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The Impact of Lumbar Stabilization and Thoracic Mobilization Exercises on Pain, Disability and Quality of Life in Individuals with Chronic Low Back Pain

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The aim of this study was to evaluate the effectiveness of adding thoracic mobilization to lumbar stabilization exercises in the treatment of chronic low back pain (CLBP). Fifty-four patients with chronic low back pain were randomly assigned to two groups: The Lumbar Stabilization (LS) group and the Lumbar Stabilization plus Thoracic Mobilization (LS+TM) group. Pain intensity, functional disability, and quality of life were assessed using the Visual Analog Scale (VAS), the Quebec Low Back Pain Disability Scale (QLBPD), and the EuroQOL-5D-3L, respectively. Both groups participated in a six-week intervention program with three sessions per week. Significant improvements in pain intensity, functional disability, and quality of life were observed in both groups ($p < 0.05$). However, post-intervention analysis showed that the LS+TM group had higher effect sizes for functional disability ($\eta^2=0.768$) and quality of life ($\eta^2=0.731$) compared to the LS group ($p < 0.05$). Although both exercises were effective in managing chronic low back pain, the addition of thoracic mobilization to lumbar stabilization exercises provided greater benefits in terms of functional recovery and overall well-being.
Keywords: Low back pain, exercise, disability evaluation, life quality

Kronik Bel Ağrısı Olan Bireylerde Lomber Stabilizasyon ve Torasik Mobilizasyon Egzersizlerinin Ağrı, Engellilik ve Yaşam Kalitesi Üzerindeki Etkisi

ÖZ

Bu çalışmanın amacı, kronik bel ağrısı (KBA) tedavisinde lomber stabilizasyon egzersizlerine ek olarak torasik mobilizasyon uygulamasının etkinliğini değerlendirmektir. Elli dört kronik bel ağrısı hastası, Lomber Stabilizasyon (LS) grubu ve Lomber Stabilizasyona ek Torasik Mobilizasyon (LS+TM) grubu olmak üzere iki gruba rastgele atanmıştır. Ağrı şiddeti, fonksiyonel disabilite ve yaşam kalitesi sırasıyla Görsel Analog Skalası (GAS), Quebec Bel Ağrısı Disabilite Skalası (QLPSD) ve EuroQOL-5D-3L ile değerlendirilmiştir. Her iki grup da haftada üç seans olmak üzere altı haftalık bir müdahale programına katılmıştır. Her iki grupta da ağrı şiddeti, fonksiyonel disabilite ve yaşam kalitesinde anlamlı iyileşmeler gözlemlenmiştir ($p < 0,05$). Ancak, müdahale sonrası analizlerde LS+TM grubunun, LS grubuna kıyasla fonksiyonel disabilitede ($\eta2=0.768$) ve yaşam kalitesinde ($\eta2=0.731$) etki büyüklüğü yüksekti ($p < 0,05$). Her iki egzersiz de kronik bel ağrısının yönetiminde etkili olsa da, torasik mobilizasyonun lomber stabilizasyon egzersizlerine eklenmesi, fonksiyonel iyileşme ve genel iyilik hali üzerinde daha önemli faydalar sağlamıştır.

Anahtar Kelimeler: Bel ağrısı, egzersiz, disabilite değerlendirme, yaşam kalitesi

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1 Introduction

Chronic low back pain (CLBP) is a prevalent condition characterized by low back pain lasting longer than 12 weeks, where motor dysfunctions of the lumbosacral spinal stabilizers play a significant role (Loeser & Treede, 2008; Treede et al., 2008). The kinetic chain model is a biomechanical framework that facilitates the performance of desired activities in distal segments of the body, where any segmental dysfunction adversely affects the movement quality of other segments (Ben Kibler & Sciascia, 2004; Burkhart et al., 2003). To ensure quality movement, lumbar-pelvic stability and dynamic stabilization of the thoracic and cervical regions are essential (Michaelson et al., 2003; Moseley, 2004). Segmental dysfunctions can impair kinesthetic perception, coordination, and postural control.

Proper body stabilization should be adapted to the pelvis, vertebrae, and other segments of the kinetic chain. When this system functions efficiently, loads on the body are evenly distributed, and excessive stress on the joints is prevented (Kibler et al., 2006). Lumbar stabilization forms the basis for trunk dynamic control that facilitates the production, transfer, and control of force and movement in distal parts of the kinetic chain (Kibler et al., 2006). The spinal stabilization system comprises the passive musculoskeletal system, the active musculoskeletal system, and the neural control system. Weakness in the core region affects normal kinematics and neuromuscular control (Kweon et al., 2013). Spinal stabilization involves not only muscle strength but also the central nervous system (Akuthota et al., 2008). In stabilization exercises, patients focus on maintaining the neutral position of the trunk. Recent studies emphasize the importance of activating thoracic spinal muscles to support complete functional recovery (Kibler et al., 2006; Yilmaz Yelvar et al., 2016).

The literature has demonstrated that thoracic mobilization can effectively aid in the stabilization of the lumbar spine (Kibler et al., 2006). Various studies have shown that the "cat-cow" exercise, based on lumbar stabilization and thoracic mobilization in closed kinetic chain group exercises, is effective in reducing low back pain (Leetun et al., 2004; Yilmaz Yelvar et al., 2016). The importance of stabilization exercises in reducing intradiscal pressure and protecting surrounding structures is emphasized (Leetun et al., 2004; Panjabi, 1992). Thus, incorporating such exercises into the rehabilitation programs of patients with CLBP is crucial.

Exercise is considered an effective approach in the treatment of low back pain (Akuthota et al., 2008; Atlas & Nardin, 2003; Turk & Okifuji, 2002). However, the question of which type of exercise is the most effective remains unresolved. There is limited evidence on whether thoracic mobilization exercises, in addition to lumbar stabilization exercises, are more effective than lumbar stabilization exercises alone for patients with chronic low back pain. This study aims to investigate whether a thoracic mobilization exercise program, when added to lumbar stabilization, is more effective than a lumbar stabilization exercise program alone in reducing pain and functional impairment and improving quality of life in patients with CLBP. Our hypothesis is that a thoracic mobilization exercise program, in addition to lumbar stabilization, will be more effective in reducing pain and functional impairment and in enhancing quality of life in patients with chronic low back pain.

2 Methodology

2.1 Ethical Considerations

This study received approval from the Istanbul Okan University Faculty of Science, Social Sciences, and Non-Invasive Health Sciences Research Ethics Committee on April 27, 2022 (Protocol No. 154). All participants were informed in detail about the study's objectives, procedures, and potential risks. Written informed consent was obtained from each participant before their inclusion in the study.

2.2 Sample Size Calculation

Sample size was determined using G*Power software. Based on prior research on chronic low back pain, a minimum of 54 participants (27 per group) was required to achieve a statistical power of 80.3% with a significance level of 0.05 (Kostadinović et al., 2020).

2.3 Groups and Randomization

Participants were randomly assigned to one of two groups using a sealed envelope method. Those selecting a red envelope were assigned to the Lumbar Stabilization (LS) group (n=27), while those selecting a blue envelope were assigned to the Lumbar Stabilization + Thoracic Mobilization (LS+TM) group (n=27). A blinded researcher conducted baseline and post-intervention assessments for all participants. Both groups underwent a 6-week intervention consisting of three 45-minute sessions per week.

2.4 Participants

The study included 54 individuals diagnosed with chronic low back pain who sought treatment at the Physical Therapy and Rehabilitation Department of Medical Park Pendik Hospital.

Inclusion Criteria: Participants were aged between 25 and 64 years and of both genders, with chronic low back pain persisting for a minimum of 12 weeks.

Exclusion Criteria: Excluded were individuals with Cauda Equina syndrome, ankylosing spondylitis, chest deformities (e.g., pectus carinatum, excavatum), spina bifida, rheumatoid arthritis, spondylolisthesis, spondylolysis, fractures, or post-surgical spinal conditions. Additionally, those with diabetes, spinal inflammation, tumors, or pregnancy were ineligible.

2.5 Assessment

Participants completed a sociodemographic form to gather relevant background information. Pain intensity was assessed using the Visual Analog Scale (VAS), while functional status was evaluated with the Quebec Back Pain Disability Scale (QBPDS). Quality of life was measured using the EuroQOL-5D-3L questionnaire.

Visual Analog Scale (VAS): The VAS, a common tool for subjective pain assessment, consists of a 10-centimeter horizontal line, where "0" indicates no pain and "10" represents the worst imaginable pain (Clark et al., 2003). Participants marked a point on the line corresponding to their current pain level.

Quebec Back Pain Disability Scale (QBPDS): The QBPDS assesses functional status by measuring the difficulty of performing specific activities related to low back pain (Speksnijder et al., 2016) . Participants rated their difficulty on a 0-5 scale, with 0 indicating no difficulty and 5 indicating an inability to perform the activity. A higher total score reflects greater functional limitations. The Turkish version of the QBPDS has demonstrated adequate validity and reliability for use in this population (Melikoglu et al., 2009).

EuroQOL-5D-3L: The EuroQOL-5D-3L evaluates quality of life across five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension is rated on a 3-level Likert scale, and a visual analog scale compares the respondent's current health state to the best and worst imaginable states. The Turkish version of the EQ-5D-3L has been validated and normed, with the York method used to calculate and interpret the EQ-5D index score (Kaya, n.d.).

2.6 Treatment Program

Lumbar Stabilization Exercises: The lumbar stabilization exercises were designed to target the pelvic ring muscles to develop a neutral lumbar spine. The co-contraction of the Transversus Abdominis and Multifidus muscles formed the foundation of the exercises. These exercises were organized into five main positions: supine, hook-lying, quadruped, prone, sitting, and standing, with basic posture training provided for each.

In basic posture training, each patient's "neutral spine" position was determined, which meant positioning the pelvis in a midline alignment without anterior or posterior pelvic tilt. The exercise program began with stretching exercises of 10 repetitions, followed by 30 repetitions of neutral spine exercises. The program ended with another set of 10 repetitions of stretching exercises. Throughout all exercises, maintaining a neutral spine position was prioritized. In the following weeks, to increase difficulty, movements were modified by moving the extremities away from the trunk.

Thoracic Mobilization Exercises: The selected exercises included scapular upward rotation, scapular elevation, the cat-camel exercise, and wall slides. Participants were given clear instructions for each exercise, with a focus on proper breathing techniques. Visual aids were provided to demonstrate correct positions and muscle activation.

Wall Slides: This exercise aimed to improve thoracic flexion and extension by activating the rhomboids, erector spinae, multifidus, and transversus abdominis muscles. Participants stood facing a wall with their hands flat, shoulders adducted, and elbows extended. They performed controlled thoracic spine flexion and extension while maintaining a neutral pelvis. This exercise was repeated 10 times.

Cat-Camel Exercise: Designed to enhance thoracic flexion and extension while activating the trapezius, levator scapula, rhomboids, erector spinae, multifidus, and transversus abdominis muscles. Participants started in a quadruped position, alternating between arching (cat position) and rounding (camel position) their backs, with a focus on thoracic spine movement. The exercise was performed in 10 repetitions.

Scapular Elevation: This exercise isolated scapular movement. Participants either sat or stood upright, shrugged their shoulders upward, and held the position for 5 seconds.

Scapular Upward Rotation: This exercise isolated scapular movement. Participants started with their arms at their sides, bent at a 90-degree angle. They then reached forward and upward with their arms, maintaining slight external rotation, held the top position for 5 seconds, and returned to the starting position.

3 Results

The study was conducted with a total of 54 participants, comprising 27 in the Lumbar Stabilization (LS) group and 27 in the Lumbar Stabilization + Thoracic Mobilization (LS+TM) group. The number of males was 14 (51.9%) in the LS group and 12 (44.4%) in the LSTM group. The median age of participants was 34 years in the LS group and 35 years in the LSTM group. The demographic characteristics of the participants were similarly distributed between the two groups (p>0.05, Table 1).

Table 1: *Baseline Features of Participants*

	Groups		
	LS *n*=27	LS+TM *n*=27	Test (*p*)
Gender. *n* (*%*)			
Male	14 (%51.9)	12 (%44.4)	χ^2=0.297 *p*=0.586
Female	13 (%48.1)	15 (%55.6)	
Age, y			
X ± *SS*	35.56 ± 7.55	37.81 ± 8.49	*t*=-1.033 *p*=0.306
M (*min-max*)	34 (26-56)	35 (25-60)	

Independent Samples t-Test (t); Chi-Square Test (χ^2); Descriptive statistics are given as mean (X), standard deviation (SD), median (M), minimum (min), maximum (max), number (n), percentage (%).

Comparisons of Visuel Analog Scale (VAS) measurements at follow-up times did not show a statistically significant difference between the groups (p>0.05). Both the LS and LSTM groups showed a significant decrease in VAS scores compared to pre-test levels (p<0.05). This indicates that both exercise programs led to significant improvements in VAS values (Table 2).

Table 2: *Pain Intensity Changes by Groups*

	Groups		Test Statistics †
	LS *n*=27	LS+TM *n*=27	
VAS			
Before Treatment	5.67 ± 1.21	5.11 ± 1.48	F=2.289 p=0.136 η^2=0.042
After Treatment	2.07 ± 2.00	1.37 ± 1.52	F=2.118 p=0.152 η^2=0.039
Test Statistics ϕ	**F=89.840 p<0.001 η^2=0.633**	**F=97.402 p<0.001 η^2=0.652**	
Statistical Model	**Group Effect:** F=3.524 p=0.066 η^2=0.063 **Time Effect:** F=187.166 p<0.001 η^2=0.783 **Group x Time Interaction Effect:** F=0.076 p=0.783 η^2=0.001		

Mixed Design ANOVA (F). Effect Size (η²). ϕ Within-group comparison. † Between-group comparison. Descriptive statistics are given as mean (X) and standard deviation (SD). The sections highlighted in bold are statistically significant (p<0.05).

Comparisons of disability scores related to low back pain at follow-up times revealed no significant difference between the groups at the pre-test measurement (p>0.05). However, at the post-test measurement, the average disability score for the experimental group was significantly higher than that of the control group (p<0.05). Both the LS and LSTM groups showed a significant reduction in low back pain disability scores compared to pre-test levels (p<0.05). These findings suggest that both exercise programs resulted in a significant improvement in low back pain disability scores (Table 3).

Table 3: *Comparison of Low Back Pain Disability Scores by Groups at Follow-up Times*

	Groups		Test Statistics †
	LS *n*=27	LS+TM *n*=27	
Low Back Pain Disability			
Before Treatment	56.00 ± 14.29	51.74 ± 15.62	F=1.092 p=0.301 η^2=0.021
After Treatment	17.41 ± 7.64	8.52 ± 12.85	**F=9.548 p=0.003 η^2=0.155**
Test Statistics ϕ	**F=137.507 p<0.001 η^2=0.726**	**F=172.478 p<0.001 η^2=0.768**	
Statistical Model	**Group Effect:** F=6.152 p=0.016 η^2=0.106 **Time Effect:** F=308.996 p<0.001 η^2=0.856 **Group x Time Interaction Effect:** F=0.989 p=0.324 η^2=0.019		

Mixed Design ANOVA (F). Effect Size (η²). ϕ Within-group comparison. † Between-group comparison. Descriptive statistics are given as mean (X) and standard deviation (SD). The sections highlighted in bold are statistically significant (p<0.05)

Quality of life scores were also assessed in a similar manner at follow-up times. No significant difference was observed between the groups at the pre-test measurement (p>0.05). At the post-test measurement, the average quality of life score in the experimental group was significantly higher than that in the control group (p<0.05). Both the LS and LSTM groups showed a significant decrease in quality of life scores compared to pre-test levels (p<0.05). However, the LSTM group exhibited a greater effect size in terms of functionality (Table 4).

Table 4: *Comparison of Quality of Life Scores by Groups at Follow-up Times*

	Groups		Test Statistics †
	LS *n*=27	LS+TM *n*=27	
Quality of Life Scores			
Before Treatmen	44.81 ± 11.56	41.67 ± 13.52	F=0.846 p=0.362 η^2=0.016
After Treatment	17.41 ± 8.13	13.33 ± 6.20	**F=4.286 p=0.043 η^2=0.076**
Test Statistics ϕ	**F=132.35 p<0.001 η^2=0.718**	**F=141.444 p<0.001 η^2=0.731**	
Statistical Model	**Group Effect:** F=2.631 p=0.111 η^2=0.048 **Time Effect:** F=273.719 p<0.001 η^2=0.84 **Group x Time Interaction Effect:** F=0.076 p=0.785 η^2=0.001		

Mixed Design ANOVA (F). Effect Size (η²). ϕ Within-group comparison. † Between-group comparison. Descriptive statistics are given as mean (X) and standard deviation (SD). The sections highlighted in bold are statistically significant (p<0.05).

4 Discussion

The results of this study, which investigated the effects of lumbar stabilization exercises and thoracic mobilization exercises in addition to lumbar stabilization exercises on pain and functionality in patients with chronic low back pain, indicated that both exercise programs had similar effects on pain, functional disability, and quality of life. However, it was observed that thoracic mobilization exercises in addition to lumbar stabilization exercises were slightly more effective on disability and quality of life compared to lumbar stabilization exercises alone.

Lumbar stabilization exercises are frequently used as a treatment method to reduce pain and promote functional recovery in individuals with low back pain. This approach is considered an effective physiotherapy strategy in the management of low back pain (Shamsi et al., 2015). However, there is a lack of consistent results in the current literature regarding the long-term effects of lumbar stabilization exercises compared to other treatment methods. This study showed that pain reduction was observed with both methods after a 6-week treatment period, with no significant difference between the groups (Chang et al., 2015; Niederer & Mueller, 2020; Wang et al., 2012). These findings suggest that stabilization exercises are effective in the short term but may yield different results in the long term.

A recent systematic review indicated that stabilization exercises are more effective than general exercises. Five studies demonstrated significant improvements in functional disability levels in patients undergoing stabilization exercises compared to those undergoing general exercises. In our study, both the Lumbar Stabilization Exercise Program (LSE) and the Lumbar Stabilization + Thoracic Mobilization Exercise Program (LS+TME) appeared effective in reducing pain and improving disability. However, since we did not include a group undergoing a general exercise program, such a comparison could not be made. Future research could evaluate the effects of traditional exercise therapies in addition to stabilization and mobilization (Gomes-Neto et al., 2017).

Some authors argue that stabilization therapy is not significantly better than traditional treatments. They suggest that the perceived effectiveness of stabilization therapy might be related to characteristics such as segmental instability of the spine or the size of the multifidus muscles in patients with low back pain. Our study did not include the diagnosis of other spinal disorders, resulting in a more homogeneous study group (Koumantakis et al., 2005). This homogeneity might have increased the reliability of the findings.

Studies have shown that stabilization exercises alone, as well as in combination with Transcutaneous Electrical Nerve Stimulation (TENS) and massage, are effective in increasing the thickness of the lumbar multifidus muscle in patients with non-specific chronic low back pain (Akodu et al., 2014). These findings suggest that lumbar stabilization exercises may also affect muscle structure in addition to pain and functional disability. However, our study focused solely on pain, functional disability, and quality of life, without assessing multifidus muscle thickness and strength. Therefore, additional information on the effects of other parameters such as the multifidus muscle was not provided.

Some studies have reported that adding Lumbar Stabilization Exercises (LSE) to conventional physical therapy programs does not provide additional benefits for balance, pain, and disability (Barut et al., 2023). Researchers have suggested that LSE may not be suitable for every patient and might be more effective when used in conjunction with other treatments. The fact that our study only involved exercise therapy and did not include other treatment methods might have contributed to different results. For example, longer duration studies evaluating the effects of lumbar stabilization exercises could provide more comprehensive results.

Another study examined the effects of lumbar stabilization exercises combined with thoracic mobilization exercises on low back pain and functionality. It was observed that thoracic mobilization exercises promoted functional recovery and improved quality of life in individuals with low back pain (Divya et al., 2020; Heo et al., 2015). In our study, the LS+TM group showed more significant improvements in functional disability and quality of life after treatment. It is suggested that this improvement may be attributed to the added thoracic mobilization exercises.

This study has several limitations. Muscle strength and spinal mobility of the participants were assessed using subjective measurement methods before and after treatment. Therefore, the relationship between the results and changes in these values was not sufficiently clear. Due to the high cost of body muscle strength measurement devices and spinal mobility assessment devices, they were not used in this study. Future studies with larger sample sizes may provide more reliable and generalizable results.

5 Conclusions

In conclusion, lumbar stabilization exercises and thoracic mobilization exercises are effective methods for reducing the severity of low back pain, improving functional status, and enhancing quality of life. However, further research is needed to explore how these findings can be applied in clinical practice and to determine their long-term effects. Factors such as the characteristics of the participants, the content, and duration of exercise programs need to be considered.

6 Declarations

6.1 Acknowledgement

Thank you for agreeing to participate in our study.

6.2 Funding Source

No funding to declare.

6.3 Competing Interests

No potential conflict of interest relevant to this article was reported.

6.4 Authors' Contributions

Onur Atakan Doğan: Conceptualization, data curation, funding acquisition, resources,

Emine Atıcı: Conceptualization, formal analysis, funding acquisition, investigation, methodology, project administration, softwarw, supervision, visualization, writing original draft, writing review&editing

Özgür Sürenkök: Formal analysis, resources, softwarw, supervision, validation, visualization, writing original draft, writing review&editing

7 Human and Animal Related Study

7.1 Ethical Approval

This study received approval from the Istanbul Okan University Faculty of Science, Social Sciences, and Non-Invasive Health Sciences Research Ethics Committee on April 27, 2022 (Protocol No. 154).

7.2 Informed Consent

Written informed consent was obtained from the individuals participating in the study.

References

Akodu, A., Akinbo, S., & Odebiyi, D. (2014). Effect of Stabilization Exercise on Lumbar Multifidus Muscle Thickness in Patients with Non-specific Chronic Low Back Pain. *Iranian Rehabilitation Journal*, *12*(2), 6–10.

Akuthota, V., Ferreiro, A., Moore, T., & Fredericson, M. (2008). Core stability exercise principles. *Current Sports Medicine Reports*, *7*(1), 39–44. https://doi.org/10.1097/01.CSMR.0000308663.13278.69

Atlas, S. J., & Nardin, R. A. (2003). Evaluation and treatment of low back pain: An evidence-based approach to clinical care. *Muscle & Nerve*, *27*(3), 265–284. https://doi.org/10.1002/mus.10311

Barut, K., Taştaban, E., & Şendur, Ö. (2023). The Effect of Lumbar Stabilization Exercises on Chronic Low Back Pain Patients. *Sdü Tıp Fakültesi Dergisi*, *30*(4), 610–618. Https://Doi.Org/10.17343/sdutfd.1309984

Ben Kibler, W., & Sciascia, A. (2004). Kinetic chain contributions to elbow function and dysfunction in sports. *Clinics in Sports Medicine*, *23*(4), 545–552, viii. https://doi.org/10.1016/j.csm.2004.04.010

Burkhart, S. S., Morgan, C. D., & Kibler, W. B. (2003). The disabled throwing shoulder: Spectrum of pathology Part III: The SICK scapula, scapular dyskinesis, the kinetic chain, and rehabilitation.*Arthroscopy: The Journal of Arthroscopic & Related Surgery: Official Publication of the Arthroscopy Association of North America and the International Arthroscopy Association*, *19*(6), 641–661. https://doi.org/10.1016/s0749-8063(03)00389-x

Chang, W.-D., Lin, H.-Y., & Lai, P.-T. (2015). Core strength training for patients with chronic low back pain. *Journal of Physical Therapy Science*, *27*(3), 619–622. https://doi.org/10.1589/jpts.27.619

Clark, P., Lavielle, P., & Martínez, H. (2003). Learning from pain scales: Patient perspective. *The Journal of Rheumatology*, *30*(7), 1584–1588.

Divya, null, Parveen, A., Nuhmani, S., Ejaz Hussain, M., & Hussain Khan, M. (2020). Effect of lumbar stabilization exercises and thoracic mobilization with strengthening exercises on pain level, thoracic kyphosis, and functional disability in chronic low back pain. *Journal of Complementary & Integrative Medicine*, *18*(2), 419–424. https://doi.org/10.1515/jcim-2019-0327

Gomes-Neto, M., Lopes, J. M., Conceição, C. S., Araujo, A., Brasileiro, A., Sousa, C., Carvalho, V. O., & Arcanjo, F. L. (2017). Stabilization exercise compared to general exercises or manual therapy for the management of low back pain: A systematic review and meta-analysis. *Physical Therapy in Sport: Official Journal of the Association of Chartered Physiotherapists in Sports Medicine*, *23*, 136–142. https://doi.org/10.1016/j.ptsp.2016.08.004

Heo, M.-Y., Kim, K., Hur, B.-Y., & Nam, C.-W. (2015). The effect of lumbar stabilization exercises and thoracic mobilization and exercises on chronic low back pain patients. *Journal of Physical Therapy Science*, *27*(12), 3843–3846. https://doi.org/10.1589/jpts.27.3843

Kaya, N. (n.d.). *Larinjektomili Bireylerin Sağlığa ilişkin Yaşam Kalitesini Değerlendirmede EuroQol Ölçeğinin Güvenirlik ve Geçerliği (*)*.

Kibler, W. B., Press, J., & Sciascia, A. (2006). The role of core stability in athletic function. *Sports Medicine (Auckland, N.Z.)*, *36*(3), 189–198. https://doi.org/10.2165/00007256-200636030-00001

Kostadinović, S., Milovanović, N., Jovanović, J., & Tomašević-Todorović, S. (2020). Efficacy of the lumbar stabilization and thoracic mobilization exercise program on pain intensity and functional disability reduction in chronic low back pain patients with lumbar radiculopathy: A randomized controlled trial. *Journal of Back and Musculoskeletal Rehabilitation*, *33*(6), 897–907. https://doi.org/10.3233/BMR-201843

Koumantakis, G. A., Watson, P. J., & Oldham, J. A. (2005). Trunk muscle stabilization training plus general exercise versus general exercise only: Randomized controlled trial of patients with recurrent low back pain. *Physical Therapy*, *85*(3), 209–225.

Kweon, M., Hong, S., Jang, G. U., Ko, Y. M., & Park, J. W. (2013). The Neural Control of Spinal Stability Muscles during Different Respiratory Patterns. *Journal of Physical Therapy Science*, *25*(11), 1421–1424. https://doi.org/10.1589/jpts.25.1421

Leetun, D. T., Ireland, M. L., Willson, J. D., Ballantyne, B. T., & Davis, I. M. (2004). Core stability measures as risk factors for lower extremity injury in athletes. *Medicine and Science in Sports and Exercise*, *36*(6), 926–934. https://doi.org/10.1249/01.mss.0000128145.75199.c3

Loeser, J. D., & Treede, R.-D. (2008). The Kyoto protocol of IASP Basic Pain Terminology. *Pain*, *137*(3), 473–477. https://doi.org/10.1016/j.pain.2008.04.025

Melikoglu, M. A., Kocabas, H., Sezer, I., Bilgilisoy, M., & Tuncer, T. (2009). Validation of the Turkish version of the Quebec back pain disability scale for patients with low back pain. *Spine*, *34*(6), E219-224. https://doi.org/10.1097/BRS.0b013e3181971e2d

Michaelson, P., Michaelson, M., Jaric, S., Latash, M. L., Sjölander, P., & Djupsjöbacka, M. (2003). Vertical posture and head stability in patients with chronic neck pain. *Journal of Rehabilitation Medicine*, *35*(5), 229–235. https://doi.org/10.1080/16501970306093

Moseley, G. L. (2004). Impaired trunk muscle function in sub-acute neck pain: Etiologic in the subsequent development of low back pain? *Manual Therapy*, *9*(3), 157–163. https://doi.org/10.1016/j.math.2004.03.002

Niederer, D., & Mueller, J. (2020). Sustainability effects of motor control stabilisation exercises on pain and function in chronic nonspecific low back pain patients: A systematic review with meta-analysis and meta-regression. *PloS One*, *15*(1), e0227423. https://doi.org/10.1371/journal.pone.0227423

Panjabi, M. M. (1992). The stabilizing system of the spine. Part II. Neutral zone and instability hypothesis. *Journal of Spinal Disorders*, *5*(4), 390–396; discussion 397. https://doi.org/10.1097/00002517-199212000-00002

Shamsi, M. B., Sarrafzadeh, J., & Jamshidi, A. (2015). Comparing core stability and traditional trunk exercise on chronic low back pain patients using three functional lumbopelvic stability tests. *Physiotherapy Theory and Practice*, *31*(2), 89–98. https://doi.org/10.3109/09593985.2014.959144

Speksnijder, C. M., Koppenaal, T., Knottnerus, J. A., Spigt, M., Staal, J. B., & Terwee, C. B. (2016). Measurement Properties of the Quebec Back Pain Disability Scale in Patients With Nonspecific Low Back Pain: Systematic Review. *Physical Therapy*, *96*(11), 1816–1831. https://doi.org/10.2522/ptj.20140478

Treede, R.-D., Jensen, T. S., Campbell, J. N., Cruccu, G., Dostrovsky, J. O., Griffin, J. W., Hansson, P., Hughes, R., Nurmikko, T., & Serra, J. (2008). Neuropathic pain: Redefinition and a grading system for clinical and research purposes. *Neurology*, *70*(18), 1630–1635. https://doi.org/10.1212/01.wnl.0000282763.29778.59

Turk, D. C., & Okifuji, A. (2002). Psychological factors in chronic pain: Evolution and revolution. *Journal of Consulting and Clinical Psychology*, *70*(3), 678–690. https://doi.org/10.1037//0022-006x.70.3.678

Wang, X.-Q., Zheng, J.-J., Yu, Z.-W., Bi, X., Lou, S.-J., Liu, J., Cai, B., Hua, Y.-H., Wu, M., Wei, M.-L., Shen, H.-M., Chen, Y., Pan, Y.-J., Xu, G.-H., & Chen, P.-J. (2012). A meta-analysis of core stability exercise versus general exercise for chronic low back pain. *PloS One*, *7*(12), e52082. https://doi.org/10.1371/journal.pone.0052082

Yilmaz Yelvar, G. D., Çirak, Y., Dalkilinç, M., Demir, Y. P., Baltaci, G., Kömürcü, M., & Yelvar, G. D. Y. (2016). Impairments of postural stability, core endurance, fall index and functional mobility skills in patients with patello femoral pain syndrome. *Journal of Back and Musculoskeletal Rehabilitation*. https://doi.org/10.3233/BMR-160729