DOI: 10.4274/tod.galenos.2025.86094
Turk J Osteoporos 2025;31(3):169-77

Acute Impact of Spinal Manipulation on Pain and Muscle Mechanical Properties in Chronic Low Back Pain: An Assessor Blinded, Randomized Controlled Trial

Kronik Bel Ağrısında Spinal Manipülasyonun Ağrı ve Kasın Mekanik Özellikleri Üzerine Akut Etkisi: Değerlendiriciye Kör, Randomize Kontrollü Bir Çalışma

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Abstract

Objective: Chronic low back pain (CLBP) represents one of the most challenging and costly musculoskeletal conditions to manage. A variety of therapeutic approaches, including exercise training, pain management strategies, and spinal manipulation and mobilization, are employed in its treatment. Among these, clinical spinal manipulation and mobilization techniques are widely regarded as one of the most effective interventions for reducing pain and disability, offering both short- and long-term benefits. High-velocity spinal manipulation is commonly adopted for treating CLBP and has been associated with changes in muscle activity, but the evidence is controversial. The aim of this study was to analyze the immediate effects of two manual spinal techniques (MST) on pain, flexibility, and muscle mechanical properties in CLBP.
Materials and Methods: This single-blinded, randomized comparative trial used a pre- and post-test design. Participants were randomly assigned to two groups: Group 1 received Maitland’s posterior-anterior central vertebral pressure mobilization technique, and group 2 underwent the lumbar roll technique. Assessments were conducted at baseline and immediately after the interventions. Muscle mechanical properties were measured using MyotonPro, pain intensity was evaluated using a visual analog scale (VAS), and flexibility was assessed through the sit and reach test and the modified Schober test.
Results: Following the interventions, significant improvements were observed in VAS scores and sit-and-reach test results in both groups. Analysis of Schober test data revealed a significant improvement in group 2 ($p<0.001$). Mechanical properties of the paravertebral muscles at the L3-L4 vertebral level were assessed using MyotonPro, showing statistically significant enhancements in elasticity (Hz) and dynamic stiffness (N/m) in both groups post-intervention. However, no statistically significant differences were identified between the groups.
Conclusion: Both MSTs demonstrated efficacy in alleviating pain, reducing muscle stiffness, and enhancing flexibility. In this study, manipulations were applied to the symptomatic side, which yielded positive outcomes in pain reduction and muscle properties. However, further research is needed to determine whether the symptomatic side is superior in terms of therapeutic efficacy.
Keywords: Chronic low back pain, spinal manipulation, mobilization, muscle mechanical properties, MyotonPro

Öz

Amaç: Kronik bel ağrısı (KBA), yönetimi en zorlayıcı ve en maliyetli kas-iskelet sistemi rahatsızlıklarından biri olarak kabul edilmektedir. Egzersiz eğitimi, ağrı yönetim stratejileri ve spinal manipülasyon gibi çeşitli terapötik yaklaşımlar bu durumun tedavisinde kullanılmaktadır. Bu yöntemler arasında klinik spinal manipülasyon, hem kısa hem de uzun vadeli faydalar sağlayarak ağrı ve fiziksel kısıtlılığı azaltmada en etkili müdahalelerden biri olarak yaygın şekilde kabul görmektedir. Yüksek hızda uygulanan spinal manipülasyon teknikleri, KBA tedavisinde yaygın olarak tercih edilmekte ve kas aktivitesinde değişikliklerle ilişkilendirilmektedir; ancak bu konuda mevcut kanıtlar çelişkilidir. Bu çalışmanın amacı, KBA’lı bireylerde iki farklı spinal manipülasyon tekniğinin klinik sonuçlar ve kas mekanik özellikleri üzerindeki anlık etkilerini analiz etmektir.
Gereç ve Yöntem: Bu tek-körlemeli, randomize karşılaştırmalı çalışma, ön test–son test desenine sahiptir. Katılımcılar rastgele iki gruba ayrılmıştır: Grup 1, Maitland’ın postero-anterior merkezi vertebral bası tekniğini alırken, Grup 2 ise lumbal roll tekniğine tabi tutulmuştur.

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Received/Geliş Tarihi: 11.04.2025 **Accepted/Kabul Tarihi:** 01.07.2025 **Epub:** 21.08.2025 **Publication Date/Yayınlanma Tarihi:** 05.12.2025

Cite this article as/Atıf: Aracı A, Kurt EE, Taş S. Acute impact of spinal manipulation on pain and mechanical properties in chronic low back pain: an assessor blinded, randomized controlled trial. Turk J Osteoporos. 2025;31(3):169-77

Öz

Değerlendirmeler, müdahale öncesi ve hemen sonrasında gerçekleştirilmiştir. Kas mekanik özellikleri MyotonPro cihazı ile ölçülmüş; ağrı düzeyi görsel analog skala (VAS) ile değerlendirilmiş; esneklik ise otur-uzan testi ve modifiye Schober testi kullanılarak belirlenmiştir.

Bulgular: Uygulamalar sonrasında her iki grupta da VAS skorları ile otur-uzan testi sonuçlarında anlamlı iyileşmeler gözlenmiştir. Schober testi analizinde, yalnızca Grup 2'de istatistiksel olarak anlamlı bir gelişme saptanmıştır (p<0,001). L3-L4 vertebral düzeyindeki paravertebral kasların mekanik özellikleri, MyotonPro cihazı ile değerlendirilmiş olup, her iki grupta da elastisite (Hz) ve dinamik sertlik (N/m) parametrelerinde anlamlı artışlar görülmüştür. Bununla birlikte, gruplar arasında istatistiksel olarak anlamlı bir fark bulunmamıştır.

Sonuç: Her iki spinal manipülasyon tekniği de, ağrının hafifletilmesi, kas sertliğinin azaltılması ve esnekliğin artırılması açısından etkili bulunmuştur. Elde edilen bulgular doğrultusunda, terapötik etkinliğin en üst düzeye çıkarılması için manipülasyonların semptomatik tarafa uygulanması önerilmektedir.

Anahtar kelimeler: Kronik bel ağrısı, spinal manipülasyon, mobilizasyon, kas mekanik özellikleri, MyotonPro

Introduction

Worldwide, low back pain (LBP) has become the leading cause of disability (1). In most cases, a specific patho-anatomic cause of back pain cannot be identified (2). A range of treatment approaches, including exercise therapy, pain management strategies, and spinal manipulation, are commonly employed in the management of chronic LBP (3,4).

Stochkendahl et al. (1) proposed an evidence-based, stepped-care clinical guideline for the diagnosis and management of LBP, emphasizing non-pharmacologic and patient-centered strategies. Their approach highlights the importance of patient education, encouragement of physical activity, and, where appropriate, the use of manual therapies such as spinal manipulation. Advanced imaging and invasive interventions are reserved for cases presenting with "red flag" symptoms. Within the scope of such guidelines, spinal manipulative therapy (SMT) is widely recognized as a valuable tool for reducing pain and disability (5). Nevertheless, uncertainty remains regarding which SMT techniques are most effective, the ideal treatment frequency, and which patient profiles are likely to benefit. A central debate persists on whether SMT should be applied to regions with the most pronounced biomechanical dysfunction or to areas exhibiting the highest pain sensitivity (6).

Reduced spinal mobility is one of the causes of back pain. Specifically, the decrease in the isometric resistance and strength of the spinal extensor muscles leads to greater loading on passive structures (6). This can result in plastic deformation, possible strain, and consequently, a loss of flexibility in these structures. When flexibility is reduced, the mechanical efficiency of the joint is limited, and energy consumption increases (6). When spinal mobility is reduced, the likelihood of LBP increases. In 90% of patients with LBP, movement restrictions are observed in at least one of the following tests: fingertip-to-floor distance, trunk flexion/extension, lateral flexion, modified Schober test, and knee extension (6). Therefore, the use of SMT is necessary to increase the mobility of the lumbar region.

SMT, which encompasses both mobilization and manipulation techniques, exerts its therapeutic effects on pain and movement restriction through distinct yet complementary mechanisms (7-9). Mobilization involves the application of low-velocity, rhythmic passive forces targeting joint capsules and surrounding soft tissues to improve tissue flexibility and enhance range of motion. This technique also contributes to pain modulation by reducing muscle spindle hyperexcitability and activating endogenous inhibitory pathways within the central nervous system (10). In contrast, manipulation involves a high-velocity, low-amplitude (HVLA) thrust that often produces joint cavitation, leading to changes in intradiscal pressure and mechanical mobility, while simultaneously triggering a cascade of neurophysiologic responses that inhibit nociceptive transmission (8). Recent evidence indicates that SMT is particularly effective in managing acute and subacute musculoskeletal disorders, primarily due to its ability to rapidly induce peripheral and central neurophysiological responses (11-13). Activation of type I and II mechanoreceptors during SMT suppresses nociceptive input at the level of the spinal dorsal horn, resulting in localized hypoalgesia (11). Concurrently, descending pain modulatory systems such as the periaqueductal gray matter in the brainstem are engaged, producing widespread analgesic effects beyond the site of application. This bidirectional neurophysiologic mechanism also induces transient changes in corticospinal excitability and sensorimotor integration, potentially affecting not only pain perception but also motor outputs such as postural control and muscle tone (11-13). These effects typically emerge within 5 to 30 minutes post-intervention and diminish within a few hours, positioning SMT as a clinically relevant and effective option for short-term symptom relief, particularly in acute care settings (12).

Techniques such as the Maitland spinal mobilization used in this study involve central posteroanterior (PA) pressure applications to reduce muscle spasm and alleviate LBP. It has been reported to be particularly effective when pain is of equal intensity on both sides (14). On the other hand, the literature frequently mentions the use of side-lying manipulation technique in cases of chronic low back pain (CLBP) (15). However, studies evaluating the acute effects of mobilization and manipulation techniques on muscle mechanical properties are rare in the literature (6,16,17). The primary objective of this study was to investigate the immediate effects of Maitland's PA central vertebral pressure mobilization technique and the side-lying lumbar manipulation technique on muscle mechanical properties, pressure pain threshold, and joint range of motion in patients with CLBP. A secondary objective was to compare the relative effectiveness of these two manual therapy techniques in improving the measured outcomes.

Materials and Methods

Study design and setting: This randomized, assessor-blinded comparative study aimed to evaluate the effects of the lateral lumbar spinal manipulation technique and Maitland's PA central vertebral mobilization technique (18) on the mechanical properties of muscles and their impact on the pressure-pain threshold.

Sample size: A power analysis was conducted to determine the required sample size for this study. To achieve 80% statistical power at a 5% level of significance, it was estimated that detecting a clinically meaningful difference of approximately 64 N/m (equivalent to 15%) in lumbar extensor muscle stiffness would require at least 10 participants per group. This calculation was based on an assumed baseline stiffness of 320 N/m and a standard deviation (SD) of 74 N/m. (19).

Ethics approval and consent to participate: This study was approved by the Non-Interventional Ethics Committee of Alanya Alaaddin Keykubat University (approval no: 10354421, date: 14/03/2021) and was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki (1964) and its subsequent revisions. The trial was registered on ClinicalTrials.gov (ID: NCT05057091; last verified: 09/2024). All procedures were performed in compliance with relevant institutional guidelines and regulatory standards. Written informed consent was obtained from all participants prior to their inclusion in the study.

Eligibility criteria and search strategy: The data were collected in the Department of Physical Medicine and Rehabilitation at Alanya Alaaddin Keykubat University Faculty of Medicine in between June 2021 and September 2021. The diagnosis of CLBP was made by a physiatrist. Volunteers aged between 18 and 65 years who were diagnosed as having CLBP by a physician were included in the study. Participants were excluded (1) if they had a risk of pregnancy, (2) were using pacemakers or had metal implants in their body, (3) had vertebral fractures, (4) cancer, (5) osteoporosis, (6) body mass index (BMI) above 30 kg/m^2, (7) neurologic diseases that might lead to muscle weakness and spasticity, and (8) primary or/and secondary degenerative vertebral diseases (18)

All interventions were administered by a physiotherapist (A.A) who had 15 years of clinical experience, specialized training in spinal manipulation therapy, and was a certifed osteopathic practioner. This practitioner was responsible for obtaining medical histories and conducting clinical assessments for all participants. Pre- and post-intervention measurements were performed by a second physiotherapist (S.T) who was blinded to group allocation to minimize assessment bias.

Randomization: Covariate adaptive randomization was performed using a computer program for the optimal allocation of patients to two groups (covariates: age, sex, and BMI).

Intervention

Group 1 – Maitland's posterior-anterior central vertebral pressure mobilization technique: Participants in this group were positioned in the prone position. The therapist identified the vertebral segments associated with the highest pain sensitivity through palpation. Using the pisiform bones of the hands, the therapist applied PA central vertebral mobilization directly to the spinous processes of the identified vertebrae (20). For the unilateral PA mobilization, both thumbs were positioned one over the other on the spinous process of the targeted vertebra, and an average discrete pressure of approximately 4 kg was applied (20).

Illustration of the PA central vertebral mobilization technique, where the therapist applies pressure on the spinous process of the identified painful vertebrae (Figure 1).

Group 2 – Side-lying lumbar spinal manipulation: Participants in this group were positioned in the side-lying posture with the painful side facing upward, while the therapist stood in front of them. Initially, the upper leg was flexed until movement was detected in the vertebral segment corresponding to the pain site. The interspinous space was then palpated, and the foot of the flexed leg was placed into the popliteal fossa of the lower leg for stabilization. In the second phase of positioning, the therapist grasped the lower shoulder to induce contralateral trunk rotation and hyperextension. This was done by pulling the shoulder until movement was again perceived at the interspinous level, thereby isolating the symptomatic vertebra between adjacent segments. With this alignment maintained, the patient was gently rolled toward the therapist. Finally, a HVLA thrust was delivered using the therapist's arm and body. The thrust was applied simultaneously in two opposing directions: anteriorly to the pelvis and posteriorly to the shoulder (21).

Demonstration of the side-lying lumbar spinal manipulation

Figure 1. Maitland's PA central vertebral mobilization technique
PA: Posteroanterior

technique, highlighting the steps of positioning, alignment, and application of high-speed, low-amplitude thrust for targeted spinal mobilization (Figure 2).

Outcomes measures: This was a randomized single-blinded comparative study, involving pre- and post-measurement tests. Assessments were performed at baseline and immediately after SMT interventions. The dependent variables were the mechanical properties of muscles, LBP level, and lumbar region flexibility.

Lumbar Region Flexibility Assessment

Modify Schober test: Lumbar region flexion flexibility was measured using a modified Schober test. For measurement, the examiner marked both posterior superior iliac spine and then drew a horizontal line at the center of both marks.

Participants were instructed to perform maximum trunk flexion by bending forward. The distance between the two vertical marks was re-measured during full flexion. The difference between the baseline and flexed position was recorded in centimeters. A value between 0-5 cm was interpreted as reduced lumbar flexibility, >10 cm indicated increased flexibility, and values between 5-10 cm were considered within the normal range (22).

Sit and reach test: The patients sat in a long sitting position with their knees straight and the soles of their feet flat against the bottom of the test board. The feet were positioned to be approximately shoulder width apart, and the patient extended forward from the waist and hip so that the elbows, wrists, and fingers were stretched. During the test, attention was paid to keeping the knees straight. The tested patient pushed the measuring board forward on the test stand with their fingers and waited 1-2 seconds at the last point. The place where the feet made contact with the test stand was taken as the starting point, point 0. The distance between the fingertip and the starting point was measured and recorded in cm as "-" if it was ahead of the 0 point, and "+" if it was behind (23).

Mechanical properties measurements: MyotonPro was described as valid (24) and dependable (25-27) for assessing muscle mechanical parameters. The information below is provided by MyotonPro: (3) oscillation frequency (an indicator of tone), (4) dynamic stiffness (an indicator of stiffness), and (5) logarithmic attenuation (related to elasticity). A physiotherapist with 3 years of myotonometric measurement experience who was blinded to the groups conducted the measurements.

Figure 2. Side-lying lumbar spinal manipulation

Measurements for the lumbar extensor muscle were taken 3 cm from the midpoint of the L3/L4 intervertebral gap. The mean of three consecutive measurements was recorded (25,26).

Visual analog scale (VAS): The severity of the patient's pain was assessed using the VAS. This scale typically consists of a 10 cm horizontal or vertical line, with "no pain" at one end and "unbearable pain" at the other. The patient marks a point on the line to indicate their level of pain. The distance between the starting point and the marked point is measured in centimeters (cm) and recorded. On this scale, "0" represents no pain, "5" indicates moderate pain, and "10" pain ever experienced (28).

Statistical Analysis

For statistical analysis, the IBM SPSS version 20.0 software (IBM Corporation, Armonk, NY) was used. For normal distribution, data are reported as mean ± SD. Data that are not normally distributed are shown as the median interquartile range. Categorical data are represented as a percentage (%). The Shapiro-Wilk test was used to determine the normality of the data distribution. When the data distribution was normal, Taleb's test was used to evaluate statistically significant differences. The Mann-Whitney U test was employed if the data were not regularly distributed. The chi-square test was used to perform qualitative comparisons of the groups. The paired t-test was used to compare repeated measurements in each group if the data were regularly distributed. The Wilcoxon test was used if the data distribution was not normal. The statistical significance threshold was set as $p<0.05$.

Results

A total of 29 (23 females, 6 males) diagnosed with CLBP were enrolled in the study, with a mean age of 38.48±11.35 years. Of these, 14 patients were allocated to group 1, which received Maitland PA central vertebral pressure and PA unilateral vertebral pressure mobilization, and 15 patients were assigned to group 2, which underwent side-lying lumbar spine manipulation (Figure 3). This figure illustrates the process of patient enrollment, group allocation, interventions, and analysis throughout the study.

The demographics of the patients are illustrated in Table 1. There were no statistically significant variations in sex, age, BMI, or pain duration between the groups (all $p>0.005$).

The study addressed the differences between the before and after values of both groups. Change, as well as intra-group and inter-group differences, were assessed (Table 2).

Pain Intensity (VAS)

Following the interventions, both groups' pain levels decreased significantly. However, no significant difference in VAS change

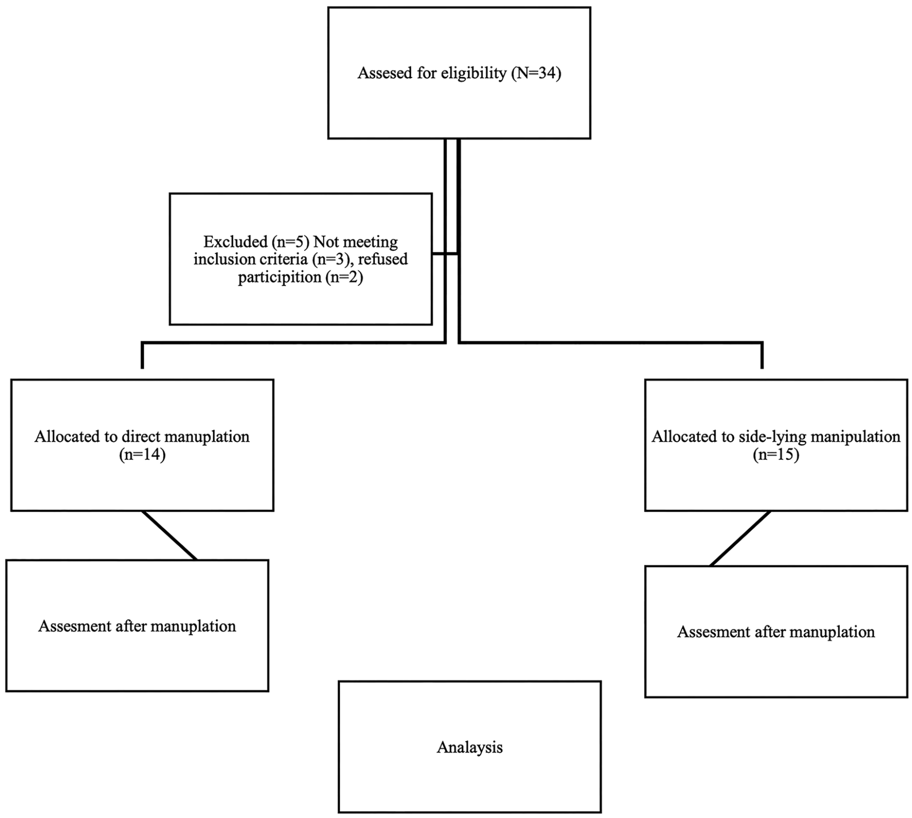

Figure 3. Flowchart of the study design

Table 1. Demographic data of the patients

	Maitland's posterior-anterior central vertebral pressure (group 1)	Lumbar roll techinique (group 2)	p
Age*	37.64±13.36	35.40±9.44	0.604
Sex (male/female)	3 (21.4%)/11 (78.6%)	3 (20%)/14 (80%)	0.924
BMI*	25.16±2.87	22.43±6.80	0.170
Pain duration* (month)	6.15±7.79	6.26±9.32	0.965

*: Mean ± standard deviation (normally distributed data), BMI: Body mass index

from baseline was seen between the groups. Group 1 reported a decrease in VAS from 5.71±1.77 to 3.64±2.27 (p=0.006), while Group 2 improved from 4.46±1.16 to 2.06±1.18 (p=0.001). However, there was no statistically significant difference between the groups in VAS change scores (p=0.533).

Lumbar Flexibility (Schober Test)

The Schober test revealed a significant increase only in Group 2 (from 4.57±3.49 to 5.33±3.37, p<0.001*), whereas no significant difference was detected in Group 1 (p=0.980). The intergroup comparison of change scores was not statistically significant (p=0.780).

Hamstring Flexibility (Sit and Reach Test)

When the sit and reach test data were compared before and after the intervention, both group 1 (p=0.004*b) and group 2 (p=0.003*b) showed a significant difference. However, the change scores between the groups were not significantly different (p=0.561).

Paravertebral Muscle Mechanical Properties at L3-L4 Level (MyotonPro)

When the mechanical changes in the paravertebral muscles in the L3-L4 vertebral space were assessed using a MyotonPro before and after the intervention, significant changes in (1) logarithmic decrement [related to elasticity (Hz)] (p=0.028*a) were found. In repeated tests in both groups, no difference in dynamic stiffness (2) [indicator of stiffness (N/m) (p=0.020*a)] or oscillation frequency [indicator of tone (dec)] was identified. In both groups, dynamic stiffness values [indicator of stiffness (N/m)] (p=0.020*a) and (3) oscillation frequency revealed no significant change.

Following the intervention, both groups' VAS scores and sit-reach tests improved significantly. The Schober test data were examined, and it was discovered that there was only a significant difference in group 2 (p=0.001*).

Discussion

The present study aimed to compare the acute effects of two spinal manipulation techniques Maitland's PA central vertebral pressure mobilization technique and side-lying lumbar spinal manipulation in individuals diagnosed with CLBP. The results demonstrated that both intervention methods were effective in reducing pain intensity, decreasing muscle stiffness, and enhancing flexibility.

Despite the positive outcomes observed in both groups, no statistically significant difference was identified between the techniques. This finding suggests that the two spinal manipulation approaches may produce comparable short-term clinical benefits in the management of CLBP. These results support the flexibility of clinical decision-making in choosing either technique based on practitioner expertise or patient preference, without compromising therapeutic efficacy.

The significant reduction in pain intensity observed in both groups aligns with previous literature (20,29), and is likely mediated through spinal and supraspinal pain modulation mechanisms. Although the systematic review by Coulter et al. (17) suggested spinal manipulation may be more effective than mobilization for pain reduction, it also noted limited effects on function. Similarly, Bussières et al. (30) emphasized that spinal manipulation should be integrated with education, exercise, and behavioral approaches to maximize its impact on range of motion and clinical outcomes.

Our results are consistent with previous research indicating that both mobilization and manipulation alleviate pain by modulating muscle spindle sensitivity and engaging endogenous analgesic pathways (29,31). In line with Cardinale et al. (32), even a single session of manipulation significantly improved flexibility outcomes such as the sit and reach test.

Table 2. Functional measurements at baseline and after manipulation; differences between two measurements

	Maitland's posterior-anterior central vertebral pressure (group 1)		**Lumbar roll techinique (group 2)**		**Group 1 vs. Group 2 intragroup**
	Mean ± SD	**p**	**Mean ± SD**	**p**	
VAS					
Baseline	5.71±1.77[a]	0.006*	4.46±1.16[a]	0.001*	
End of manuplation	3.642.27[a]		2.06±1.18[a]		
Change	1.50±2.07[b]		2.40±1.00[b]		0.533[b]
Schober test					
Baseline	6.00±4.00[b]	0.98	4.57±3.49[a]	**<0.001***	
End of manipulation	6.00±3.25[b]		5.33±3.37 [a]		
Change	1.00±1.00[b]		1.00±1.00[b]		0.780[b]
Sit and reach test					
Baseline	-4.00±12.25[b]	**0.004***[b]	-3.50±16.00[b]	**0.003***[b]	
End of manipulation	-1.00±13.75[b]		-1.00±13.00[b]		
Change	4.00±5.00[b]		2.00±4.00[b]		0.561[b]
L3-L4 frequency (Hz)					
Baseline	14.45±1.24[a]	0.546[a]	15.02±2.16[a]	**0.028***[a]	
End of manipulation	14.58±1.50[a]		14.58±1.83[a]		
Change	4.00±5.00[b]		2.00±4.00[b]		0.270[b]
L3-L4 stiffness (N/m)					
Baseline	268.50±54.04[a]	0.750[a]	292.33±79.72[a]	**0.020***[a]	0
End of manipulation	264.57±48.31[a]		268.20±66.40[a]		
Change	6.00±48.75[b]		14.00±34.00[b]		0.186[b]
L3-L4 dec					
Baseline	1.21±0.19[a]	0.840[a]	1.14±0.25[a]	0.412[a]	
End of manipulation	1.20±0.19[a]		1.16±0.26[a]		
Change	0.05±0.14[b]		- 0.02±0.07[b]		0.62[b]

[a]: Mean ± standard deviation (SD) (normally distributed data), [b]: Median ± interquartile range (non-normally distributed data), VAS: Visual analog scale, *: p<0.05

In the current study, both manipulation techniques led to significant improvements in sit and reach scores, indicating a favorable impact on hamstring flexibility and posterior chain mobility.

This finding highlights the potential of spinal interventions to modulate not only local spinal biomechanics but also distal muscle extensibility, possibly via reflex inhibition or improved neuromuscular coordination.

However, no significant improvement in the Schober test was observed in the Maitland group, mirroring the findings of Abe et al. (6), who reported limited acute effects of this technique on spinal flexion in young adults with LBP.

Notably, side-lying lumbar manipulation was more effective in improving lumbar flexion as assessed by the modified Schober test, suggesting this technique may offer advantages in enhancing segmental mobility. Improvement in fingertip-to-floor distance supports the role of manipulation in resolving mechanical restrictions and improving joint kinematics (33,34).

In terms of mechanical muscle properties, both groups showed improvements in elasticity and a reduction in stiffness, in contrast to Wu et al. (35), who reported increased stiffness post-manipulation. These discrepancies may be due to differences in population characteristics or measurement methods, and support the hypothesis that both biomechanical and neurophysiologic mechanisms including proprioceptive input and central pain modulation may be involved (36).

A recent meta-analysis by de Zoete et al. (37) confirmed the short-term efficacy of SMT for pain and function in patients with CLBP. However, although SMT showed superiority over sham interventions, it was only marginally more effective than other active interventions, highlighting the importance of incorporating SMT within a broader multimodal pain management strategy.

Study Limitations

There are some limitations to this study that should be noted. One of the main limitations is the relatively small sample size, which limits the generalizability of the findings and may reduce statistical power, especially for secondary outcomes. However, because this study was primarily designed to evaluate the effects SMT techniques on muscle architecture, power analysis was calculated based on muscle architecture measurements. A control or placebo group was not included in the study plan because it would be ethically inappropriate not to intervene in patients presenting with pain. The observed improvements may also be influenced by non-specific factors such as patient expectations, natural variability of symptoms, or repeated measurements, limiting the ability to isolate treatment-specific effects.

Despite these limitations, the study possesses several notable strengths. It addresses a significant gap in the literature by directly comparing the acute effects of two widely used SMT techniques—Maitland mobilization and side-lying lumbar manipulation—within a randomized, assessor-blinded design. Moreover, the use of clinically relevant outcome measures, including pain intensity (VAS), spinal flexibility (modified Schober and fingertip-to-floor tests), and muscle stiffness, enhances the applicability of the findings to clinical practice. Nevertheless, future studies incorporating control groups, long-term follow-up assessments, and stratified analyses are essential to deepen our understanding of the therapeutic mechanisms and optimize treatment strategies

Conclusion

In conclusion, both the Maitland mobilization technique and side-lying lumbar spinal manipulation appear to be effective interventions for the management of CLBP. Although no significant differences were found between the techniques in this study, their clinical utility may be optimized when selected based on individual patient profiles and incorporated into personalized treatment protocols.

Given the multifactorial nature of CLBP, the integration of these manual therapy techniques within multimodal rehabilitation approaches including education, exercise, and behavioral strategies may further enhance therapeutic outcomes. Future research should continue to explore how these methods can be effectively combined to maximize both short- and long-term benefits, guided by the growing body of evidence in the literature.

Ethics

Ethics Committee Approval: This study was approved by the Non-Interventional Ethics Committee of Alanya Alaaddin Keykubat University (approval no: 10354421, date: 14/03/2021) and was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki (1964) and its subsequent revisions.

Informed Consent: Informed consent for publication was obtained from all patients.

Acknowledgments

We express our deepest gratitude to all the participants who volunteered for our study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: A.A., S.T., Concept: A.A., E.E.K., S.T., Design: S.T., Data Collection or Processing: A.A., E.E.K., S.T., Analysis or Interpretation: A.A., E.E.K., S.T., Literature Search: A.A., E.E.K., S.T., Writing: A.A., E.E.K.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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