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Effects of Core Stability Training on Muscle Physiology among Adults with Low Back Pain

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Abstract
Background: The effects of core stability training (CST) on muscle physiology in adults with chronic low back pain(CLBP) are still debatable. Objectives: To explore the effects of CST on muscle physiology in adults with CLBP. Methods: Eligible studies published in English from inception to October 2023 were extracted from PubMed, Web of Science, and Scopus in this review. Pedro was used for scoring and followed the PRISMA guidelines. Findings: Core muscle strength (1 study), thickness (4 studies), and activation (6 studies) favored CST. Conclusion: CST was more effective in improving core muscle strength, and activation for patients with CLBP.

Keywords: Core stability training; Muscle physiology; Low back pain

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1.0 Introduction

Low back pain (LBP) is the primary cause of disability years lived globally, and it poses a significant challenge to the global health system(Ghafouri et al., 2023). LBP refers to any uncomfortable stimulation between the twelfth pair of ribs and hip creases that can induce mild to severe disorders with or without leg discomfort(Ferreira et al., 2023). It is generally characterized as non-specific (90%) or specific (10%) and as acute (6 weeks), subacute (6-12 weeks), or chronic (greater than 12 weeks)(Frizziero et al., 2021). Two-thirds of adults are believed to have experienced or will have non-specific low back pain (NSLBP) at some point in their lives(Areeudomwong et al., 2019). NSLBP has no clear pathophysiology as to what causes the pain. However, it is thought to be caused by variables such as profound core muscle weakness(Areeudomwong et al., 2019). The core, which is made up of muscles that stabilize the spine, pelvis, and hips, is essential for maintaining posture and facilitating daily motions. As a result, resolving the multifarious issues offered by LBP may require strengthening and optimizing core muscle physiology. The muscle physiology of this study includes core muscle activation

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and fatigue, core muscle strength and endurance, and core muscle thickness. These indicators respond to different aspects of core muscle function and may be strongly associated with LBP.

However, the best effective treatment for LBP still needs to be discovered. The most recent clinical practice guidelines encourage patients to remain physically active, as prolonged inactivity is detrimental to healing and overall well-being(Stochkendahl et al., 2017). Core stability training (CST) has emerged as a promising approach for improving core muscle physiology. The primary objective of CST is to replicate normal muscle function by re-educating the deep trunk muscles and coordinating both deep and superficial trunk muscles (Akhtar et al., 2017).

This study aims to investigate the cumulative body of evidence on the efficacy of CST as a therapeutic intervention for improving muscle physiology in individuals with CLBP. To determine whether CST is more effective relative to other therapies in improving various specific measures of muscle physiology in patients with CLBP

2.0 Literature Review

2.1 Muscle physiology

2.1.1 Core muscle activation

During diverse functional tasks, LBP is related to trunk kinematics and muscle activation (Hemming et al., 2019). A study has shown that patients with CLBP had delayed activation of deep abdomen and back muscles and increased activation of superficial trunk muscles (Kamel et al., 2021).

2.1.2 Core muscle fatigue

LBP, lumbar back muscle fatigue, and reduced contractility are caused by each other. Muscle fatigue has been found in studies to hurt the coordination and stability of improved movement patterns (Ghamkhar et al., 2019).

2.1.3 Core muscle thickness

One study showed that the cross-sectional area of the multifidus muscle at multiple segments on the painful side of LBP patients was significantly smaller than that on the non-painful side (Wan et al., 2015). Core muscle thickness may have a positive correlation with core muscle strength. Decreased core muscle thickness may lead to decreased core strength and, thus, core instability.

2.1.4 Core muscle strength

The core muscles of the abdomen and the back work together to maintain the body's posture control and lumbar spine stability and play a role in the body's daily behavior patterns. A study has shown that the weakness of the lumbar extensor muscles and the imbalance of the lumbar and abdominal muscles will lead to a decrease in the stability of the lumbar spine, changes in the body posture pattern, and compensatory movements in other parts, resulting in LBP(Czaprowski et al., 2018).

2.2 Core stability training

Core muscle weakness has been linked to persistent LBP in studies. CST is a standard method for recovering trunk muscle functioning and achieving optimal lumbar stability throughout regular activities (Mohammadi et al., 2023). CST can improve the transversus abdominis and multifidus thickness and the anti-fatigue ability of the patient's core muscles, thereby improving the patient's balance ability. However, a comprehensive study found that specialized stabilizer exercises may have a role in some people with CLBP, but they are no more helpful than other active therapies (Khodadad et al., 2019). At present, it is unclear which sub-indicators of CST's efficacy in improving muscle physiology in patients with CLBP are still controversial compared to other therapies, and which sub-indicators have a consensus on its efficacy.

In summary, previous studies have shown that patients with CLBP have varying degrees of muscle physiology abnormalities, which are mainly manifested as delayed activation of deep trunk core muscles, core muscle fatigue, decreased core muscle thickness, and decreased core muscle strength, which in turn lead to decreased trunk stability and uncoordinated activities. Although some studies have demonstrated that CST can improve muscle physiology in CLBP patients, it is still controversial whether CST is the most effective method in improving muscle physiology in CLBP patients. In this study, we attempted to summarise the advantages and disadvantages of CST relative to other therapies in improving the muscle physiology of CLBP patients by systematically collating, evaluating, and analyzing the results of previous studies. In this way, it will make a positive contribution to the exploration of the most effective CLBP therapies.

3.0 Methodology

3.1 Study design
This study is a systematic review.

3.2 Inclusion and exclusion criteria
To be considered, an article must contain the following characteristics: (1) an RCT design; (2) patients with LBP aged 18-60 years old; (3) used CSE as an intervention, and there was a control group that got conventional intervention or another intervention; (4)the primary outcomes of interest was muscle physiology(muscle activation, muscle fatigue, muscle thickness, muscle strength, muscular endurance, or muscle control) or(and) pain intensity; (5) low back pain that has lasted at least three months. If a study met any of the following criteria, it was considered disqualified: (1) participants with LBP caused by specific conditions or pathologies; (2) the study sample mean age was either ≥60 years or <18 years; (3) review, case report, meeting abstract, commentaries, systematic reviews, qualitative papers, poster abstracts, or monograph; (4) conference papers; (5) unclear outcome indicators or incomplete data; (6) full text not available; (7) studies conducted in languages other than English; (8) repeatedly published research.

3.3 Search strategy
To locate studies fulfilling the inclusion criteria, we searched the following databases from inception to October 2023: PubMed, Web of Science, and Scopus. Grey literature was excluded due to the diversity of scientific rigor and the lack of criteria for conducting systematic grey literature searches(Paez, 2017). The primary phrases "core stabilization exercise," core stability training," core stability," stabilization exercise," low back pain," back pain," lumbar pain," and"LBP" were employed. In adherence to the PICO framework, the specified keywords were systematically explored through Medical Subject Heading (MeSH) phrases, amalgamated using Boolean operators ("AND," "OR," and "NOT"), aligning with the clinical research question. See APPENDIX A for the entire search strategy.

Two reviewers (LP and YY) were utilized to screen for appropriate titles, abstracts, and complete papers using the pre-specified criteria. When inclusion criteria were not met, articles were eliminated. In cases where there was disagreement, a third reviewer (ZZ) was consulted. To ensure that the results were reported systematically, the PRISMA standards were followed(Page et al., 2021).

3.4 Data extraction
Following the selection of studies, data were extracted using a data extraction form for the characteristics of subjects' average age, sample size, interventions, follow-up, outcomes, and findings(see Table 1).

The PEDro scale, an article evaluation system, was utilized to assess the quality and validity of each study. The tool had 11 items, each of which needed a yes/no response: yes received 1 point, no received 0 points. Item 1 is connected to external validity. Items 2-9 correspond to a paper's internal validity. The PEDro scale had a total score of 10. PEDro ratings ranged from excellent (9 to 10), acceptable (6 to 8), reasonable (4-5), and bad (less than 4)(Kakavas et al., 2023).

Table 1 Major characteristics of included studies

Article	Subjects	Intervention	Follow Up	Outcomes	Findings	PEDro score
1.Areeudomwong P et al.,2019	•N=45 •Average age: CSE=24.08±1.00 PNF=24.00±8.47 CG=24.36±9.97	•CSE: practiced recruitment of deep trunk muscles •PNF: 5 repetitions of each PNF training for three sets, with a 30 s rest between repetitions and a 60 s rest after each set. •CG: ultrasound for 5-10min + 20-min general trunk strengthening exercise •Duration: 4 weeks •3 times/wk, 30min/session	3 months	Pain(NPRS), activations of RA, TrA, ICLT and LM muscles(S-EMG)	• CSE and PNF training provided short-term and long-term effects on pain, and increased deep trunk muscle activity in CLBP patients. • There was no significant difference between CSE and PNF in terms of improvement of back pain and muscle physiology.	9/10
2.Cai C et al.,2017	•N=84 •Average age: LL=28.9± 5.3 LE=26.1± 4.1 SE=26.9± 6.4	•All participants warm-up(general stretching and stationary bicycling for 15 minutes) •LL: resistance exercises targeting the knee and hip muscles •LE: progressive back extensors training •SE: a series of TrA and LM muscle activation and motor control training •Duration: 8 weeks •2 times/wk, 30min/session	3 months and 6 months	Pain(NPRS), Lower limb strength(isokinetic dynamometer), TrA and LM activations(ultrasound image), lumbar extensor muscle fatigability(S-EMG)	• All three groups improved pain (p < 0.001), and the LL group had the most significant improvement. • Knee extension strength increased (p < 0.001) in the LL group, which was higher than the other groups (p < 0 .001). • All 3 groups improved similarly in back muscles function.	6/10
3.Mendes PRF et al.,2022	•N=14 •Average age: CSE=27±2 CG=27±1	•CSE: three phases progressing with the level of difficulty +.usual exercise routine. •CG: usual exercise routine such as running, cycling, swimming and bodybuilding +an explanatory class at end •Duration: 12 weeks	Post-intervention	Pain(NPRS), maximum isometric strength and trunk muscle resistance(manual dynamometer)	• The CSE improved pain better(p=0.04). • Trunk muscle strength remains unchanged in the CSE, while the CG presented a decrease in flexural strength to the right side (p=0.04).	7/10

		•2 times/wk, 45min/session			• There was no difference in the rates of resistance to fatigue between groups.	
4.Kang TW et al.,2017	•N=24 •Average age: SE=43.41±5.96 SEUS=42.83±6.99	•All subjects 5-min warm-up, and 5-min cool-down. •SE: elbow-toe, back bridge, side bridge, and 290 curl-up motions on stable surface + GPT •SEUS: elbow-toe, back bridge, side bridge, and 290 curl-up motions on unstable surface + GPT GPT(general physical therapy), consisting of hot pack treatment at 80 ◦C, interferential current therapy (2000–2500 Hz), and ultrasonic treatment •Duration: 6 weeks •30min/session, 5 times /wk	Post-intervention	Pain(VAS), back muscle strength(DBMSM)	• All post-test values in the unstable surface group improved significantly more than those in the stable surface group. • After the intervention, all dependent variables at the 6-week post-test had significantly improved than those in the pre-test results in both groups.	6/10
5.Park et al.,2023	•N=70 •Average age: AB=44.8±10.8 SE=43.0±10.6	•All subjects 10-min warm-up, 30-min SE, and 10-min cool-down. •AB: performed SE with AB. •SE: performed SE, breathe normally without special emphasis on breathing. •Duration: 24 weeks •50min/session, 2 times /wk	1month and 3 months	Pain(VAS), spine extensor strength(Medx extension machine)	• Spine extensor strength was improved in both groups. • Pain and function were also improved in both groups, but the effect was stronger in the AB group than in the SE group.	8/10
6.Sipaviciene et al.,2020	•N=70 •Average age: SE=38.3±5.1 CG=38.5 ± 6.2	•All subjects 5-min warm-up, and 5-min cool-down(static and dynamic stretching exercises) • SE: strengthen the deep trunk stabilizing muscles (especially TrA, IO and LM) and control pelvic muscles. • CG: improve trunk flexor and extensor muscles strength • Duration: 20 weeks • 45min/session, 2 times /wk	4 weeks, 8 weeks and 12 weeks	Pain(VAS), cross-sectional area of the multifidus muscle(ultrasound)	• Positive effects for the cross-sectional area of the multifidus muscle, and pain lasted for 4 weeks in CG and for 12 weeks in SE group. • The LM strength increased and lasted for 8 weeks in both groups.	5/10
7.Salamat et al.,2017	•N=32 •Average age: CSE=35.83±9.31 MCG=36.09± 9.6	• CSE: exercises involved coordinated training and independent activity of deep trunk muscles. • MCG: normalize the abnormal movement patterns and postures and to relax trunk muscles. • Duration: 4 weeks • 45min/session, 2 times /wk	Post-intervention	Pain(NPRS), FRR of LM and ICLT(S-EMG)	• Pain reduced in both groups, with no significant difference between the groups. • FRR of LM did not change in either group after treatment. • FRR of ICLT was significantly increased after treatment in MCG.	5/10
8.Wang et al.,2023	•N=42 •Average age: PPCE=26.00(24.5-28.5) CSE=25.00(23.5-30.0)	• PPCE: 1.core muscles against gravity on a stable platform. 2. trunk muscle against gravity on an unstable surface. 3. exercise performed on unstable and less supporting surface with resistance training. • CSE: prone-plank, single legbridge, side-plank, double leg-bridge, and birddog. • Duration: 8 weeks • 30min/session, 3 times /wk	6 months	Pain(VAS), thickness and contractility of TrA and LM(ultrasound)	• The results has no significant difference between 2 group. • After 6-month follow-up the scores of 2 groups decreased significantly compared to before. • The thickness of bilateral TrA and left MF ($p < 0.05$) was elevated .	9/10
9.Bae et al.,2018	•N=39 •Average age: SUE=32.7± 6.1 CSE=32.4 ± 10.7	•SUE: sit-up exercise using a new training device. • CSE: low-intensity isometric contractions first, then gradually perform co-contraction of muscles through dynamic functional tasks. • Duration: 4 weeks • 30min/session, 3 times /wk	6 months	Pain(VAS), abdominal muscle thickness(Ultrasound), motor activity of core muscles(S-EMG)	• Thickness ratios of RA and EO in SUE group and those of TrA in CSE group showed significant difference after exercise ($p < 0.05$). • The ratio of activation of IO relative to RA and pain improved in both groups ($p < 0.05$).	6/10

					• Pain had no significant difference between 2 groups(p> 0.05).	
10.Naroei et al.,2020	•N=34 •Average age: CSE=32.23±6.32 CG=32.13±6.96	• CSE: performed 16 core stabilization exercises. • CG: transcutaneous electrical nerve stimulation and a 'hot-pack'. • Duration: 4 weeks • 15min/session, 5 times /wk	Post-intervention	Pain(VAS), thickness of trunk muscle(Ultrasound), Multifidus, TrA and Gmax activity (S-EMG)	• CSE increased contracted thickness of TrA and Gmax. •The pain in both groups decreased after treatment, but the decrease in the CSE group was more significant(P<0.05).	6/10
11.Franca et al.,2012	•N=30 •Average age: SE=42.07±8.15 CG=41.53±4.41	• SE: exercises focused on the TrA and LM muscles • CG: exercises focused on stretching the erector spinae, hamstrings, and triceps surae. • Duration: 6 weeks • 30min/session, 2 times /wk	Post-intervention	Pain(VAS &McGill pain questionnaire), TrA muscle activation capacity (PBU)	• As compared with baseline, both groups relieve pain (P<0.001). • SE group had significantly higher gains for all variables. • The CG group did not effectively activate the TrA (P=0.94).	7/10
12.Sengul et al.,2021	•N=42 •Average age: SE=40.78±8.8 CG=43.32±8.85	• SE:first stage(40min), TrA and pelvic floor muscles were contracted. Progression (60min), do exercises in supine, prone, quadruped, bridge, sitting positions, and lastly with Swiss ball • CG: improve strength and flexibility of lumbopelvic muscles. • Duration: 6 weeks • 3 days / week	Post-intervention	Pain(VAS), core strength(partial curl-up test), trunk endurance(trunk flexor, trunk extensor, and bilateral side bridge) tests	• When comparing groups for gain scores, there were more significant improvements in pain during activity, trunk endurance and function after SE (p < 0.05).	6/10
13.Danneels et al.,2001	•N=59 •Average age: SE=43±13 SE+DRT=44±12 SE+DSRT=43±12	• SE: activate the multifidus in a specific progression of exercises • SE+DRT: SE+alternated progressive resistance training, concentric and eccentric movements. • SE+DSRT: SE+interrupted progressive resistance training, cycling movement. 5s static contraction between concentric and eccentric phase / time. • Duration: 10 weeks	Post-intervention	Multifidus cross sectional area(standard computed tomography images)	• The cross sectional area of the multifidus muscle was significantly increased at all levels after training in SE+DSRT, and no significant diferences were found in other 2 groups.	6/10
14.Alp et al.,2014	•N=48 •Average age: SE=48(36-43) CG=51(25-64)	• SE: warming (5 minutes), stretching (5 minutes), stabilization exercises for the multifidus/TrA muscles (30 minutes), and cooling (5 minutes), 3 times / week, for a total of 45-60 minutes a day. • CG: lumbar isometric and lumbar flexion-extension exercises, 1x20 repetitions a day • Duration: 6 weeks	Post-intervention	Pain(VAS), endurance of abdominal muscles(Krause-Weber test), endurance of dorsal extensors (Sorensen test)	• All variables were improved in 2 groups except endurance of dorsal extensors in CG group. • There was no significant difference in relieving pain between two groups. • SE group can improve endurance of dorsal extensors better.	8/10
15.Franca FR et al., 2010	•N=30 •Average age: SE=42.07±8.15 CG=41.73±6.42	• SE: segmental stabilization, exercises focused on the TrA and LM muscles. • CG: superficial strengthening, exercises focused on the RA, IO, EO, and erector spinae. • Duration: 6 weeks • 2 times / week, 30 min / session	Post-intervention	Pain(VAS, McGill pain questionnaire), TrA muscle activation capacity (PBU)	• As compared to baseline, both treatments were effective in relieving pain (p<0.001). • Those in the SE had significant gains for all variables when compared to CG (p<0.001).	7/10
16.Alrwaily et al., 2019	•N=30 •Average age: SE=38.33 ± 11.3 SE+NMES=33.40 ± 9.0	• SE： abdominal, side support, and quadruped exercises, 20min / session. • SE+NMES： abdominal, side support, and quadruped exercises, 20min / session. The NMES was applied to the lumbar paraspinal muscles for 20 min / session. • Duration: 6 weeks • 2 times / week	Post-intervention	Pain(NPRS), Paraspinal muscle strength(Biodex 3 Prodynamometer)	• Supplementing SE with NMES did not offer any additional clinical benefit for the chronic low back pain patients. • After treatment, the low back pain and paravertebral muscle strength of the two groups of patients were significantly improved.(P<0.05).	6/10

17.Amiri et., 2022	•N=38 •Average age: SE=32.4±7.6 Flexi-bar=35.2 ± 5.6	• SE: ADIM at the supine position, ADIM with heel slides, ADIM with bridging, ADIM with single leg bridging, bird-dog exercise, and supine dead bug. • Flexi-bar: chest and back, lower back and chest, deep back extensors, core muscles, multifidus, torso musculature, glutes, bottom	Post-intervention	Pain(NPRS), back muscles endurance(Sorensen test)	• Neither of the two interventions wasn't superior in reducing pain. • Flexi-bar showed significant improvement in back muscles endurance over SE(p < 0.001). • Pain and back muscle endurance improved significantly in both groups after training(p < 0.001).	7/10
18.Nabavi et al,2017	•N=41 •Average age: SE=40.75±8.23 CG=34.05±10.75	• SE: stabilization exercises + electrotherapy • CG: routine exercises + electrotherapy • Duration: 4 weeks • 3 times / week	Post-intervention	Pain(VAS), muscle dimensions of right and left TrA and lumbar multifidus (Ultrasonic-ES 500)	• Pain and muscle size were improved obviously in both groups except the right-side LM cross-sectional area of CG after interventions . • Theres's no significant differences between both groups on pain and muscle dimensions.	7/10
19.Suh et al,2019	•N=60 •Average age: FE=53.54±15.69 WE=54.15±13.89 SE=57.40±15.88 SWE=54.75±14.98	• FE=flexibility exercise • WE=walking exercise • SE=stabilization exercises • SWE=stabilization with walking exercise • Duration: 6 weeks • 5 times / week, 30-60min / session	6week and 12 week	Pain(VAS), endurance in 3 postures (supine, side-lying, and prone), strength of lumbar extensor(manual muscle tester)	• SE and WE significantly improved pain. • WE and SWE significantly improved muscular endurance of back muscles. • There was no significant difference between the 4 groups with pain at pre-, immediately post-, and 6 weeks-post exercise.	7/10
20.Ahmadizadeh et al., 2019	•N=32 •Average age: SE=31.12±8.29 CG=34.19±8.36	•All subjects performed stretching (10-min warm-up, and 10-min cool-down) . • SE: self-care training plus 24 sessions of stabilization exercises • CG: self-care training • Duration: 8 weeks • 3 times / week, 60min / session	Post-intervention	Pain(VAS), abdominal muscle activity(Ultrasonography)	• Only in SE group the TrA muscle activity during abdominal hollowing exercises were significantly increased (p <0.05). • There was no significant difference between the two groups in pain(p >0.05).	8/10
21.Guthrie et al., 2012	•N=51 •Average age: TSE=23.8 ±7.0 SB=22.5± 5.1	• TSE: traditional bridge exercise consisted of 4 possible levels. • SB: 4 possible levels of the suspension-bridging exercise • All subjects performed 5 repetitions at each level and were progressed based on specific criteria.	Post-intervention	Muscle thickness of EO, IO, and TrA during an ADIM(Ultrasound imaging), muscle thickness(contraction ratio of EO, IO, and TrA)	• Neither TSE nor SB has an immediate clinical effect on EO, IO, or TrA activation immediately after a single exercise intervention. • There was a significant group-by-time interaction wherein TSE resulted in greater TrA contraction after exercise than SB.	7/10
22.Kwon et al.,2020	•N=30 •Average age: SE=31.67 ± 8.91 CG=35.33± 6.76	• SE: conducted ADIM in prone, hook-lying, quadruped, and straight-standing positions • CG: trunk strengthening exercise. • Each motion was maintained for 10 seconds. Each motion /15 times and 3 repetitions / set.	Post-intervention	Pain(VAS), TrA activation capacity(PBU)	• SE for LBP patients is more effective than CG in improving pain , and TrA activation capacity. • There were no significant differences between 2 groups in TrA thickness.	6/10
23.Hosseinifar et al.,2013	•N=37 •Average age: SE=40.1±10.8 CG=36.6±8.2	• All subjects warming up (pedaled a stationary bike for 5 minutes and then did stretching exercises for 10 minutes). • SE: Stabilization exercises were performed in 6 levels from easy to difficult. Each exercise 10 times for 10 seconds with low intensity.	Post-intervention	Pain(VAS), the thicknesses of the MF and TrA muscles(ultrasound apparatus)	• After interventions, the pain score decreased in both groups. • Thickness of left multifidus increased significantly during resting and contracting in SE. • Thickness of right TrA during	5/10

		• CG: McKenzie includs 6 exercises: four extension-type exercises and two flexion-type and two flexion-type exercises. • Duration: 6 weeks • 3 times / week, 60min / session			ADIM, and thickness of left TrA during active straight leg raising increased significantly in SE. • Pain, thickness of right TrA during ADIM, and thickness of left TrA during active straight leg raising in SE group were greater than those on Mackenzie.	
24.Ehsani et al, 2020	•N=47 •Average age: SE=36.40 ± 7.02 CG=35.50 ± 6.12	• All subjects warming up and cooldown (on a treadmill and stretching exercises) in each session. • SE: stabilization exercises with emphasis on the isolated contraction of the TrA, MF, and pelvic floor muscles and co-contractions of the involved muscles in the different positions. • CG: general exercise without emphasis on contraction of the TrA, MF, and pelvic floor muscles. • Duration: 6 weeks • 3 times / week, 40min / session	Post-intervention	Pain(VAS), lateral abdominal muscles thickness(ultrasound imaging)	• The results indicated significant increases in TrA muscle thickness during standing (P = 0.02) and significant decreases in pain following SE (P<0 .001). • The CG group revealed only significant decreases in pain after intervention (P = 0.03). • The SE group exhibited greater changes of pain after the intervention.	9/10
25.Ulger et al., 2020	•N=35 •Average age: SE=55.08 ± 2.67 Yoga=47.12 ± 7.07	• SE: 1.activated the core muscles in various positions. 2. more complex movements such as bridge exercises. 3.exercises with resistance bands and the exercise ball. • Yoga: yoga program • Duration: 16 weeks • 2 times / week, 60min / session	Post-intervention	Pain(VAS), TrA muscle activation(stabilizer biofeedback device)	• Pain improved significantly after both interventions (P < 0.05). And both approaches were similarly effective on pain. • Improvements in the stabilization program were higher on the TrA activation (P < 0.05).	6/10
26.Chan et al., 2020	•N=30 •Average age: PSE=33.30±5.78 CSE=33.8±4.93	• PSE=DMST+pain management • TSE=MBG3(modified curl-up, kneeling side bridge, and bird dog)+pain management • Duration: 5 weeks • (3 exercises, 3 sets, 10 repetitions with 5 s contraction hold)	Post-intervention	Pain(NRPS), trunk enduranc of flexion, extension and lateral (time-based static hold test)	• Both PSE and TSE improves pain and trunk endurance (p < 0.001). • Therr's no significant difference in all outcomes betweent 2 groups (p> 0.05).	8/10

KEY

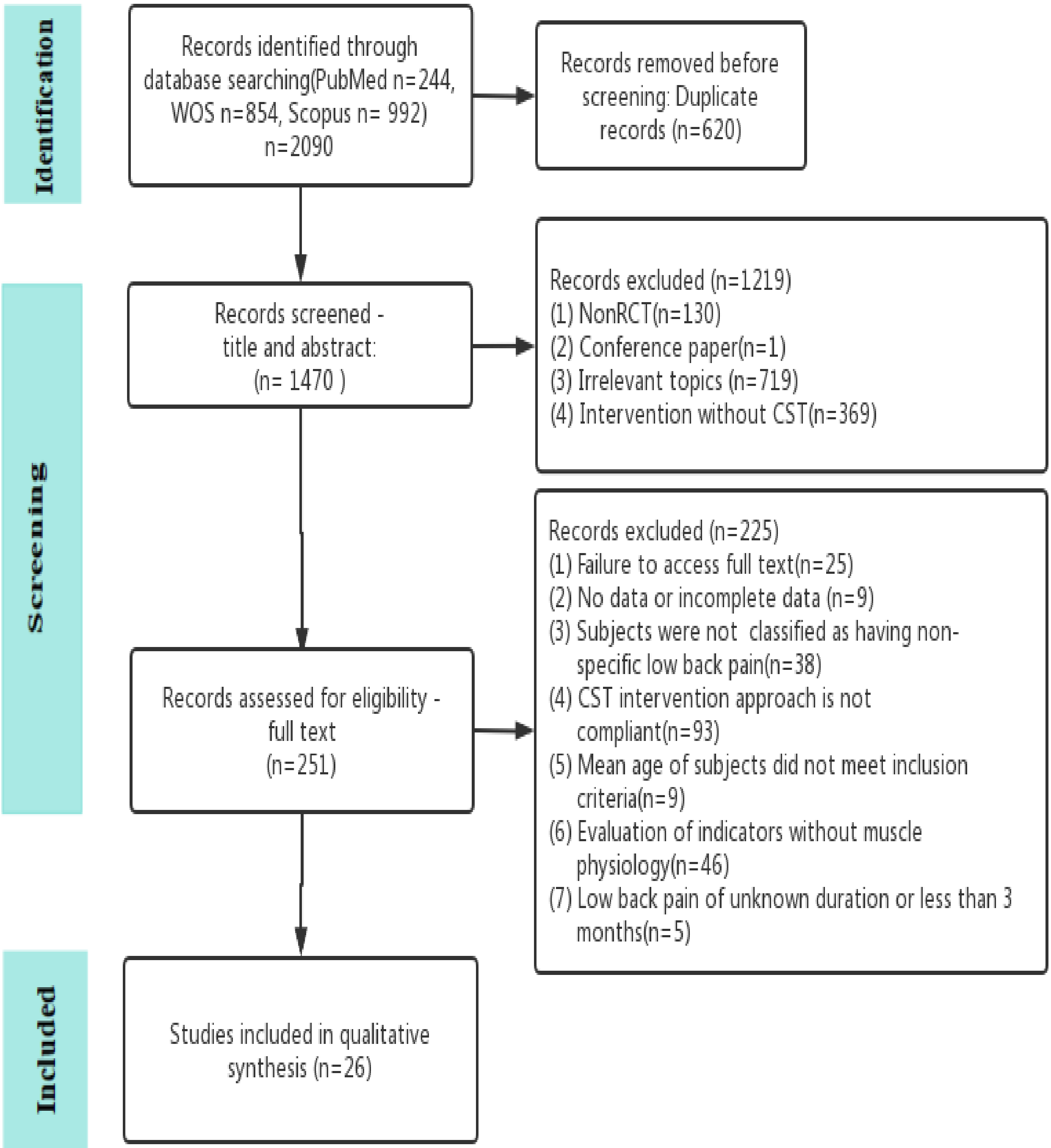
CSE=Core Stabilization Exercises, CG=Control group, NPRS=Numerical Pain Rating Scale, SE=Stabilization Exercises, LM=Lumbar Multifidus, TrA=Transversus Abdominis, VAS=Visual Analog Scale, S-EMG=Surface Electromyography, RA=Rectus Abdominis, ICLT=Iliocostalis lumborum Pars Thoracis , LL=Lower limb, LE= lumbar Extensor, SFE=Spinal Flexibility Exercise, DBMSM=Digital Back Muscle Strength Meter, AB=Abdominal Bracing, MCG=Movement Control Group, FRR=Flexion Relaxation Ratio , PPCE=Progressive Postural Control Exercise, PBU=Pressure Biofeedback Unit, DRT=Dynamic Resistance Training, DSRT=Dynamic-Static Resistance Training, NMES=Neuromuscular Electrical Stimulation, FE=Flexibility Exercise, WE=Walking Exercise, SWE=Stabilization with Walking Exercise, ADIM=Abdominal Drawing-In Maneuver, IO=Internal Oblique, EO= External Oblique, DMST=Progressive Dynamic Muscular Stabilization technique, PSE=Progressive Stabilization Exercise, TSE=Traditional Stabilization Exercise, SM=Spinal Mobilization, SB=Suspension Bridging, SEUS=Stabilization Exercise on Unstable Surface, SUE=Sit-Up Exercis

4.0 Findings

4.1 Results of PRISMA and Pedro's Scoring

Fig. 1 depicts the search results—the original search produced 2090 items, which were then reviewed for inclusion. There were 620 duplicate entries eliminated, leaving 1470 articles. Following the filtering of article titles and abstracts, 251 articles remained. Following a full-text review, 26 studies were incorporated.

Fig. 1: PRISMA Flow Diagram



The table below provides the findings of each study's evaluation using the PEDro scale (Table 2).

Table 2 PEDro scale for each study

Articles	1. Eligibility Criteria	2. Random Allocation	3. Concealed Allocation	4. Baseline Comparability	5. Blind Subjects	6. Blind Therapists	7. Blind Assessors	8. Measures of key outcomes from more than 85% of subjects	9. Intention to treat analysis	10. Between-group comparisons	11. Point Estimates &variability	PEDro score
1. Areeudomwong et al.,2019	√	√	√	√	×	√	√	√	√	√	√	9/10
2. Cai et al.,2017	√	√	Unclear	√	√	×	×	√	×	√	√	6/10
3. Mendes et al.,2020	√	√	Unclear	√	×	×	√	√	√	√	√	7/10
4. Kang et al.,2017	√	√	Unclear	√	Unclear	Unclear	Unclear	√	√	√	√	6/10
5. Park et al.,2023	√	√	√	√	√	×	√	√	×	√	√	8/10
6. Sipaviciene et al.,2020	√	√	Unclear	√	Unclear	Unclear	Unclear	√	Unclear	√	√	5/10
7. Salamat et al.,2017	√	√	Unclear	√	Unclear	×	Unclear	√	×	√	√	5/10
8. Wang et al.,2023	√	√	√	√	√	√	√	√	×	√	√	9/10
9. Bae et al.,2018	√	√	√	√	Unclear	Unclear	Unclear	√	×	√	√	6/10
10. Narouei et al.,2020	√	√	Unclear	√	√	×	×	√	×	√	√	6/10
11. França et al.,2012	√	√	√	√	Unclear	Unclear	Unclear	√	√	√	√	7/10
12. Sengul et al., 2021	√	√	√	√	Unclear	Unclear	Unclear	√	×	√	√	6/10
13. Danneels et al., 2001	√	√	Unclear	√	Unclear	Unclear	Unclear	√	√	√	√	6/10
14. Alp et al., 2014	√	√	√	√	×	×	√	√	√	√	√	8/10
15. Franca et al., 2010	√	√	√	√	Unclear	Unclear	Unclear	√	√	√	√	7/10
16. Alrwaily et al., 2019	√	√	√	√	×	×	×	√	×	√	√	6/10
17. Amiri et., 2022	√	√	√	√	×	×	Unclear	√	√	√	√	7/10
18. Nabavi et al., 2017	√	√	√	√	Unclear	×	×	√	√	√	√	7/10
19. Suh et al., 2019	√	√	√	√	×	×	√	√	×	√	√	7/10
20. Ahmadizadeh et al., 2019	√	√	√	√	×	×	√	√	√	√	√	8/10
21. Guthrie et al., 2012	√	√	√	√	×	×	√	√	×	√	√	7/10
22. Kwon et al., 2020	√	√	Unclear	√	Unclear	Unclear	Unclear	√	√	√	√	6/10
23. Hosseinifar et al., 2013	√	√	Unclear	√	Unclear	Unclear	Unclear	√	×	√	√	5/10
24. Ehsani et al, 2020	√	√	√	√	√	√	√	√	×	√	√	9/10
25. Ulger et al., 2020	√	√	√	√	Unclear	Unclear	Unclear	√	×	√	√	6/10
26. Chan et al., 2020	√	√	√	√	×	×	√	√	√	√	√	8/10

4.2 Findings of major characteristics of included studies
This study found that the controversy persists regarding whether CST can more effectively enhance pain relief, trunk muscular endurance, core muscle thickness, and activation compared to alternative treatments, despite its similarity to resistance exercises for knee and hip muscles and progressive back extensor training. Nevertheless, CST demonstrates superior efficacy in enhancing trunk muscle strength compared to other interventions.

4.2.1 Articles on CST improving low back pain in adults
In terms of improvement in pain intensity, eight studies showed that CST was more effective than other exercise therapies(Ehsani et al., 2019; França et al., 2012; Hosseinifar et al., 2013; Kwon et al., 2020; Mendes et al., 2022; Salik Sengul et al., 2021; Sipaviciene & Kliziene, 2020; Suh et al., 2019). One study was an excellent quality study, five studies were good quality studies, and two studies were fair quality studies. Ten studies, however, concluded that CST had no advantage over other exercise therapies in improving pain(Ahmadizadeh et al., 2020; Alp et al., 2014; Amiri et al., 2022; Areeudomwong & Buttagat, 2019; Bae et al., 2018; Franca et al., 2010; Nabavi et al., 2018; Salamat et al., 2017; Ulger et al., 2023; Wang et al., 2022). Three of the studies were excellent quality studies, six were good quality studies, and one was a fair quality study. In addition, one high-quality study showed that CST was more effective than passive therapy in improving lower back pain(Narouei et al., 2020).

4.2.2 Articles on CST improving trunk muscular endurance in adults
In terms of improving trunk muscular endurance, two good-quality studies showed that CST was more effective than other exercise therapies(Alp et al., 2014; Salik Sengul et al., 2021). However, two good-quality studies showed that CST was less effective than Flexi-bar exercise, walking exercise, and stabilization with walking(Amiri et al., 2022; Suh et al., 2019).

4.2.3 Articles on CST improving core muscle thickness in adults
Regarding improving core muscle thickness or cross-sectional area, four studies showed that CST was more effective than other exercise therapies(Ehsani et al., 2020; Hosseinifar et al., 2013; Narouei et al., 2020; Sipaviciene & Kliziene, 2020). One study was an excellent-quality study, one was a good-quality study, and two were fair-quality studies. However, three studies concluded that CST was not superior to other exercise therapies(Kwon et al., 2019; Nabavi et al., 2018; H. Wang et al., 2023). One study was an excellent-quality study, and two studies were good-quality studies. In addition, one good-quality study showed that muscle dimensions of TrA and multifidus increased after CST intervention(Nabavi et al., 2018).

4.2.4 Articles on CST improving core muscle fatigue in adults
In terms of improving core muscle fatigue, two good-quality studies have shown that CST has no advantage over other exercise therapies in improving core muscle fatigue(Cai et al., 2017; Mendes et al., 2022).

4.2.5 Articles on CST improving core muscle activation in adults
In terms of improving core muscle activation, six studies have shown that CST is more effective than other exercise therapies(Ahmadizadeh et al., 2020; Areeudomwong & Buttagat, 2019; Franca et al., 2010; França et al., 2012; Kwon et al., 2020; Ulger et al., 2023), one of which was an excellent quality study, and the others were good quality studies. However, two studies have concluded that there is no advantage of CST over other exercise therapies(Areeudomwong & Buttagat, 2019; Cai et al., 2017), one of which was an excellent quality study, and the other was a good quality study.

4.2.6 Articles on CST improving trunk muscle strength in adults
In terms of improving muscle strength, one good quality study showed that CST was more effective in increasing trunk muscle strength in individuals with LBP relative to a usual exercise routine(Mendes et al., 2022).

5.0 Discussion
For this systematic review, 26 RCTs were identified that compared CST with at least one control group; 7 of them had extended follow-up. The overall quality of the trials was moderate, with 23 publications receiving a PEDro score of 6 at least. Only studies with clearly specified CST as the major treatment were included after a considerable number of prospective studies were removed.

5.1 Effects of CST on pain intensity, trunk muscular endurance, core muscle thickness and fatigue among adults with low back pain
Regarding Effects of CST on pain intensity, trunk muscular endurance, core muscle thickness and fatigue among adults with low back pain, the results of the present study suggest that the results of different previous studies are not consistent. Although 22 studies have shown that CST can be more effective in improving pain intensity, trunk muscular endurance, core muscle thickness or fatigue in patients with CLBP to varying degrees relative to other therapies, 20 studies have disagreed. These indicated that it is still controversial whether CST can better improve pain, trunk muscular endurance, core muscle thickness and *fatigue* than other exercise therapies. The reason may be related to the different CST intervention methods used in different studies, or it may be related to the different applicability of CST to different age groups. Exercise therapy, particularly active exercise therapy, is recognised as an effective treatment for CLBP, providing over 20% pain relief and improving function by up to 23%(Hayden et al., 2020). CST, Pilates exercises, motor control, resistance exercise and aerobic exercise are the right choices for pain relief and improved function(Nascimento et al., 2018; Eliks et

al.,2019; Owen et al.,2019). However, it is often difficult to determine the optimal form of exercise because of the wide variety of exercise methods and individual differences. It has been suggested that the choice of exercise should be based on individual preferences and abilities(Malfliet et al., 2019).

5.2 Effects of CST on core muscle strength and Activation among Adults with low back pain

According to the findings, CST is more advantageous than other exercise therapies in improving core muscle strength, and activation in patients with LBP. The reason for this could be that CST is typically performed on unsteady planes. Compared with other exercise therapies, it can stimulate and activate the small, deep muscle groups of the patient's trunk more effectively, thereby enhancing core muscle strength. Studies have confirmed that trunk muscular weakness, profound trunk muscle weakness has been linked to persistent LBP in studies (Wang et al., 2022). This may increase the risk of lumbar spine instability, additional spine damage, and, eventually, diminished physical activity. CST is a standard method for recovering trunk muscle functioning and achieving optimal lumbar stability throughout regular activities (Mohammadi et al., 2023).

5.3 Strengths of the study

This study is the first systematic review to explore the effect of CST on improving muscle physiology in patients with CLBP. The PEDro scale was utilized for quality assessments.

5.4 Clinical Implications

The results of this study can be used in clinical exercise therapy especially core stabilisation training for the treatment of chronic low back pain. It serves as a valuable reference for both low back pain patients and clinical workers in optimizing treatment plans, as well as aiding health system institutions in developing clinical guidelines for low back pain.

5.5 Future research

Future research should look into other factors such as functional performance, quality of life, disability, fear avoidance, global improvement, costs, and return to employment, and should concentrate on standardizing CST intervention procedures and determining the appropriate age group for CST treatment in patients with LBP.

6.0 Conclusion & Recommendations

This study has several limitations. First, only research written in English and published as full papers were considered, and no unpublished articles were searched. Second, only RCT studies on CST for the treatment of CLBP were included. Third, in terms of trial quality, several publications needed more information to assess the data's quality and clinical significance. Furthermore, relatively few research have looked at the long-term implications of CST in the treatment of CLBP.

This review revealed that relative to other exercise treatments, for LBP patients, CST was more efficacious in improving core muscle strength and activation, but CST did not have an advantage in improving core muscle fatigue, whereas the efficacy of CST in improving pain, trunk muscle endurance, and core muscle thickness is still controversial.

Based on the results of this study, the clinical use of CST is recommended to improve muscle physiology in patients with CLBP, especially in terms of improving core muscle strength and the degree of core muscle activation. The efficacy of CST in combination with other active exercise therapies in improving muscle physiology and function in CLBP patients should be further explored in the future through multicentre, large-sample clinical randomised trials.

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Paper Contribution to Related Field of Study

Provides a reference for the clinical optimization of LBP treatment prescriptions and efficient improvement of pain and muscle physiology in patients with CLBP.

References

Amiri, F., Mohsen Roostayi, M., Naimi, S. S., & Akbarzadeh Baghban, A. (2022). Stabilization Exercises versus Flexi-Bar Exercises in Chronic Non-Specific Low Back Pain: Pain, Disability, Back Muscles Endurance. A Randomized Controlled Trial. Muscle Ligaments and Tendons Journal, 12(04), 604.

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.

Czaprowski, D., Stoliński, Ł., Tyrakowski, M., Kozinoga, M., & Kotwicki, T. (2018). Non-structural misalignments of body posture in the sagittal plane. Scoliosis and Spinal Disorders, 13(1).

Ferreira, M. L., Katie de Luca, Haile, L. M., Steinmetz, J. D., Culbreth, G. T., Cross, M., Kopec, J. A., Ferreira, P. H., Blyth, F. M., Buchbinder, R., Hartvigsen, J., Wu, A.-M., Saeid Safiri, Woolf, A., Collins, G. S., Ong, K. L., Stein Emil Vollset, Smith, A. E., Cruz, J. A., & Kai Glenn Fukutaki. (2023). Global, regional, and national burden of low back pain, 1990–2020, its attributable risk factors, and projections to 2050: a systematic analysis of the Global Burden of Disease Study 2021. The Lancet Rheumatology, 5(6), e316–e329.

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.

Georgios Kakavas, Giannakopoulos, I., Αθανάσιος Τσιόκανος, Potoupnis, M., & Panagiotis Tsaklis. (2023). The Effect of Ball Heading and Subclinical Concussion On the Neuromuscular Control Of The Lower Limb: A Systematic Review. The International Journal of Sports Physical Therapy, 18(5).

Ghafouri, M., Ghasemi, E., Rostami, M., Mahtab Rouhifard, Rezaei, N., Nasserinejad, M., Khashayar Danandeh, Amin Nakhostin-Ansari, Ghanbari, A., Alireza Borghei, Amiri, A., Azin Teymourzadeh, Taylor, J. B., Moghadam, N., & Ramin Kordi. (2023). The quality of care index for low back pain: a systematic analysis of the global burden of disease study 1990–2017. Archives of Public Health, 81(1).

Ghamkhar, L., & Kahlaee, A. H. (2019). The effect of trunk muscle fatigue on postural control of upright stance: A systematic review. Gait & Posture, 72, 167–174.

Hayden, J. A., Wilson, M. N., Stewart, S., Cartwright, J. L., Smith, A. O., Riley, R. D., van Tulder, M., Bendix, T., Cecchi, F., Costa, L. O. P., Dufour, N., Ferreira, M. L., Foster, N. E., Gudavalli, M. R., Hartvigsen, J., Helmhout, P., Kool, J., Koumantakis, G. A., Kovacs, F. M., & Kuukkanen, T. (2020). Exercise treatment effect modifiers in persistent low back pain: an individual participant data meta-analysis of 3514 participants from 27 randomised controlled trials. British Journal of Sports Medicine, 54(21), 1277–1278.

Hemming, R., Sheeran, L., van Deursen, R., & Sparkes, V. (2019). Investigating differences in trunk muscle activity in non-specific chronic low back pain subgroups and no-low back pain controls during functional tasks: a case-control study. BMC Musculoskeletal Disorders, 20(1).

Kamel, E., Abdelmajeed, S., El Khozamy, H., & Hassan, K. (2021). Trunk and hip muscles activation patterns in subjects with and without chronic low back pain: a systematic review. Physiotherapy Quarterly, 29(2), 79–88.

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.

Kwon, S. H., Oh, S. J., & Kim, D. H. (2019). The effects of lumbar stabilization exercise on transversus abdominis muscle activation capacity and function in low back pain patients. Isokinetics and Exercise Science, 28(2), 1–6.

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.

Mohammadi, V., Letafatkar, A., Amir, A., & Jafarnezhadgero. (2023). Number 1. Physical Treatments. PTJ, 13(1), 55–66.

Owen, P. J., Miller, C. T., Mundell, N. L., Verswijveren, S. J., Tagliaferri, S. D., Brisby, H., Bowe, S. J., & Belavy, D. L. (2019). Which specific modes of exercise training are most effective for treating low back pain? Network meta-analysis. British Journal of Sports Medicine, 54(21), 1279–1287.

Paez, A. (2017). Gray literature: an Important Resource in Systematic Reviews. Journal of Evidence-Based Medicine, 10(3), 233–240.

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., & McGuinness, L. A. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. Systematic Reviews, 10(1).

Rique, P., Gomes, S. R. A., Costa, L. D. O., Liguori, L., L C C Bulhões, & Brasileiro, J. S. (2022). Core stabilisation exercises reduce chronic low back pain in Air Force fighter pilots: a randomised controlled trial. PubMed, e002005–e002005.

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.

Stochkendahl, M. J., Kjaer, P., Hartvigsen, J., Kongsted, A., Aaboe, J., Andersen, M., Andersen, M. Ø., Fournier, G., Højgaard, B., Jensen, M. B., Jensen, L. D., Karbo, T., Kirkeskov, L., Melbye, M., Morsel-Carlsen, L., Nordsteen, J., Palsson, T. S., Rasti, Z., Silbye, P. F., & Steiness, M. Z. (2017). National Clinical Guidelines for non-surgical treatment of patients with recent onset low back pain or lumbar radiculopathy. European Spine Journal, 27(1), 60–75.

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.

Wang, H., Zheng, J., Fan, Z., Luo, Z., Wu, Y., Cheng, X., Yang, J., Zhang, S., Yu, Q., Lo, W. L. A., & Wang, C. (2022). Impaired static postural control correlates to the contraction ability of trunk muscle in young adults with chronic non-specific low back pain: A cross-sectional study. Gait & Posture, 92, 44–50.

APPENDIX A: Search strategy

Database	String Used
Pubmed	(((((((((((core stabilization exercise[Title/Abstract]) OR (core stabilization training[Title/Abstract])) OR (core stability exercise[Title/Abstract])) OR (core stability training[Title/Abstract])) OR (stability training[Title/Abstract])) OR (stability exercise[Title/Abstract])) OR (stabilization training[Title/Abstract])) OR (stabilization exercise[Title/Abstract])) OR (stability[Title/Abstract])) OR (stabilization[Title/Abstract])) OR (motor control[Title/Abstract])) AND (((((((((((((low back pain[MeSH Terms]) OR (lumbar pain[MeSH Terms])) OR (sciatica[MeSH Terms])) OR (lower back pain[Title/Abstract])) OR (back pain[Title/Abstract])) OR (backache[Title/Abstract])) OR (dorsalgia[Title/Abstract])) OR (lumbago[Title/Abstract])) OR (lumbar disc herniation[Title/Abstract])) OR (intervertebral disc disease[Title/Abstract])) OR (pelvic girdle pain[Title/Abstract])) OR (LBP[Title/Abstract])) AND ((("randomized controlled trial"[Publication Type]) OR RCTs[Title/Abstract])) OR (random allocation[Title/Abstract])) NOT ("review"[Publication Type]) AND ("english"[Language]) AND ("humans"[Filter]))
Web of science	(((((((((((TS=(core stabilization exercise)) OR TS=(core stabilization training)) OR TS=(core stability exercise)) OR TS=(core stability training)) OR TS=(stability training)) OR TS=(stability exercise)) OR TS=(stabilization training)) OR TS=(stabilization exercise)) OR TS=(stability)) OR TS=(stabilization)) OR TS=(motor control)) AND ((((((((((((TS=(low back pain)) OR TS=(lumbar pain)) OR TS=(sciatica)) OR TS=(lower back pain)) OR TS=(back pain)) OR TS=(backache)) OR TS=(dorsalis)) OR TS=(lumbago)) OR TS=(lumbar disc herniation)) OR TS=(intervertebral disc disease)) OR TS=(pelvic girdle pain)) OR TS=(LBP)) AND (((TS=(randomized controlled trial)) OR TS=(RCTs)) OR TS=(random allocation)) NOT (DT=(Review)) AND (LA=(English))
Scopus	(TITLE-ABS-KEY(core stabilization exercise) OR TITLE-ABS-KEY(core stabilization training) OR TITLE-ABS-KEY(core stability exercise) OR TITLE-ABS-KEY(core stability training) OR TITLE-ABS-KEY(stability training) OR TITLE-ABS-KEY(stability exercise) OR TITLE-ABS-KEY(stabilization training) OR TITLE-ABS-KEY(stabilization exercise) OR TITLE-ABS-KEY(stability) OR TITLE-ABS-KEY(stabilization) OR TITLE-ABS-KEY(motor control)) AND (TITLE-ABS-KEY(low back pain) OR TITLE-ABS-KEY(lumbar pain) OR TITLE-ABS-KEY(sciatica) OR TITLE-ABS-KEY(lower back pain) OR TITLE-ABS-KEY(back pain) OR TITLE-ABS-KEY(backache) OR TITLE-ABS-KEY(dorsalis) OR TITLE-ABS-KEY(lumbago) OR TITLE-ABS-KEY(lumbar disc herniation) OR TITLE-ABS-KEY(intervertebral disc disease) OR TITLE-ABS-KEY(pelvic girdle pain) OR TITLE-ABS-KEY(LBP)) AND (TITLE-ABS-KEY(randomized controlled trial) OR TITLE-ABS-KEY(random allocation)) AND NOT (DOCTYPE(re)) AND (LANGUAGE(english))