Available Online at www.e-iph.co.uk
Indexed in Clarivate Analytics WoS, and ScienceOPEN

E-B Environment - Behaviour Proceedings Journal

AcE-Bs2024Langkawi

https://www.amerabra.org

e-IPH e-International Publishing House Ltd., United Kingdom

12th ASIAN Conference on Environment-Behaviour Studies,
Holiday Villa Beach Resort & Spa, Langkawi Island, Malaysia, 01-03 Mar 2024

Effects of Core Stability Exercise on Functional Performance among Adults with Low Back Pain

Lin Pipeng[1,4*], Zarina Zahari [1,2], Azliyana Azizan[1,3], Yang Yajun[4]
** Corresponding Author*

[1] Centre of Physiotherapy, Faculty of Health Sciences, Universiti Teknologi MARA, Puncak Alam, 42300 Selangor, Malaysia.
[2] Advanced Rehabilitation Engineering in Diagnostic and Monitoring Research Group(AREDiM), Electrical Engineering Studies, College of Engineering, Universiti Teknologi MARA, Cawangan Pulau Pinang, Permatang Pauh Campus, 13500 Permatang Pauh, Penang, Malaysia.
[3] Clinical and Rehabilitation Exercise Research Group, Faculty of Health Sciences, Universiti Teknologi MARA, Puncak Alam, 42300 Selangor, Malaysia.
[4] Sports Rehabilitation Department, Faculty of Physical Education, Minzu Normal University of Xingyi, Xingyi City, 562400 Guizhou Province, China.

chndoctor2022@gmail.com ; zarinazahari@uitm.edu.my; azliyana9338@uitm.edu.my; 814208445@qq.com
Tel: 0176418719

Abstract
The influence of Core Stability Exercise (CSE) on functional performance in adults with Chronic Low Back Pain (CLBP) is a debated topic. This study aimed to explore CSE effects on functional performance in this demographic. English-language studies until October 2023 were systematically gathered from Web of Science, Scopus, and PubMed, with PEDro scoring and adherence to PRISMA guidelines. Notably, CSE showed superiority over passive therapy in enhancing proprioception, as supported by one study. In conclusion, while CSE demonstrates proficiency in improving proprioception, its effects on aspects like pain, balance, motor control, functionality, metabolic capacity, and postural sway in CLBP vary.

Keywords: Core stability exercise; Functional performance; Low back pain

DOI: https://doi.org/10.21834/e-bpj.v9i28.5790

1.0 Introduction

Low back pain (LBP), a leading cause of medical consultations (Alkhathami et al., 2023), refers to pain between the 12th rib and the inferior gluteal fold (Zahari et al., 2023). Categorized as non-specific (90%), specific (10%), acute (up to 6 weeks), sub-acute (6-12 weeks), or chronic (over 12 weeks) (Frizziero et al., 2021), non-specific LBP (NSLBP) impacts about two-thirds of the population (Areeudomwong et al., 2019). Functional performance examination holds particular importance in chronic NSLBP care, assessing balance, motor control, functionality, proprioception, metabolic capacity, and postural sway (Van Dijk et al., 2017; Alkhathami et al., 2023).

While the optimum management technique is still debatable, remaining physically active has been shown to help reduce NSLBP. A clinical practice guidelines of exercise therapy for the treatment of LBP found that therapeutic exercise was beneficial in relieving pain in chronic non-specific low back pain (CNSLBP) patients (Pangarkar et al., 2019). However, there is an ongoing dispute about which

eISSN: 2398-4287 © 2024. The Authors. Published for AMER & cE-Bs by e-International Publishing House, Ltd., UK. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/). Peer–review under responsibility of AMER (Association of Malaysian Environment-Behaviour Researchers), and cE-Bs (Centre for Environment-Behaviour Studies), College of Built Environment, Universiti Teknologi MARA, Malaysia.
DOI: https://doi.org/10.21834/e-bpj.v9i28.5790

sort of exercise is most effective. More recently, core stability exercise (CSE) has been regarded as the best option for LBP rehabilitation (Smrcina et al., 2022). CSE was found to be more beneficial than general exercises in reducing pain and improving physical function in patients with LBP, as well as more successful than a placebo intervention in treating lumbar segmental instability (Wang et al., 2012). It can reverse pain-induced motor cortex remodelling, improve muscle behaviour, and retrain the critical function of local trunk muscles for neuromuscular control of spinal stability (Hlaing et al., 2021). As far as we know, previous research comparing the effects of CSE and general exercise on trunk muscular activation and stability index in individuals with chronic LBP yielded inconsistent results (França et al., 2010; Shamsi et al.,2017). However, so far, no systematic review has been published to investigate the impact of CSE on functional performance. Therefore, this systematic review is necessary to identify the effect of CSE on functional performance.

This systematic review aimed to investigate the extensive body of evidence concerning the effectiveness of CSE as a treatment intervention for improving functional performance in people with CNSLBP.

2.0 Literature Review

LBP is one of the most common musculoskeletal disorders in healthcare systems that leads to disability (Zahari et al., 2023). LBP is also a burden to the country's economic state because persons with LBP might have frequent hospital visits and the same will increase work absenteeism (Morais et al., 2018). Evidence suggests that increased pain sensitivity is linked to poor LBP outcomes, including impaired functional performance (Butera et al., 2022).

2.1 Balance

Balance function refers to the ability to maintain stability and control body posture during various activities and positions. Balance, which is essential for most daily activities, may be compromised in patients with LBP. A study found that patients with LBP have more movement speed and area of motion in bipedal standing than healthy people, and their balance skills are worse(Nogueira et al., 2020). Impaired balance, reflecting deficient motor control in sustaining balance and body alignment during movement (Piscitelli, 2016), significantly influences individuals' functional performance and motor behavior. Physical therapy interventions play a critical role in addressing balance deficits associated with LBP. These interventions often include exercises aimed at improving core stability, enhancing proprioception, promoting muscle strength and endurance, and optimizing neuromuscular control. Additionally, interventions may focus on addressing pain-related fear and promoting confidence in movement to improve overall balance function.

2.2 Motor control

Muscle control is required for spinal posture, stability, and movement, and it relies on constant communication between the motor and sensory systems (Meier et al., 2019). Low back pain might be caused by abnormal motor control as a result of an incompletely stabilized spine (Garbenytė et al., 2018). According to one study, motor control in LBP patients is disrupted at multiple levels of the neurological system (Van Dieën et al., 2017). Impaired neuromuscular control, particularly of the lumbar multifidus, is the underlying cause of pain (Russo et al., 2018).

2.3 Functionality

In individuals with LBP, a complex interplay exists between function and the condition. LBP adversely impacts physical aspects like mobility, flexibility, strength, and postural control. Conversely, compromised function, e.g., poor posture or muscle imbalances, contributes to LBP development or exacerbation. Functionality, often assessed with a timed sit-to-stand test, reveals poorer physical performance in older individuals with LBP. The sitting-rising test, highlighted by Rodrigues et al. (2017), is particularly discerning for evaluating functional status in those with LBP.

2.4 Proprioception

Proprioception is the major somatosensory feedback system, with feedback provided by mechanoreceptors on deep and superficial tissues, including muscle spindles (Meier et al., 2019). Efficient and adaptive motor function requires accurate and precise sensory input, and a loss in proprioceptive input has been linked to changes in cortical neuroplasticity, which may impact sensorimotor cortex organization and top-down trunk motor control (Van Dieën et al., 2019). Patients with LBP have lower proprioception (Hu et al., 2017).

2.5 Metabolic capacity

Clinically, the 6-minute walk test (6MWT) is usually used to measure metabolic capacity. One study showed that both yoga and stabilization exercises increase the 6MWT distance (Ulger et al., 2023). Both cardiopulmonary endurance and trunk deep and superficial muscle activations are determinants of gait performance (Lamoth et al., 2006). In this context, we consider that yoga primarily increases walking distance through breathing exercises, cardiopulmonary development, trunk and lower extremity muscle endurance improvement, and that CSE also supports deep muscle activation and trunk stability.

2.6 Postural sway

Postural sway refers to the involuntary movements that occur when maintaining an upright position, and it is a crucial aspect of balance control. In general, factors that contribute to altered postural sway in patients with LBP include disruptions in proprioception, muscle activation patterns, and neuromuscular control. The relationship between postural sway and low back pain underscores the intricate connections between musculoskeletal function and balance control. One study showed that patients with LBP had a larger range of

motion swings than healthy people (Berenshteyn et al., 2019). However, another study showed that among both men and women, no significant disparity in body sway velocity was observed between the LBP patients and healthy controls (Brumagne et al., 2008).

3.0 Methodology

3.1 Search strategy

To discover studies that satisfied the inclusion criteria, we searched Web of Science, PubMed, and Scopus from inception to October 2023. Grey literature was excluded due to variable scientific quality and a lack of systematic search criteria (Paez 2017). Phrases such as "core stability," "stabilisation exercise," "core stabilisation exercise," "core stability training," "lumbar pain," "low back pain," "LBP" and "back pain," were used to describe them. For a detailed search method, see APPENDIX A. The search fields mainly include title, keywords and abstract. Zotero was chosen as the literature screening tool.

3.2 Inclusion criteria

For consideration, an paper must meet the following conditions: (1) RCT design; (2) inclusion of individuals with LBP aged 18 to 60; (3) Use CSE as an intervention, with a control group receiving alternative therapies; Karnati and Sreekar Kumar Reddy (2015) define a core stability training programme as activities that promote contraction between the abdominals and back extensors in order to maintain spinal stability and engage the patient functionally. (4) primary objectives centred on muscle physiology, which included muscular activation, exhaustion, thickness, strength, endurance, or control, and pain severity; (5) Include persons who have had low back discomfort for at least three months. Studies were deemed disqualified if they fulfilled any of the following criteria: The study type included reviews, case reports, and so on. The outcome indicators were unclear or incomplete. Studies conducted with patients who have received other treatment for their LBP within the previous six months. The repeatedly published research.

3.3 Study selection

LP and YY were assigned to screen abstracts, titles, and whole papers based on predetermined criteria. Articles that did not match the inclusion criteria were excluded. Disagreements were addressed after consulting with a third reviewer (ZZ). Adhering to the PRISMA guidelines (Page et al., 2021) resulted in a systematic reporting of outcomes.

3.4 Data extraction and analysis

The Pedro scale, used for article rating, determines the study's validity. Item 1 concerns external validity, with 11 items that need a yes/no response (1 point for yes, 0 points for no). Items 2-9 address a paper's internal validity. The PEDro scale provides a total score of 10, with assessments ranging from outstanding (9-10), decent (6-8), bearable (4-5), and poor (<4) (Foley et al., 2006).

4.0 Findings

4.1 Article screening and quality assessment results

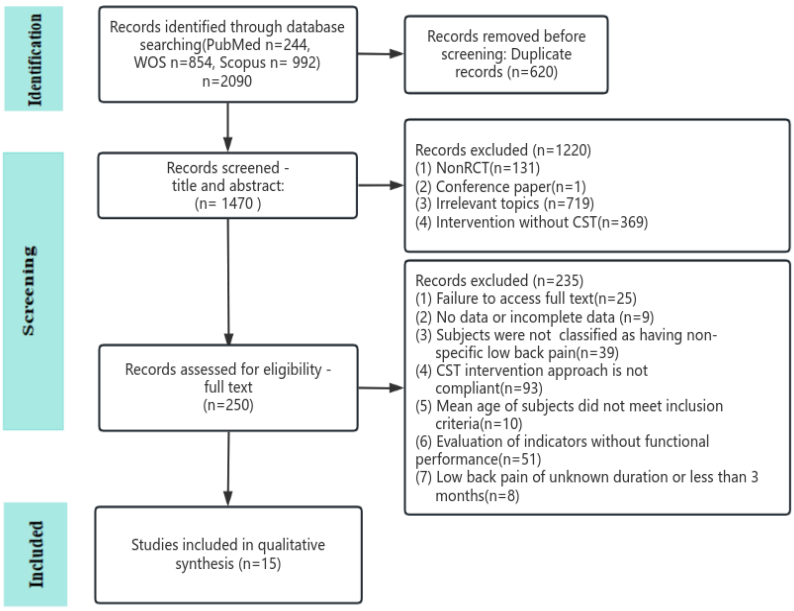

Figure 1: PRISMA Flow Diagram

Figure 1 illustrates the outcomes of the search process. The initial search generated 2090 items, which underwent a review for inclusion. After eliminating 620 duplicate entries, 1470 articles remained. Subsequent filtering of article titles and abstracts resulted in 250 articles. After a thorough full-text review, 15 studies met the inclusion and exclusion criteria and were incorporated into this systematic review.

Table 1 summarises the evaluation findings from each study by the PEDro scale.

Table 1. PEDro scale

Articles	1. Eligibility Criteria	2. Random Allocation	3. Concealed Allocation	4. Baseline Comparability	5. Blind Subjects	6. Blind Therapists	7. Blind Assessors	9. Intention to treat analysis	10. Between-group comparisons	11. Point Estimates &variability	PEDro score
1. Rhee et al., 2012	√	√	√	√	Unclear	Unclear	Unclear	√	√	√	6/10
2. Sarker, et al., 2021	√	√	Unclear	√	×	×	×	√	√	√	6/10
3. Khodadad et al., 2020	√	√	√	√	×	×	√	√	√	√	8/10
4. Wang et al., 2023	√	√	Unclear	√	√	√	√	√	√	√	9/10
5. Salavati et al., 2015	√	√	Unclear	√	√	×	√	√	√	√	8/10
6. Alshehre et al., 2023	√	√	√	√	√	×	√	√	√	√	9/10
7. Alkhathami et al., 2023	√	√	Unclear	√	×	√	√	√	√	√	8/10
8. Sengul et al., 2021	√	√	√	√	Unclear	Unclear	Unclear	√	√	√	7/10
9. Alp et al., 2014	√	√	√	√	×	×	√	√	√	√	8/10
10. Gorji et al., 2022	√	√	√	√	Unclear	Unclear	Unclear	√	√	√	7/10
11. Kim et al., 2014	√	√	√	√	Unclear	Unclear	√	√	√	√	8/10
12. Hwangbo et al., 2015	√	√	Unclear	√	Unclear	Unclear	Unclear	√	√	√	6/10
13. Ulger et al., 2023	√	√	√	√	Unclear	Unclear	Unclear	√	√	√	7/10
14. Chan et al., 2020	√	√	Unclear	√	×	×	√	√	√	√	7/10
15. Andrusaitis et al., 2011	√	√	√	√	Unclear	√	√	√	√	√	9/10

According to the PEDro scale data, almost all studies were found to have a low risk of bias for the bulk of the items. Three studies received a score of 9, indicating that they were of exceptional quality. Twelve studies received scores between 6 and 8, indicating that they were of good quality. The mean PEDro score for the 15 studies was 7.53, with a range of 6 to 9. Due to the nature of the investigation, most studies were unable to blind the subjects(12 trials) or therapists(12 trials). Other prevalent flaws included the failure to blind assessors in 6 trials and the failure to conceal allocation in 6 trials. Each article's data was extracted independently using a standardised data extraction system that aligned with the PICO model of the clinical research question. The previously collected data, including the PEDro score for each study, were then organized according to the following factors:

- General information: author and year of publication;
- Subjects: sample size, average age of participants, duration of back pain, and grouping of subjects;
- Interventions/Controls: content, duration, and frequency of interventions;
- Follow-up(s): post-intervention and re-evaluations;
- Outcomes: type of outcome taken into account;
- Findings: an overview of the findings.

4.2 Results of key characteristics of included research

4.2.1 Articles on CSE improving pain intensity

The effectiveness of CSE in relieving pain in CLBP patients over other therapies is debatable. Seven studies have found that CSE is more helpful than other therapy in relieving pain in persons with CLBP (Alkhathami et al., 2023; Andrusaitis et al., 2011; Khodadad et al., 2020; Kim et al., 2015; Rhee et al., 2012; Salik Sengul et al., 2021; Sarker et al., 2020). However, eight studies concluded that CSE was similarly effective in improving pain in patients with CLBP compared with other therapies (Alp et al., 2014; Alshehre et al., 2023; Chan et al., 2020; Hwangbo et al., 2015; Khodadad et al., 2020; Salavati et al., 2016; Ulger et al., 2023; H. Wang et al., 2023). One study showed that pain neuroscience education plus muscle control exercise could be more helpful than CSE in alleviating pain in CLBP patients(Gorji et al., 2022).

4.2.2 Articles on CSE improving balance

Whether CSE is more effective than other treatments in improving balance in patients with CLBP is controversial. Six studies have shown that CSE is effective in improving patient balance after the intervention compared to pre-intervention (Alshehre et al., 2023; Chan et al., 2020; Gorji et al., 2022; Hwangbo et al., 2015; Rhee et al., 2012; Salavati et al., 2016). Four studies suggest that CSE can be more effective in improving body balance in patients with CLBP relative to other therapies (Alshehre et al., 2023; Hwangbo et al., 2015; Rhee et al., 2012; Salavati et al., 2016). However, four studies concluded that the difference in effectiveness between CSE and other therapies in improving body balance in patients with CLBP was not significant (Alshehre et al., 2023; Andrusaitis et al., 2011; Chan et al., 2020; Gorji et al., 2022).

4.2.3 Articles on CSE improving motor control

Whether CSE is more effective than other treatments in improving motor control in patients with CLBP is controversial. Three studies believe that CSE can be more effective than other treatments in improving motor control in CLBP patients (Alkhathami et al., 2023; Khodadad et al., 2020). However, three studies concluded that there was little difference in the effectiveness of CSE in improving motor control in CLBP patients (Khodadad et al., 2020; Salik Sengul et al., 2021; H. Wang et al., 2023).

4.2.4 Articles on CSE improving functionality

Whether CSE is more effective than other treatments in improving functionality in patients with CLBP is controversial. One study has shown that CSE is effective in improving functionality in CLBP patients after the intervention compared to before the intervention (Salik Sengul et al., 2021), but both studies showed insignificant differences in the effect of CSE in improving functionality relative to traditional exercise therapy.

4.2.5 Articles on CSE improving proprioception

One study showed that CSE could be more effective than transcutaneous electrical nerve stimulation and hot pack therapy in improving proprioception among CLBP patients (Kim et al., 2015).

4.2.6 Articles on CSE improving metabolic capacity

Whether CSE is more effective than other treatments in improving metabolic capacity in patients with CLBP is controversial. One study showed that CSE was effective in improving metabolic capacity in CLBP patients after the intervention compared to pre-intervention, but the efficacy was similar to Yoga (Ulger et al., 2023).

4.2.7 Articles on CSE improving postural sway

Whether CSE is more effective than other treatments in improving postural sway in patients with CLBP is controversial. One study showed that the spinal manipulative therapy and CSE were more effective than the conventional treatment in improving postural sway, with the spinal manipulative therapy having the best effect (Sarker et al., 2020)

5.0 Discussion

5.1 Effects of CSE on pain, balance, motor control, functionality, metabolic capacity, and postural sway among adults with LBP

A study by May & Johnson (2008) determined that CSE may have a role in individuals with CNSLBP but is not superior to other active therapies. Similar findings were reported in two additional studies (Kim et al., 2015; Ulger et al., 2023). Smrcina et al. (2022), providing Grade B evidence, suggested potential benefits of CSE in treating pain in CNSLBP patients. Additionally, Frizziero et al. (2021) proposed integrating CSE into a comprehensive approach for CNSLBP, advocating for its combination with other therapeutic exercise modalities. Results indicate varying opinions on CSE effectiveness: 7, 4, 3, and 1 study supporting its superiority in improving pain, balance, motor control, and postural sway respectively, while 8, 4, 3, 2, and 1 study suggests similarity with other therapies in improving pain, balance, motor control, functionality, and metabolic capacity respectively. One study each argues CSE's ineffectiveness in improving pain and postural sway. This controversy may stem from different patient compliance, CSE intervention methods, intervention duration, or limited maintenance of therapeutic effects. Age-specific efficacy wasn't explored in previous studies. Additionally, Nwodo et al. (2022) found short-term CSE superiority over general exercise, but long-term pain severity differences were negligible (Wang et al., 2012), suggesting the need for enhanced CSE regimens and strategies for prolonged efficacy.

5.2 Effects of CSE on proprioception among adults with LBP

Previous studies have shown that impaired proprioception and balance have been observed in patients with LBP, impacting their movement patterns (Nogueira et al., 2020). This study showed that CSE can be more effective than transcutaneous electrical nerve stimulation and hot pack therapy in improving proprioception among CLBP patients (Kim et al., 2015). This may be due to the fact that CSE is an active exercise training and can target the contraction of small trunk muscles, which activates the proprioceptors located deep in the joints and muscles. Transcutaneous electrical nerve stimulation and hot pack therapy, on the other hand, are passive therapies that may play a positive role in maintaining muscle strength but are not effective in improving proprioception. However, since only 1 study was found to support this finding, more studies are needed to verify the validity of this finding.

5.3 Limitations

This study possesses various limitations. Firstly, it exclusively incorporated research composed in English and disseminated as complete papers, with no exploration of unpublished articles. Secondly, the inclusion criteria were comprised solely of randomized controlled trials (RCTs) investigating CSE for managing CNSLBP. Third, there needs to be more studies examining the enduring consequences of CSE in the context of CNSLBP treatment. Fourth, this study exhibits a degree of bias as it did not comprehensively incorporate gray literature into the literature review and discussion. Finally, the sole utilization of the PEDro scale as the quality assessment tool, without an examination of the cutoff score, raises concerns about the appropriateness and comprehensiveness of the quality assessment method, indicating a need for further improvement.

5.4 Clinical Implications

Based on the results of this study, it is recommended that clinical workers and LBP patients give priority to using CSE to improve lumbar proprioception. Compared with other active exercise therapies, whether CSE should be recommended for use in patients with low back pain for other functional properties besides waist proprioception still requires further research to reach a consensus.

5.5 Future research

In the future, it is necessary to further explore and compare the long-term efficacy of CSE with other active exercise therapies in improving pain intensity, balance, motor control, function, metabolic capacity and postural sway in patients with CNSLBP of different ages, thereby promoting the clinical search for more effective methods to improve functional performance of patients with CLBP.

6.0 Conclusion

In the context of CNSLBP, CSE exhibits potential superiority over alternative therapies in enhancing proprioception. Nevertheless, its influence on various aspects, including pain intensity, balance, motor control, functionality, metabolic capacity, and postural sway in CLBP, is a subject of debate. CSE is recommended for improving lumbar proprioception in CLBP patients. Future investigations should delve into the mechanisms by which CSE improves the functional performance of CLBP patients, aiming to design more effective exercise programs to alleviate the adverse symptoms in this population.

Acknowledgment

We express gratitude to Minzu Normal University of Xingyi, China, for its financial support through the discipline construction project and the Grant GIP (SKJS202339SKJS202339), and we acknowledge the Journal Support Fund from the Institute of Post-graduate Studies (IPSis) of the UITM.

References

Alkhathami, K., Alshehre, Y., Brizzolara, K., Weber, M., & Wang-Price, S. (2023). Effectiveness of Spinal Stabilization Exercises on Movement Performance in Adults with Chronic Low Back Pain. International Journal of Sports Physical Therapy, 18(1), 169-172. https://doi.org/10.26603/001c.68024

Alshehre, Y. M., Alkhathami, K., Brizzolara, K., Weber, M., & Wang-Price, S. (2023). Effectiveness of Spinal Stabilization Exercises on Dynamic Balance in Adults with Chronic Low Back Pain. International Journal of Sports Physical Therapy, 18(1), 173-187. https://doi.org/10.26603/001c.68075

Areeudomwong, P., & Buttagat, V. (2019). Comparison of Core Stabilisation Exercise and Proprioceptive Neuromuscular Facilitation Training on Pain-related and Neuromuscular Response Outcomes for Chronic Low Back Pain: A Randomised Controlled Trial. The Malaysian Journal of Medical Sciences : MJMS, 26(6), 77–89. https://doi.org/10.21315/mjms2019.26.6.8

Berenshteyn, Y., Gibson, K., Hackett, G. C., Trem, A. B., & Wilhelm, M. (2018). Is standing balance altered in individuals with chronic low back pain? A systematic review. Disability and Rehabilitation, 41(13), 1514–1523. https://doi.org/10.1080/09638288.2018.1433240

Butera, K. A., Fox, E. J., Bishop, M. D., Coombes, S. A., Beneciuk, J. M., & George, S. Z. (2022). Low Risk for Persistent Back Pain Disability Is Characterized by Lower Pain Sensitivity and Higher Physical Performance. Physical Therapy, 102, 1–9. https://doi.org/10.1093/ptj/pzab283

Dickson Nwodo, O., Olanrewaju Ibikunle, P., Linda Ogbonna, N., Umezulike Ani, K., Christain Okonkwo, A., Joy Eze, C., Uchenna Onwudiwe, C., Uroko Ezeja, G., & Adaobi Maduanusi, I. (2022). Review of core stability exercise versus conventional exercise in the management of chronic low back pain. African Health Sciences, 22(4), 148–167. https://doi.org/10.4314/ahs.v22i4.19

Frizziero, A., Pellizzon, G., Vittadini, F., Bigliardi, D., & Costantino, C. (2021). Efficacy of Core Stability in Non-Specific Chronic Low Back Pain. Journal of Functional Morphology and Kinesiology, 6(2), 37. https://doi.org/10.3390/jfmk6020037

Gorji, S. M., Mohammadi Nia Samakosh, H., Watt, P., Henrique Marchetti, P., & Oliveira, R. (2022). Pain Neuroscience Education and Motor Control Exercises versus Core Stability Exercises on Pain, Disability, and Balance in Women with Chronic Low Back Pain. International Journal of Environmental Research and Public Health, 19(5), 2694. https://doi.org/10.3390/ijerph19052694

Hu, H., Zheng, Y., Wang, X., Chen, B., Dong, Y., Zhang, J., Liu, X., & Gong, D. (2017). Correlations between lumbar neuromuscular function and pain, lumbar disability in patients with nonspecific low back pain. Medicine, 96(36), e7991. https://doi.org/10.1097/md.0000000000007991

Hwangbo, G., Lee, C.-W., Kim, S.-G., & Kim, H.-S. (2015). The effects of trunk stability exercise and a combined exercise program on pain, flexibility, and static balance in chronic low back pain patients. Journal of Physical Therapy Science, 27(4), 1153–1155. https://doi.org/10.1589/jpts.27.1153

Khodadad, B., Letafatkar, A., Hadadnezhad, M., & Shojaedin, S. (2019). Comparing the Effectiveness of Cognitive Functional Treatment and Lumbar Stabilization Treatment on Pain and Movement Control in Patients With Low Back Pain. Sports Health, 12(3), 289–295. https://doi.org/10.1177/1941738119886854

Lamoth, C. J. C., Meijer, O. G., Daffertshofer, A., Wuisman, P. I. J. M., & Beek, P. J. (2005). Effects of chronic low back pain on trunk coordination and back muscle activity during walking: changes in motor control. European Spine Journal, 15(1), 23–40. https://doi.org/10.1007/s00586-004-0825-y

Meier, M. L., Vrana, A., & Schweinhardt, P. (2018). Low Back Pain: The Potential Contribution of Supraspinal Motor Control and Proprioception. The Neuroscientist, 25(6), 583–596. https://doi.org/10.1177/1073858418809074

Mohamad Chan, E. W., Md Nadzalan, A., Othman, Z., Hafiz, E., & A. Hamid, M. S. (2020). The Short-Term Effects of Progressive vs. Conventional Core Stability Exercise in Rehabilitation of Nonspecific Chronic Low Back Pain. Sains Malaysiana, 49(10), 2527–2537. https://doi.org/10.17576/jsm-2020-4910-18

Pangarkar, S. S., Kang, D. G., Sandbrink, F., Bevevino, A., Tillisch, K., Konitzer, L., & Sall, J. (2019). VA/DoD Clinical Practice Guideline: Diagnosis and Treatment of Low Back Pain. Journal of General Internal Medicine, 34(11), 2620–2629. https://doi.org/10.1007/s11606-019-05086-4

Piscitelli, D. (2016). Motor rehabilitation should be based on knowledge of motor control. Archives of Physiotherapy, 6(1). https://doi.org/10.1186/s40945-016-0019-z

Salik Sengul, Y., Yilmaz, A., Kirmizi, M., Kahraman, T., & Kalemci, O. (2021). Effects of stabilization exercises on disability, pain and core stability in patients with non-specific low back pain: A randomized controlled trial. Work, 70(1), 1–9. https://doi.org/10.3233/wor-213557

Sethi, J., Sarker, K., & Mohanty, U. (2020). Comparative clinical effects of spinal manipulation, core stability exercise, and supervised exercise on pain intensity, segmental instability, and health-related quality of life among patients with chronic nonspecific low back pain: A randomized control trial. Journal of Natural Science, Biology and Medicine, 11(1), 27. https://doi.org/10.4103/jnsbm.jnsbm_101_19

Smrcina, Z., Woelfel, S., & Burcal, C. (2022). A Systematic Review of the Effectiveness of Core Stability Exercises in Patients with Non-Specific Low Back Pain. International Journal of Sports Physical Therapy, 17(5). https://doi.org/10.26603/001c.37251

Ulger, O., Oz, M., & Ozel Asliyuce, Y. (2023). The Effects of Yoga and Stabilization Exercises in Patients With Chronic Low Back Pain: A Randomized Crossover Study. Holistic Nursing Practice, 37(4), E59. https://doi.org/10.1097/HNP.0000000000000593

Wang, H., Fan, Z., Liu, X., Zheng, J., Zhang, S., Zhang, S., Yu, Q., Lo, W. L. A., Chen, X., & Wang, C. (2022). Effect of Progressive Postural Control Exercise Versus Core Stability Exercise in Young Adults with Chronic Low Back Pain: A Randomized Controlled Trial. Pain and Therapy, 12(1), 293–308. https://doi.org/10.1007/s40122-022-00458-x

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

Zarina Zahari, Nurul Amira Arnuin, Mohd, M., & Lin, P. (2023). Type of Sitting Posture and Low Back Pain among University Students. Environment-Behaviour Proceedings Journal, 8(24), 247–252. https://doi.org/10.21834/ebpj.v8i24.4683