Musculoskelet Rehabil. 2017; 30(6):1303-1309. doi: 10.3233/BMR-169673. PMID: 28946522.

17. Amzolini A.M, Neagoe CD,Avramescu TE, Mitrea A, Traistaru R, Micu ES. Ianosi S.L, Matei D. Understanding Non-Pharmacological Treatments for Fibromyalgia Functional and Well-Being Status: The Role of Literacy. Healthcare 2024. 12, 1956.
18. Huang H, Xie H, Zhang G, Xiao W, Ge L, Chen S, Zeng Y, Wang C, Li H. Effects of dynamic neuromuscular stabilization training on the core muscle contractility and standing postural control in patients with chronic low back pain: a randomized controlled trial. BMC Musculoskelet Disord. 2025; 26(1):213. doi: 10.1186/s12891-025-08417-1. PMID: 40025463; PMCID: PMC11871613.
19. Kaushik M, Ahmad I. Bridging Dynamic Neuromuscular Stabilization Synergism with Movement Control Impairment Related Non-Specific Low Back Pain: Scoping Review. J Musculoskelet Neuronal Interact. 2024; 24(4):420-432. PMID: 39616512; PMCID: PMC11609563.
20. Kong L, Zhang Z, Li Y, Zhu X, Fan J, Meng L, Zhang Q. Effects of Dynamic Neuromuscular Stabilization/Vojta Therapy on Pain Intensity and Physical Function in Individuals with Low Back Pain: A Systematic Review and Meta-Analysis. Iran J Public Health. 2024;53(9):1910-1923. doi: 10.18502/ijph.v53i9.16447. PMID: 39429656; PMCID: PMC11490336.
21. Suarez-Rodriguez V, Fede C, Pirri C, Petrelli L, Loro-Ferrer JF, Rodriguez-Ruiz D, De Caro R, Stecco C. Fascial Innervation: A Systematic Review of the Literature. Int J Mol Sci. 2022;23(10):5674. doi: 10.3390/ijms23105674. PMID: 35628484; PMCID: PMC9143136.
22. Blanco-Giménez P, Vicente-Mampel J, Gargallo P, Maroto-Izquierdo S, Martín-Ruíz J, Jaenada-Carrilero E, Barrios C. Effect of exercise and manual therapy or kinesiotaping on sEMG and pain perception in chronic low back pain: a randomized trial. BMC Musculoskelet Disord. 2024;25(1):583. doi: 10.1186/s12891-024-07667-9. PMID: 39054514; PMCID: PMC11270888.
23. Mahdieh L, Zolaktaf V, Karimi MT. Effects of dynamic neuromuscular stabilization (DNS) training on functional movements. Hum Mov Sci. 2020;70:102568. doi: 10.1016/j.humov.2019.102568. Epub 2020 Jan 13. PMID: 31950895.
24. Kang S, Park I, Ha MS. Effect of dynamic neuromuscular stabilization training using the inertial load of water on functional movement and postural sway in middle-aged women: a randomized controlled trial. BMC Womens Health. 2024;24(1):154. doi: 10.1186/s12905-024-02972-w. PMID: 38438927; PMCID: PMC10910739.
25. Frank C, Kobesova A, Kolar P. Dynamic neuromuscular stabilization & sports rehabilitation. Int J Sports Phys Ther. 2013;8(1):62-73. PMID: 23439921; PMCID: PMC3578435.
26. Schwind J, Learman K, O'Halloran B, Showalter C, Cook C. Different minimally important clinical difference (MCID) scores lead to different clinical prediction rules for the Oswestry disability index for the same sample of patients. J Man Manip Ther. 2013;21(2):71-8. doi: 10.1179/2042618613Y.0000000028. PMID: 24421616; PMCID: PMC3649353.
27. Fritz JM, Irrgang JJ. A comparison of a modified Oswestry Low Back Pain Disability Questionnaire and the Quebec Back Pain Disability Scale. Phys Ther. 2001;81(2):776-88. doi: 10.1093/ptj/81.2.776. Erratum in: Phys Ther. 2008 Jan;88(1):138-9. PMID: 11175676.
28. Chiarotto A, Terwee CB, Ostelo RW. Choosing the right outcome measurement instruments for patients with low back pain. Best Pract Res Clin Rheumatol. 2016;30(6):1003-1020. doi: 10.1016/j.berh.2017.07.001. Epub 2017 Jul 23. PMID: 29103546.
29. Chiarotto A, Vanti C, Cedraschi C, Ferrari S, de Lima E Sà Resende F, Ostelo RW, Pillastrini P. Responsiveness and Minimal Important Change of the Pain Self-Efficacy Questionnaire and Short Forms in Patients With Chronic Low Back Pain. J Pain. 2016;17(6):707-18. doi: 10.1016/j.jpain.2016.02.012. Epub 2016 Mar 11. PMID: 26975193. https://journals.sagepub.com/doi/10.3233/BMR-200206
30. World Health Organization. WHO guideline for non-surgical management of chronic primary low back pain in adults in primary and community care settings. Geneva: World Health Organization; 2023.
31. González-Gómez L, Moral-Munoz JA, Rosales-Tristancho A, Cuevas-Moreno A, Cardellat-González M, Rodríguez-Domínguez ÁJ. Exercise Therapy Versus Manual Therapy for the Management of Pain Intensity, Disability, and Physical Function in People With Chronic Low Back Pain: A Systematic Review With Meta-Analysis and Meta-Regression. Eur J Pain. 2025;29:e70090. doi:10.1002/ejp.70090.
32. Cashin AG, Furlong B, et al. Analgesic effects of non-surgical and non-interventional treatments for low back pain: a systematic review and meta-analysis of placebo-controlled randomised trials. BMJ Evid Based Med. 2025;30(4):222–231. PMID: 40101974.
33. Matei D, Traistaru R, Amzolini AM, Ianosi LS, Neagoe CD, Mitrea A, Clenciu D, Avramescu TE. A Comparative Study on the Pain Threshold Experienced by Fibromyalgia Patients Following Acute SARS-CoV-2 Infection. Life 2024, 14, 942.
34. Hayden JA, Ellis J, Ogilvie R, Stewart SA, Bagg MK, Stanojevic S, Yamato TP, Saragiotto BT. Some types of exercise are more effective than others in people with chronic low back pain: a network meta-analysis. J Physiother. 2021;67(4):252–262. doi:10.1016/j.jphys.2021.09.004.
35. Smith BE, Littlewood C, May S. An update of stabilisation exercises for low back pain: a systematic review with meta-analysis. BMC Musculoskelet Disord. 2014;15:416. doi:10.1186/1471-2474-15-416.

36. Narenthiran P, Granville Smith I, Williams FMK. Does the addition of manual therapy to exercise therapy improve pain and disability outcomes in chronic low back pain: A systematic review. J Bodyw Mov Ther. 2025;42:146-152. doi: 10.1016/j.jbmt.2024.12.004. Epub 2024 Dec 10. PMID: 40325660.
37. Lapuente-Hernández D, Gil-Calvo M, et al. Home Physical Exercise Interventions in Chronic Non-Specific Low Back Pain: Systematic Review and Multivariate Meta-Analysis. Healthcare. 2025;13(17):2094.
38. Popescu C, Matei D, Trăistaru R. The Role of Kinesiotherapy in Enhancing Physical Performance and Self-Esteem: A Prospective Observational Study in Obese Adolescents. Balneo and PRM Research Journal 2024. 15(4): 75.