Do Improved Trunk Mobility and Isometric Strength Correlate with Improved Pain and Disability after Multimodal Rehabilitation for Low Back Pain?

A melhora da mobilidade e da força isométrica do tronco se correlacionam com a melhora da dor e da incapacidade após a reabilitação multimodal para dor lombar?

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Abstract

Objective To determine the correlation between posttreatment trunk range of motion (ROM) and isometric strength (TIS) and pain and disability in patients who underwent multimodal rehabilitation for low back pain (LBP).

Methods In this prospective cohort study, 122 patients undergoing multimodal rehabilitation for LBP were analyzed. The pre- and posttreatment numerical pain rating scale (NPRS) and the Oswestry disability index (ODI) scores, as well as trunk ROM and TIS were compared. The Pearson correlation was used to determine correlation between posttreatment clinical outcomes and ROM and TIS.

Results At the end of treatment, the mean NPRS ($p < 0.0001$) and ODI ($p < 0.0001$) scores, mean trunk extension ($p < 0.0001$), and flexion ($p < 0.0001$) ROMs improved significantly. Similarly, posttreatment, the mean extension ($p < 0.0001$) and flexion ($p < 0.0001$) TISs improved significantly. There was a weak correlation between the NPRS score and ROM extension (r = -0.24, $p = 0.006$) and flexion strength (r = -0.28, $p = 0.001$), as well as between the ODI score and TIS extension (r = -0.30, $p = 0.0007$) and flexion (r = -0.28, $p = 0.001$).

Conclusion Despite significant improvement in pain, disability, trunk ROM, and TIS with multimodal treatment, there was a weak correlation between posttreatment pain and function and trunk ROM and TIS. Improvement in pain and function with physical rehabilitation treatment for LBP is a complex phenomenon and needs further investigation.

Keywords
► flexibility
► low back pain
► multimodal treatment
► spine

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Resumo

Objetivo Determinar a correlação entre a amplitude de movimento (ADM) do tronco pós-tratamento e a força isométrica do tronco (FIT) e a dor e a incapacidade em pacientes submetidos à reabilitação multimodal para dor lombar (DL).

Métodos Neste estudo de coorte prospectiva, 122 pacientes submetidos à reabilitação multimodal para DL foram analisados. Foram comparados os escores de escala numérica de dor pré- e pós-tratamento (END) e do índice de incapacidade Oswestry (*Oswestry disability index* – ODI), a ADM do tronco e a FIT. A correlação de Pearson foi utilizada para determinar a correlação entre desfechos clínicos e a ADM e a FIT pós-tratamento.

Resultados Ao final do tratamento, as médias de ADM ($p < 0{,}0001$) e ODI ($p < 0{,}0001$), as ADMs médias de extensão ($p < 0{,}0001$) e a flexão ($p < 0{,}0001$) do tronco melhoraram significativamente. Da mesma forma, a FIT pós-tratamento, as FITs médias de extensão ($p < 0{,}0001$) e flexão ($p < 0{,}0001$) melhoraram significativamente. Houve uma correlação fraca entre o escore do END e a ADM de extensão (r = -0,24, $p = 0{,}006$) e força de flexão (r = -0,28, $p = 0{,}001$) pós-tratamento, assim como entre o escore de ODI e FIT de extensão (r = -0,30, $p = 0{,}0007$) e flexão (r = -0,28, $p = 0{,}001$) pós-tratamento.

Conclusão Apesar da melhora significativa da dor, capacidade, ADM do tronco e FIT com tratamento multimodal, houve uma fraca correlação entre dor pós-tratamento e função e ADM e FIT de tronco. A melhora da dor e da função com o tratamento de reabilitação física para DL é um fenômeno complexo e precisa de uma investigação mais aprofundada.

Palavras-chave
- coluna vertebral
- dor lombar
- tratamento multimodal
- flexibilidade

Introduction

Strengthening exercises are an important conservative treatment modality to improve pain and functional disability for low back pain (LBP). Exercise-based therapies such as stabilization or motor control exercises, resistance exercises, and multimodal exercise therapy have been reported to be effective in improving pain and disability in patients with LBP when compared to true control or therapist hands-on treatment.[1] Most studies in the literature which have investigated the effectiveness of exercise therapy for LBP have reported their results based on self-reported patient outcome variables such as the visual analogue scale (VAS), numerical pain rating scale (NPRS), or Oswestry disability index (ODI) scores.[1–3]

Pain and disability due to chronic LBP have been associated with weakness or deconditioning of lumbar and trunk musculature.[4–6] Objective measurement of trunk strength and mobility is one way of determining the effectiveness of trunk strengthening exercises in patients with LBP. Dynamometer-based devices have been frequently used to measure and demonstrate clinical improvement in strength and mobility of the trunk in patients treated with rehabilitation therapy for LBP.[7–10]

Steele et al.,[7] in a systematic review and secondary analysis of data from studies utilizing isolated lumbar extension exercise interventions for chronic LBP, reported that an increase in lumbar extension strength significantly correlated with improved pain and disability. However, improvement in clinical outcomes as measured by VAS or ODI scores after motor control exercises or general exercise therapy may not always correlate with improvement in trunk muscle strength or mobility.[7,11–13] Mannion et al.[13] reported no correlation between lateral abdominal muscle function improvement and good clinical outcome after 9 weeks of stabilization exercise therapy in 32 patients with chronic LBP. Furthermore, the literature is lacking in studies which have investigated change in trunk mobility and strength and their correlation with clinical outcomes in patients treated with multimodal rehabilitation therapy for LBP.

Therefore, this study aimed to investigate the effect of the multimodal rehabilitation therapy on pain, disability, trunk range of motion (ROM) and isometric strength (TIS), and to determine correlation between posttreatment trunk range of motion (ROM) and trunk isometric strength (TIS) and pain and disability in patients who underwent multimodal physical rehabilitation for LBP. We hypothesized that there will be a significant improvement in ROM and TIS after treatment, which would significantly correlate to improvement in pain and disability in patients with LBP.

Methods

Study Design

This prospective, observational, cohort study was done at an outpatient clinic specializing in spine rehabilitation from January 2019 to January 2020. All patients treated conservatively with a multimodal rehabilitation program for mechanical LBP were eligible for participation in the study. The study protocol was approved by the institutional review board and ethics committee. Written informed consent was taken from all patients undergoing evaluation and treatment regarding the use of their anonymous data for this study.

Patient Population

The inclusion criterion was patients who underwent multimodal rehabilitation treatment for mechanical LBP and were evaluated using a dynamometer-based measurement of trunk mobility and isometric strength before and at the end of their treatment. The exclusion criteria were patients who could not go through device-based mobility and isometric strength testing due to contra-indications (history of vertebral fractures or abdominal hernia or abdominal surgery done in past 3 months, patient age > 75 years, patients with respiratory or cardiac conditions, pregnancy), and patients who underwent < 6 or > 36 treatment sessions. Mechanical LBP was defined as a pain arising intrinsically from the spine, which worsens with specific spine movement, and often improves with rest.[14]

Isometric Trunk Muscle Strength (TIS) and ROM Testing Protocol

Isometric trunk muscle strength and ROM testing was performed on a dynamometer-based device (David® Spine Concept System, David®Health Solutions, Helsinki, Finlândia) using a previously described protocol.[15] This was performed immediately after the consultation when the patient's NPRS score was ≤ 3. In patients with NPRS score > 3, a pain management protocol (PMP) was used during the first week of treatment, and testing was performed once NPRS reduced to ≤ 3.

The testing equipment consisted of 4 separate devices (extension, sagittal flexion, rotation, and lateral flexion). Patients were tested in the seated position and fastened in place with a knee-lock and thigh-restraining belt to immobilize both hips and thighs, allowing only lower back and trunk movements. Both TIS and ROM were measured in a standard sequence with extension first followed by flexion, rotation, and lateral flexion.

The back extension TIS test was performed with the trunk locked in 30° flexion from the upright position, forward flexion test with the trunk locked in neutral position, and rotation and lateral flexion tests with the lower body laterally rotated or shifted 30° from the neutral in the transverse or coronal planes. As an initial warm-up, patients performed three slow, sub-maximum dynamic motions at low loads throughout full trunk ROM, and three isometric test contractions at sub-maximum loads. The trunk ROM was measured in degrees and the TIS as torque in Newton-meter (Nm) units. The best value obtained out of 3 attempts was noted by the therapist. Both strength and motion values were captured by an inbuilt software and stored in its server for each patient. The entire ROM and TIS evaluations were performed under the supervision of a spine physiotherapist trained and experienced in the protocol.

Treatment Protocol

Repeated movement testing was performed in all patients during the initial 2 sessions, to establish directional preference (DP) as per the Mechanical Diagnosis and Therapy (MDT) principles.[16]

All patients who presented with NPRS scores ≥ 3 were started on a PMP, which included a combination of patient education, frequency-specific microcurrent (FSM) application, repeated DP movements based on findings of the MDT assessment technique, and basic core activation exercises for the first week.

The multimodal rehabilitation program (MRP) primarily consisted of initial sessions of active manual strengthening and stabilization exercises, followed by sessions of isokinetic device-based training based on the results of the previously performed device-based TIS and ROM test. Patients performed a set of 35 repetitions with weights on each device. All patients performed 20 minutes of manual exercises followed by 20 minutes of device-based training as part of MRP in the clinic. They were also advised to perform DP based repeated movements 4 to 5 times a day, as well as manual strengthening and stabilization exercises at least twice a day as a home exercise program. Patients underwent a minimum of 6 supervised physiotherapy sessions at the clinic.

Study Outcome Measures

Demographic data including gender, age, body mass index (BMI), lifestyle (sedentary, semi-active, or active), clinical presentation (LBP only, LBP with leg pain, and leg pain only), number of treatment sessions, and total treatment duration were recorded in all patients. Pre- and posttreatment (at discharge) clinical outcome variables of pain intensity using the NPRS score and disability using the ODI score were recorded for all patients.[17,18] The minimal clinically important difference (MCID) between pre- and posttreatment NPRS and ODI scores (i.e., 2 points for NPRS score and 10 points for ODI score) was analyzed based on the recommendations of Ostelo et al.[19]

Furthermore, pre- and posttreatment ROM was recorded in degrees as maximum extension, flexion, right and left rotation, and right and left lateral flexion. The extension-flexion ROM ratio was calculated by dividing the maximum extension with the maximum flexion to determine the extension-flexion movement imbalance.

Pre- and posttreatment TIS was recorded as maximum torque in Nm for trunk sagittal extension, sagittal flexion, rotation, and lateral flexion. The extension-flexion strength ratio was calculated by dividing the maximum extension strength value with the maximum flexion strength value (Nm) to determine extension-flexion strength imbalance.

Statistical Analysis

Pre- and posttreatment (at discharge) NPRS and ODI scores were compared to determine improvement in pain and disability after treatment. Pre- and posttreatment trunk ROM and TIS variables were compared to determine improvement in trunk movement and strength after treatment. Categorical data were compared using the Fisher exact test and continuous data were compared using the Student t-test. Correlation between posttreatment NPRS and ODI scores and mean sagittal extension, mean sagittal extension improvement, mean sagittal flexion, mean flexion ROM improvement, extension-flexion ROM ratio, mean extension strength, mean extension strength improvement, mean flexion strength, mean flexion strength improvement, and extension-flexion strength ratio were determined using the Pearson correlation coefficient. A p-value of < 0.05 was considered significant. Statistical analysis was performed using the GraphPad QuickCalcs (GraphPad Software, San Diego, CA, USA) online statistical analysis tool.

Results

During the study period, 266 patients were treated at the clinic for mechanical LBP. However, 113 patients were excluded based on treatment duration (< 6 or > 36 sessions), and 31 patients were excluded because posttreatment testing was either contra-indicated or not done. Based on the inclusion and exclusion criteria, data from 122 patients were analyzed for this study. Demographic details and clinical presentation are summarized in ►**Table 1**.

After 22.5 mean treatment sessions done over a mean treatment duration of 75.6 days, the mean NPRS ($p < 0.0001$) and ODI ($p < 0.0001$) scores significantly improved when compared to pretreatment levels (►**Table 2**). The percentage of patients achieving MCID for NPRS and ODI scores were 100 and 99%, respectively (►**Table 2**). Similarly, the mean trunk sagittal extension ($p < 0.0001$), flexion ($p < 0.0001$), right and left rotation ($p < 0.0001$), and right and left lateral flexion ($p < 0.0001$) ROMs improved significantly after treatment (►**Table 3**). However, there was no significant change ($p = 0.31$) in the extension-flexion ROM ratio after treatment (►**Table 3**). The mean extension ($p < 0.0001$), flexion ($p < 0.0001$), rotation ($p < 0.0001$), and lateral flexion ($p < 0.0001$) TISs improved significantly after treatment (►**Table 3**). Similarly, the extension-flexion strength ratio improved significantly after treatment ($p = 0.04$) (►**Table 3**).

Regarding the posttreatment NPRS score, there was weak correlation with the mean sagittal extension ROM ($r = -0.24$, $p = 0.006$) and mean sagittal flexion strength ($r = -0.28$, $p = 0.001$) (►**Table 4**). No correlation was found between posttreatment NPRS score and other independent variables (►**Table 4**).

As for the posttreatment ODI score, there was weak correlation with the mean sagittal extension strength ($r = -0.30$, $p = 0.0007$) and mean sagittal flexion strength ($r = -0.28$, $p = 0.001$) (►**Table 4**). No correlation was found between posttreatment ODI score and other independent variables (►**Table 4**).

Discussion

In this study, the mean NPRS and ODI scores, and trunk ROM and TIS values significantly improved when compared to pretreatment levels at the end of mean treatment duration of 75.6 days. The extension-flexion strength ratio improved significantly after treatment, indicating improvement in pretreatment extension-flexion muscle strength imbalance. However, there was a poor or weak correlation between posttreatment trunk ROM and TIS and NPRS and ODI scores.

Table 1 Demographic details of subjects in the study population

Parameters	Values
n	122
Mean age (years)	45.6 ± 15.2 (42.8– 48.3)
Mean BMI (kg/m^2)	27.5 ± 4.5 (26.6–28.3)
Gender	
Males	68 (56%)
Females	54 (44%)
Lifestyle	
Active	13 (10.5%)
Semi-active	29 (24%)
Sedentary	80 (65.5%)
Clinical presentation	
LBP only	41 (33.5%)
LBP + Leg pain	76 (62.5%)
Leg pain only	5 (4%)
Mean treatment duration (days)	75.6 ± 36.2 (69.1–82)
Mean number of treatment sessions	22.5 ± 7 (21.2–23.7)

Abbreviations: BMI, body mass index; LBP, low back pain; n, number of patients.
Notes: All data presented as mean ± standard deviation (95% confidence interval) or percentages.

Table 2 Pre- and posttreatment clinical outcomes in the study population

Parameters	Pretreatment	Posttreatment
n	122	122
Mean NPRS score	7.1 ± 1.7 (6.7–7.4)	0.6 ± 1.1 (0.4–0.7)
Mean NPRS score improvement		91%
Mean ODI score	48.3 ± 14.2 (45.7–50.8)	9.3 ± 7.5 (7.9–10.6)
Achieved MCID (2) for NPRS score	–	122 (100%)
Achieved MCID (10) for ODI score	–	121 (99%)

Abbreviations: MCID, minimum clinically important difference; n, number of patients; NPRS, numerical pain rating scale score; ODI, Oswestry disability index.
Notes: All data presented as mean ± standard deviation (95% confidence interval) or percentages.

Table 3 Pre- and posttreatment trunk ROM and TIS in the study population

Parameters	Pretreatment	Posttreatment	*p*-value
n	122	122	–
Sagittal extension ROM (°)			
Mean sagittal extension ROM (°)	20.8 ± 6.4 (19.6–21.9)	24.2 ± 6 (23.1–25.2)	$<$**0.0001**
Mean sagittal extension ROM improvement (°)	–	3.3 ± 7.3 (1.9–4.6)	
Mean sagittal extension ROM improvement (%)	–	16	
Sagittal flexion ROM (°)			
Mean sagittal flexion ROM (°)	39.3 ± 7.2 (38–40.5)	43.1 ± 5.4 (42.1–44)	$<$**0.0001**
Mean sagittal flexion ROM improvement (°)	–	3.8 ± 6.4 (2.6–4.9)	
Mean sagittal flexion ROM improvement (%)	–	10	
Extension-flexion ROM ratio (%)	54.1 ± 19.9 (50.5–57.6)	56.4 ± 15.3 (53.6–59.1)	0.31
Right rotation ROM (°)			
Mean right rotation ROM (°)	36.3 ± 7.7 (34.9–37.6)	44.3 ± 8.4 (42.7–45.8)	$<$**0.0001**
Mean right rotation ROM improvement (°)	–	7.9 ± 8.3 (6.4–9.3)	
Mean right rotation ROM improvement (%)	–	22	
Left rotation ROM (°)			
Mean left rotation ROM (°)	33.8 ± 7.7 (32.4–35.1)	42.7 ± 7.7 (41.3–44)	$<$**0.0001**
Mean left rotation ROM improvement (°)	–	8.9 ± 8 (7.4–10.3)	
Mean left rotation ROM improvement (%)	–	26.5	
Right lateral flexion ROM (°)			
Mean right lateral flexion ROM (°)	35.8 ± 7.4 (34.4–37.1)	40.8 ± 6.8 (39.5–42)	$<$**0.0001**
Mean right lateral flexion ROM improvement (°)	–	4.9 ± 7.2 (3.6–6.1)	
Mean right lateral flexion ROM improvement (%)	–	13.5	
Left lateral flexion ROM (°)			
Mean left lateral flexion ROM (°)	35.4 ± 7.2 (34.1–36.6)	40.8 ± 6.2 (39.6–41.9)	$<$**0.0001**
Mean left lateral flexion ROM improvement (°)	–	5.3 ± 6.4 (4.1–6.4)	
Mean left lateral flexion ROM improvement (%)	–	15	
Extension TIS (Nm)			
Mean extension strength (Nm)	107.7 ± 45.9 (99.4–115.9)	161.7 ± 54.7 (151.8–171.5)	$<$**0.0001**
Mean extension TIS improvement (Nm)	–	54.0 ± 47.6 (45.4–62.5)	
Mean extension TIS improvement (%)	–	50	
Flexion TIS (Nm)			
Mean flexion TIS (Nm)	50 ± 23.6 (45.7–54.2)	80.6 ± 32.5 (74.7–86.4)	$<$**0.0001**
Mean flexion TIS improvement (Nm)	–	30.6 ± 28.9 (25.4–35.7)	
Mean flexion TIS improvement (%)	–	61	
Extension-flexion TIS ratio (%)	252 ± 145.3 (225.9–278)	219.8 ± 93.7 (203–236.5)	**0.04**
Right rotation TIS (Nm)			
Mean right rotation TIS (Nm)	39.8 ± 20.1 (36.1–43.4)	70.1 ± 28.1 (65–75.1)	$<$**0.0001**
Mean right rotation TIS improvement (Nm)	–	30.3 ± 20.4 (26.6–33.9)	
Mean right rotation TIS improvement (%)	–	76	
Left rotation TIS (Nm)			
Mean left rotation TIS (Nm)	36.1 ± 19.9 (32.5–39.6)	64.1 ± 26.7 (59.3–68.8)	$<$**0.0001**
Mean left rotation TIS improvement (Nm)	–	28 ± 20.7 (24.2–31.7)	
Mean left rotation TIS improvement (%)	–	77.5	

Table 3 (*Continued*)

Parameters	Pretreatment	Posttreatment	*p*-value
Right lateral flexion TIS (Nm)			
Mean right lateral flexion TIS (Nm)	46 ± 21.2 (42.2–49.8)	88.2 ± 34.9 (81.9–94.4)	<**0.0001**
Mean right lateral flexion TIS improvement (Nm)	–	42.1 ± 28.4 (37–47.1)	
Mean right lateral flexion TIS improvement (%)	–	91.5	
Left lateral flexion TIS (Nm)			
Mean left lateral flexion TIS (Nm)	49.4 ± 21.6 (45.5–53.2)	90.1 ± 34.9 (83.8–96.3)	<**0.0001**
Mean left lateral flexion TIS improvement (Nm)	–	40.6 ± 27.2 (35.7–45.4)	
Mean left lateral flexion TIS improvement (%)	–	82	

Abbreviations: n, number of patients; Nm, Newton-metre; ROM, range of motion; TIS, trunk isometric strength.
Notes: All data presented as mean ± standard deviation (95% confidence interval) or percentages. A *p*-value <0.05 was considered statistically significant (bold).

Table 4 Correlation between posttreatment numerical pain rating scale (NPRS) and Oswestry disability index (ODI) scores and trunk ROM and TIS in the study population

Parameters	For posttreatment NPRS score		For posttreatment ODI score	
	Correlation coefficient (r)	*p*-value	Correlation coefficient (r)	*p*-value
Mean sagittal extension ROM	**-0.24**	**0.006**	-0.14	0.12
Mean sagittal extension ROM improvement	-0.05	0.58	-0.11	0.20
Mean sagittal flexion ROM	-0.01	0.90	-0.04	0.65
Mean sagittal flexion ROM improvement	-0.08	0.38	-0.16	0.06
Extension-flexion ROM ratio	0.04	0.66	0.02	0.80
Mean sagittal extension TIS	-0.14	0.10	**-0.30**	**0.0007**
Mean sagittal extension TIS improvement	-0.12	0.16	-0.16	0.06
Mean sagittal flexion TIS	**-0.28**	**0.001**	**-0.28**	**0.001**
Mean sagittal flexion TIS improvement	-0.16	0.06	-0.08	0.37
Extension-Flexion TIS ratio	0.01	0.89	0.17	0.05

Abbreviations: ROM, range of motion; TIS, trunk isometric strength.
Notes: A *p*-value < 0.05 was considered statistically significant (bold).

Our findings were similar to the results of previous studies which investigated changes in trunk ROM and TIS measured using a dynamometer-based device after extensor strengthening and stabilization exercises.[7,10,20–22] Steele et al.,[7] in an analysis of pooled data from 6 studies involving 281 patients with chronic LBP treated with dynamic extensor strengthening exercises, reported a significant increase in lumbar extensor muscle strength. Similarly, previous studies which analyzed patients with LBP treated with a multidisciplinary rehabilitation modality have reported significant improvement in trunk muscle strength after treatment.[23–27] These include studies which have used a combination of various treatment modalities such as patient education, motor control, stabilization and strengthening exercises,[23] back school and device-based strengthening exercises,[24] device-based strengthening exercises with heat therapy,[25] biopsychosocial therapy with elastic band resistance exercises,[26] and behavioral education with manual therapy (mobilization and massage) and heat or electrotherapy to treat LBP.[27] The current study utilized a multimodal rehabilitation program with a combination of patient education, FSM therapy, MDT based repeated movements, and manual and device-based strengthening exercises.

Demoulin et al.,[24] in an analysis of 136 patients with chronic LBP, reported a mean trunk strength (trunk extensors, flexors, lateral flexors, and rotators) improvement of 40% after 36 sessions of multidisciplinary outpatient rehabilitation program, which included device-based strengthening exercises. Freiwald et al.,[25] in a randomized control trial of 176 patients with chronic LBP, reported a mean trunk strength (trunk extensors, flexors, lateral flexors, and rotators) improvement range of 35 to 65% (depending on absence or presence of supplemental heat therapy) after 12 weeks of multidisciplinary outpatient rehabilitation program, which included device based strengthening exercises. In contrast, the 122 patients in the current study achieved a mean trunk strength (trunk extensors, flexors, lateral flexors, and rotators) improvement of 73% after a mean of 22.5 sessions of the multimodal outpatient rehabilitation program. Similar to TIS, there was a significant mean trunk ROM (trunk extension, flexion, lateral flexion, and rotation) improvement of 17% in our patients after multimodal rehabilitation therapy. This was better than the mean trunk ROM improvement of 8% reported by Demoulin et al.[24] The higher percentage of mean TIS and ROM improvement in the current study, compared to previous studies, could be due to better pain control using MDT-based repeated movements and FSM therapy, along with manual and device-based strengthening exercises. Prioritizing management and reduction of pain helped initiate intensive strengthening exercises early in the course of treatment and probably helped improve patient function and achieve significant improvement in TIS in the majority of our patients (►**Table 3**).

In the current study, there was a weak correlation between posttreatment NPRS score and extension ROM and sagittal flexion strength, as well as a weak correlation between posttreatment ODI score and sagittal extension and flexion strength. This finding was similar to the results of Steele et al.,[7] who reported weak to moderate correlation between posttreatment VAS and ODI scores, and lumbar extension strength in patients who underwent extensor strengthening for chronic LBP. Although trunk muscle strength has been associated with the functional ability,[28] improvement in pain and disability following rehabilitation treatment for LBP is a complex phenomenon and involves mechanical, neurocognitive, and psychosocial factors.[29,30] This could explain the lack of a strong correlation between improvement in TIS and trunk ROM and significant improvement in clinical outcomes in the current study.

To the best of our knowledge, this is the first study in the literature which investigated the effect of a multimodal rehabilitation treatment, which included MDT-based repeated movement and manual and device-based strengthening and stabilization exercises on trunk ROM and isometric muscle strength, in patients with LBP. However, there are a few limitations to this study. First, since all patients were prescribed a multimodal rehabilitation therapy, positive beliefs in the effects of this treatment may have added a selection bias to the study. Second, our study did not incorporate any long-term follow-up, and TIS and trunk ROM results in the long term after multimodal rehabilitation is unknown. Third, structural and functional changes in specific trunk and paravertebral muscles such as lumbar multifidus or erector spinae were not performed. However, such morphological and functional changes in trunk muscles following muscle strengthening have already been reported in previous studies.[28,31,32]

Conclusion

Multimodal rehabilitation treatment helped significantly improve trunk ROM and TIS along with pain and disability in patients with LBP. There was significant but weak correlation between improvement in pain and extensor ROM and flexion strength; as well as between disability and extension and flexion strength after multimodal rehabilitation. Improvement in pain and function with physical rehabilitation treatment for LBP is a complex phenomenon and needs further investigation.

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Conflict of Interests
The authors have no conflict of interests to declare.

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