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Effect of Core Stabilization Exercise on Young Adults with Chronic Low Back Pain

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Abstract

Background: The impact of chronic low back pain (CLBP) on younger populations is becoming more widely acknowledged, and it is a major cause of disability worldwide. Although core stabilisation exercise (CSE) is frequently used in CLBP rehabilitation, the evidence pertaining to young adults specifically has not been well defined.

Objectives: This review sought to locate, evaluate, and quantitatively combine randomized controlled trials (RCTs) investigating whether CSE reduces pain and improves functional disability in adults aged 18-35 years with chronic non-specific low back pain.

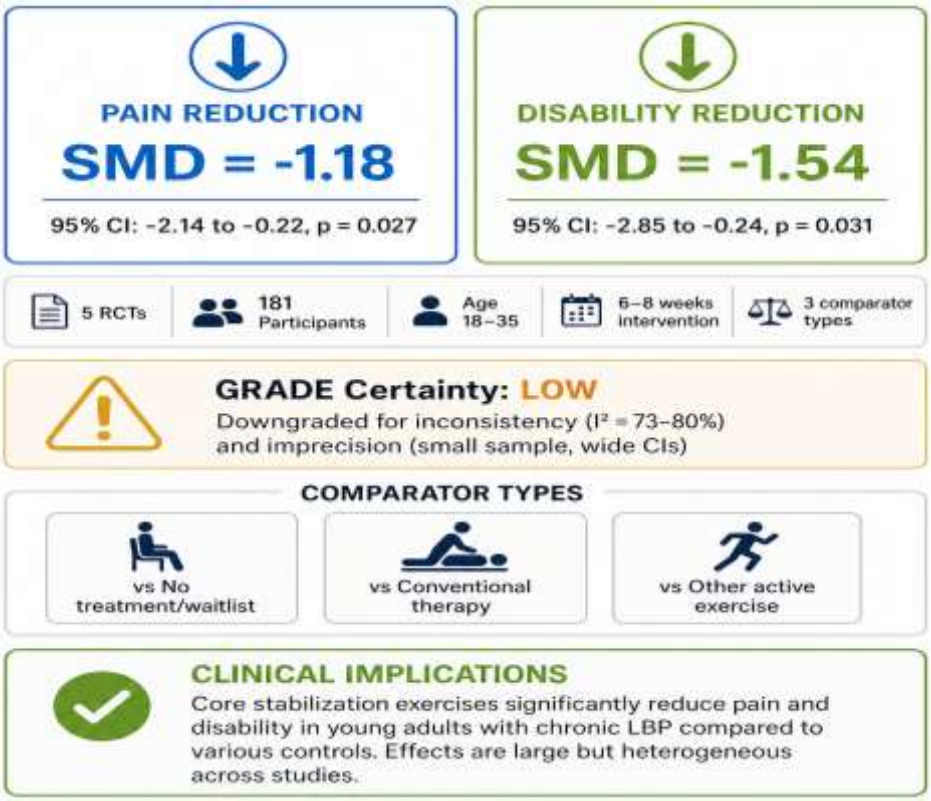
Methods: We searched for randomised trials published between January 2021 and March 2026 using WebSearch and LiteratureSearch. Studies that compared CSE with a control condition, included persons between the ages of 18 and 35 who had low back pain lasting more than 12 weeks, and used VAS/NRS to measure pain and/or ODI/RMDQ to measure disability were eligible. Using the Cochrane Risk of Bias 2 tool, methodological quality was evaluated. Using random-effects models with Hartung-Knapp adjustment, pooled estimates were produced, and Hedges' g standardised mean differences (SMDs) were used to describe treatment effects. The evidence's certainty was evaluated using GRADE and comparator-specific analyses were conducted.

Results: Five eligible RCTs contributed data from 181 participants. Mean ages were approximately 20-33 years, and treatment programs lasted 6-8 weeks. Relative to control conditions, CSE produced statistically significant improvements in pain (pooled SMD = -1.18, 95% CI -2.14 to -0.22, p = 0.027) and disability (pooled SMD = -1.54, 95% CI -2.85 to -0.24, p = 0.031). Considerable between-study variation was present for both pain (I-squared = 73.1%, tau-squared = 0.43) and disability (I-squared = 80.2%, tau-squared = 0.86). Categorizing comparators as no treatment/waitlist, conventional therapy, or another active exercise did not account for this heterogeneity. Leave-one-out analyses continued to show an overall advantage for CSE and identified Khan (2024) as the trial with the greatest influence on the pooled estimates. GRADE certainty was Low for both outcomes.

Conclusions: Among young adults with CLBP, CSE was associated with clinically relevant reductions in pain and functional limitation across the included comparisons. These estimates should not be interpreted as definitive because the results varied substantially between trials and overall certainty was Low. Larger

RCTs with stronger methodology, improved outcome-assessor blinding, and longer follow-up are required to establish the true magnitude and persistence of benefit.

Keywords: Randomised controlled trials, meta-analyses, systematic reviews, young people, persistent low back pain, and core stability



1. Introduction

One of the most common musculoskeletal conditions in the world is low back pain (LBP). The illness affects over 500 million individuals and is the leading cause of years lived with disability worldwide [1]. According to data from the Global Burden of Disease Study 2021, prevalence is expected to rise further and might surpass 800 million cases by 2050 due to population growth, ageing, and occupational exposures [1]. Although LBP has historically been associated with older persons, its prevalence among teenagers and young adults is now increasing [2, 3]. Global assessments limited to those between the ages of 15 and 49 likewise show a significant illness burden with significant geographical and sex-related variations [3].

Chronic non-specific LBP generally refers to symptoms lasting longer than 12 weeks when no distinct structural cause can be identified, and it represents most clinical presentations of LBP. Persistent pain arising in early adulthood is important because it can promote enduring patterns of activity avoidance, pain-related behavior, and repeated use of healthcare services. In younger people, commonly reported contributors include sedentary behavior, long periods of sitting during education or early employment, and low levels of physical fitness [2].

The purpose of CSE is to improve coordinated recruitment of the deep trunk muscles involved in spinal control, particularly the transversus abdominis, lumbar multifidus, internal oblique, and pelvic floor. This

rationale is supported by evidence that people with LBP may demonstrate delayed transversus abdominis activation, reduced multifidus quality through atrophy or fatty infiltration, and impaired control of stabilizing musculature. Training these muscles to activate in a more timely and coordinated manner is intended to enhance spinal stability, alleviate symptoms, and improve function. Earlier systematic reviews involving broader CLBP populations have reported moderate-to-large benefits from stabilization-focused exercise [17, 18, 19]; however, those reviews combined wide age ranges and did not provide a pooled estimate specifically for young adults.

Although recent reviews generally favor stabilization-based exercise, the reported magnitude of benefit differs across analyses. Dimitrijevic et al. (2025) synthesized 23 studies and estimated an SMD of -0.88 for pain [18]. Liu et al. (2026) reported pooled effects of approximately -0.56 for pain and -0.81 for disability across several core-muscle training approaches [19]. Conversely, the five-study review by Smrcina et al. (2022) found limited evidence that CSE outperformed alternative exercise strategies [17]. None of these reviews, however, presented pooled estimates focused specifically on young adults.

A separate evaluation of younger adults is clinically relevant for several reasons. Their symptoms may be influenced more strongly by reversible muscular or motor-control deficits and less by degenerative change associated with aging. Exercise responses may also differ because younger adults often have different baseline fitness, psychosocial circumstances, and potential for neuromuscular adaptation. Effective intervention early in adult life may therefore help prevent progression toward persistent disability and reduce the long-term personal and healthcare burden of CLBP.

Therefore, using any suitable non-CSE intervention as the comparator, this systematic review and meta-analysis looked at RCTs published between 2021 and 2026 to ascertain the impact of CSE on pain intensity and functional impairment in persons aged 18 to 35 years with chronic non-specific LBP.

2. Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines were followed in conducting and reporting the review [4].

2.1 Eligibility Criteria

Study eligibility was specified using the PICOS framework:

Population (P): Participants were required to be young adults aged 18-35 years with chronic non-specific LBP lasting at least 12 weeks. Trials with wider age limits were considered when the mean participant age fell within or close to this range and young adults comprised most of the sample.

Intervention (I): Eligible programs were described as core stabilization, core stability, lumbar stabilization, or motor control exercise. To qualify, the intervention had to deliberately train deep trunk stabilizers, including the transversus abdominis, lumbar multifidus, pelvic floor, or diaphragm, with the objective of improving motor control and spinal stability.

Comparator (C): Any control condition that did not involve CSE was accepted. This included no treatment, waitlist control, conventional physiotherapy, general exercise, and alternative active exercise programs.

Outcomes (O): Pain severity and functional impairment were the predetermined main objectives. The Oswestry Disability Index (ODI) or Roland-Morris Disability Questionnaire (RMDQ) were used to assess disability, while the Visual Analogue Scale (VAS) or Numeric Rating Scale (NRS) were used to quantify pain.

Study design (S): Only randomized controlled trials were included. Quasi-randomized, non-randomized interventional, and observational studies were excluded.

Studies were not eligible when: (1) both groups received forms of CSE without a non-CSE comparison; (2) participants had acute or subacute LBP of less than 12 weeks; (3) the sample involved a specific spinal disorder such as disc herniation or spinal stenosis; or (4) outcome information could not be extracted or transformed for quantitative synthesis.

2.2 Information Sources and Search Strategy

In order to retrieve evidence, two complimentary methods were applied. WebSearch expanded the search for recent RCTs and review literature, whereas LiteratureSearch found peer-reviewed records indexed by Consensus and Exa. The publishing window ran from January 2021 to March 2026, and unrestricted language searches were finished in August 2026. For reproducibility, the search terms were the following: "core stabilisation exercises chronic low back pain young adults randomised controlled trial," "core stability exercise intervention chronic nonspecific low back pain randomised trial pain disability outcome," in addition to "core stabilisation exercises chronic low back pain young adults RCT systematic review meta-analysis."

2.3 Selection Process

The selection procedure was handled by a single reviewer. Before potentially pertinent reports were evaluated in full, titles and abstracts were checked against the qualifying requirements. At the full-text stage, explanations for exclusion were noted. The whole PRISMA 2020 process, including identification, screening, eligibility evaluation, and ultimate inclusion, is shown in Figure 1.

2.4 Data Collection and Extraction

Data extraction was done using a standard form. Authorship, year of publication, journal, study design, group sample sizes, participant characteristics (e.g., age, sex, and duration of pain), specifics of the CSE intervention (e.g., type, duration, frequency, and number of sessions), comparator characteristics, and outcome data were all recorded from each trial. Standard deviations, between-group differences, confidence intervals, p-values, and baseline and post-treatment averages were among the extracted results. Standardised effects were obtained by applying recognised conversion techniques where data were not immediately appropriate for pooling. For pooled-SD computations, post-treatment means and SDs were preferred; between-group mean differences and 95% CIs were converted to standard errors; t-statistics and standard errors were derived using change scores with p-values; and baseline SDs were used in the absence of post-treatment SDs. All effect estimates were calculated using Hedges' g, which included the small-sample correction.

2.5 Risk of Bias Assessment

The methodological quality was assessed using the Cochrane Risk of Bias 2 (RoB 2) tool [5]. The randomisation procedure (D1), deviations from planned interventions (D2), missing outcome data (D3), outcome measurement (D4), and choice of the reported result (D5) were the five areas covered by the evaluation. The experiment was divided into three categories: Low risk, Some concerns, and High risk.

2.6 Synthesis Methods

In quantitative synthesis, a general inverse-variance random-effects model was employed. R's meta and metafor packages were used to estimate between-study variance using restricted maximum likelihood (REML) and update confidence intervals using the Hartung-Knapp technique. Hedges' g SMDs were used to report the effects; negative values indicated an advantage to CSE. I-squared with a 95% CI and Cochran's Q statistic were used to measure statistical heterogeneity. Additionally, prediction ranges were computed to characterise the likely range of real effects that may be found in a subsequent investigation. Three categories comprised comparator-based subgroup analysis, which was predefined:

(1) no treatment or waitlist, (2) conventional therapy such as physiotherapy or basic treatment, and (3) another active exercise approach, including progressive postural control exercise or traditional waist strengthening. Differences between these subgroups were tested with the between-subgroup Q statistic. Robustness and influence were examined with leave-one-out analyses, studentized residuals, Cook's distance, and DFFITS. Egger's regression was used only as an exploratory test for small-study effects because the procedure has limited statistical power when fewer than 10 studies are available.

2.7 Certainty of Evidence

The GRADE system was used to assess each primary outcome's level of evidentiary certainty [6]. Risk of bias, inconsistency, indirectness, imprecision, and potential publication bias were taken into account before classifying the evidence from the RCTs as High, Moderate, Low, or Very Low.

3. Results

3.1 Study Selection

Searches retrieved 49 records in total, including 25 from LiteratureSearch and 24 from WebSearch. Removal of 15 duplicate records left 34 unique citations for title and abstract screening. Twenty-four were excluded because they were not randomized trials or did not correspond to the target population or intervention, leaving 10 reports for full-text review. Five reports were subsequently excluded. Hlaing et al. (2021) studied subacute LBP [12]. Akodu et al. (2024) compared approaches to delivering CSE but did not include a non-CSE comparator [13]. Zheng et al. (2022) provided CSE to both groups while testing an m-health/self-compassion component [14]. Nayel et al. (2025) compared CSE alone with CSE plus Russian electrical stimulation, so both groups received CSE [15]. Elgendy et al. (2025) did not provide outcomes in a form that could be used for quantitative pooling [16]. The remaining five RCTs met all eligibility requirements and were included in the qualitative review and meta-analysis (Figure 1).

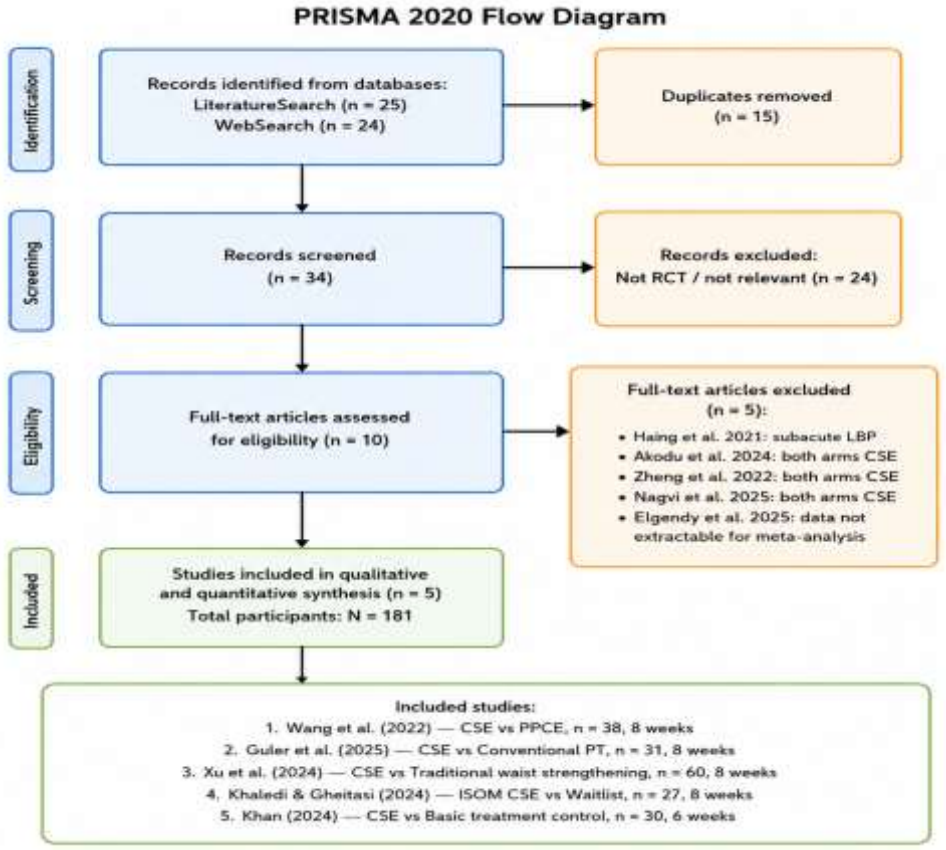


Figure 1. PRISMA 2020 flow diagram showing the identification, screening, evaluation of eligibility, and inclusion of records.

3.2 Study Characteristics

The five eligible RCTs were published from 2022 to 2025 and collectively enrolled 181 participants; individual trial samples ranged from 27 to 60. CSE was generally provided three times weekly for 6-8 weeks. Control conditions included one no-treatment/waitlist group, two conventional physiotherapy or basic-treatment groups, and two active exercise comparators, namely progressive postural control exercise and traditional waist-strengthening exercise. Every trial measured pain with the VAS and functional disability with the ODI. Table 1 summarizes the study characteristics.

Table 1. Features of the randomised controlled trials that were analysed.

Study	Participant profile (n, age, sex)	CSE program	Control	Period	Outcomes	Comparator type
Wang et al. (2022) [7]	n=33 (16 CSE / 17 PPCE) Age 18-40 10M/24F	Progressive core stability exercise (Swiss ball; staged progression)	Progressive postural control exercise (PPCE)	8 weeks	VAS, ODI, RMDQ	Other active exercise

Study	Participant profile (n, age, sex)	CSE program	Control	Period	Outcomes	Comparator type
Guler et al. (2025) [8]	n=31 (15 CSE / 16 CG) Age 18-65 NCT05302349	Swiss-ball core stabilization (3 sets x 10 repetitions)	Conventional physiotherapy (US, TENS, exercise)	8 weeks	VAS, ODI, MRI	Conventional therapy
Xu et al. (2024) [9]	n=60 (30 CSE / 30 CG) Age 18-35 All male	Progressive laboratory-based core stability training	Traditional waist-strengthening exercise	8 weeks	VAS, ODI, EMG	Other active exercise
Khaledi & Gheitasi (2024) [10]	n=27 (13 ISOM / 14 WL) Adults with NSCLBP	Isometric CSE (40-60 min; 3 sessions/week)	Waitlist control (no treatment)	8 weeks	VAS, ODI	No treatment/waitlist
Khan (2024) [11]	n=30 (15 CSE / 15 CG) Mean age 20.24	Supervised progressive core-strengthening exercise	Basic treatment (hot pack, stretching, isometric exercise)	6 weeks	VAS, ODI	Conventional therapy

3.3 Risk of Bias

The risk-of-bias evaluation is summarised in Table 2 and Figures 2 and 3. The aggregate RoB 2 rating for each of the five RCTs was "Some concerns," and none of the trials were deemed high risk in any particular domain.

Four trials in D1 were classified as having "Some concerns" because they did not give enough information on sequence generation or allocation. Guler and associates (2025),which used web-based randomization with a pre-generated allocation sequence, was judged Low risk for D1 [8]. All trials received "Some concerns" for D2 because participant and therapist blinding is usually not practical in exercise interventions. D3 was judged Low risk across studies because missing outcome data were absent or minimal. D4 received "Some concerns" in most trials because outcome assessors generally knew the assigned intervention; the MRI assessment in Guler et al. was the exception [8]. For D5, four trials had no protocol registration and were rated as having "Some concerns," whereas the prospectively registered Guler et al. (2025) trial was judged Low risk [8].

Table 2. Cochrane RoB 2 scores for the randomised studies that were part of the review.

Study	D1 Randomization	D2 Deviations	D3 Missing data	D4 Measurement	D5 Reporting	Overall
Wang et al. (2022)	Some concerns	Some concerns	Low	Some concerns	Some concerns	Some concerns
Guler et al. (2025)	Low	Some concerns	Some concerns	Some concerns	Low	Some concerns
Xu et al. (2024)	Some concerns	Some concerns	Low	Some concerns	Some concerns	Some concerns
Khaledi & Gheitasi (2024)	Some concerns	Some concerns	Low	Some concerns	Some concerns	Some concerns
Khan (2024)	Some concerns	Some concerns	Low	Some concerns	Some concerns	Some concerns

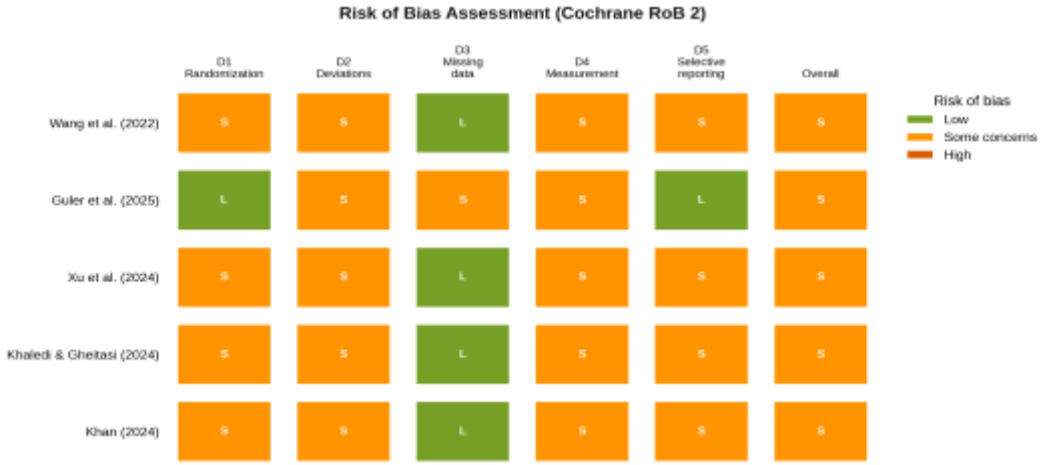


Figure 2. Summary of RoB 2 judgements at the trial level for each of the five evaluated domains.

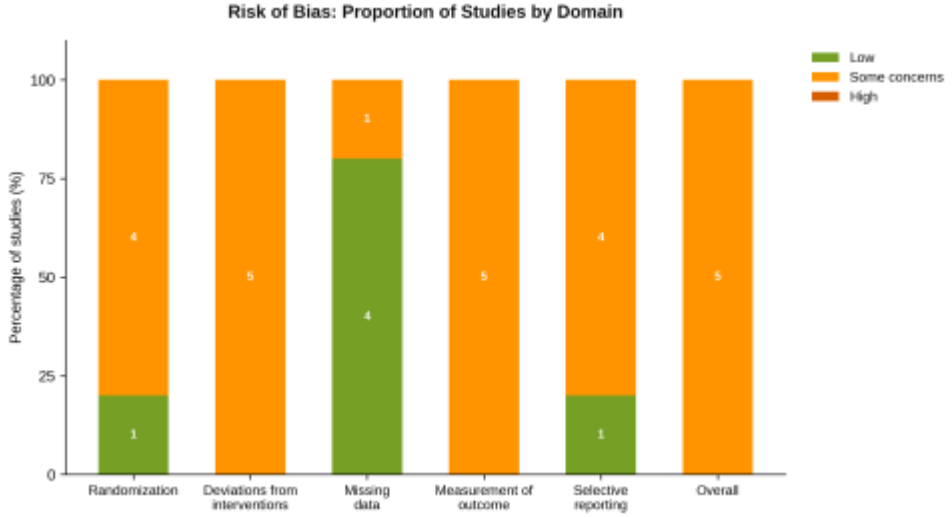


Figure 3. Percentage of risk-of-bias assessments for every RoB 2 domain.

3.4 Pain Intensity

All five studies, including 181 individuals, had VAS pain results available. A statistically significant benefit of CSE was demonstrated by random-effects pooling (pooled SMD = -1.18, 95% CI -2.14 to -0.22, p = 0.027; Figure 4), which corresponds to a substantial standardised decrease in pain. There was significant heterogeneity (tau-squared = 0.43; Cochran's Q = 14.87, df = 4, p = 0.005; I-squared = 73.1%, 95% CI 32.7-89.2%). A future experiment may perhaps demonstrate anything from a very big reduction in pain to a minor impact favouring the comparator, according to the 95% prediction interval, which is -3.22 to 0.87.

Comparator category did not significantly account for the variability between trials (Q between = 4.33, df = 2, p = 0.115). The estimated SMD was -1.39 (95% CI -2.23 to -0.55) for the single no-treatment/waitlist comparison, -1.79 (95% CI -8.66 to 5.08) for the two conventional-therapy trials, and -0.58 (95% CI -4.97 to 3.81) for the two trials using another active exercise. The very wide confidence intervals in the multi-study subgroups reflect the limited number of trials together with substantial heterogeneity within those categories.

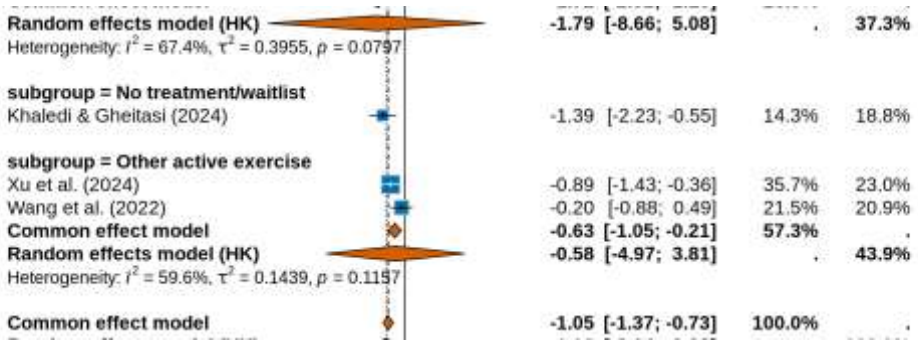


Figure 4. The combined impact of CSE on VAS pain intensity is displayed in a forest plot.

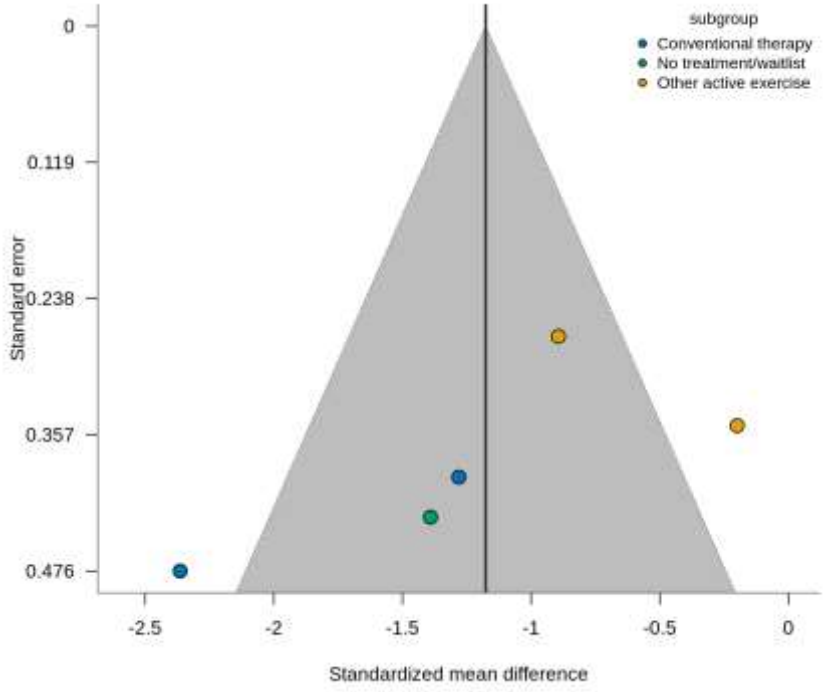


Figure 5. The funnel plot for the meta-analysis of pain intensity.

3.5 Functional Disability

Outcomes related to ODI disability were reported from all five RCTs, which included 181 individuals. Once more supporting CSE, the random-effects estimate was statistically significant (pooled SMD = -1.54, 95% CI -2.85 to -0.24, p = 0.031; Figure 6), indicating a substantial standardised improvement in impairment. Compared to pain, heterogeneity was much higher (I-squared = 80.2%, 95% CI 53.5-91.6%; tau-squared = 0.86; Cochran's Q = 20.22, df = 4, p < 0.001). The interval of the 95% forecast was between -4.41 and 1.32.

Dividing studies by comparator type did not materially explain the heterogeneity (Q between = 1.27, df = 2, p = 0.53). Subgroup estimates were -1.39 (95% CI -2.23 to -0.55) for no treatment/waitlist, -2.31 (95% CI -15.91 to 11.29) for conventional therapy, and -0.99 (95% CI -7.82 to 5.85) for other active exercise.

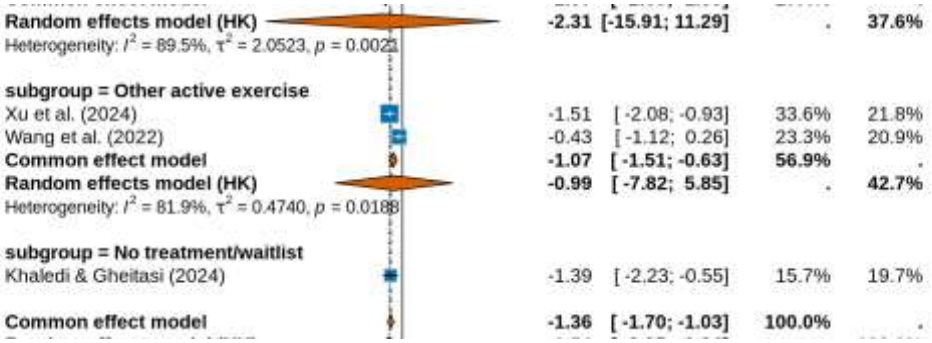


Figure 6. A forest plot illustrating how CSE and ODI functional impairment are coupled.

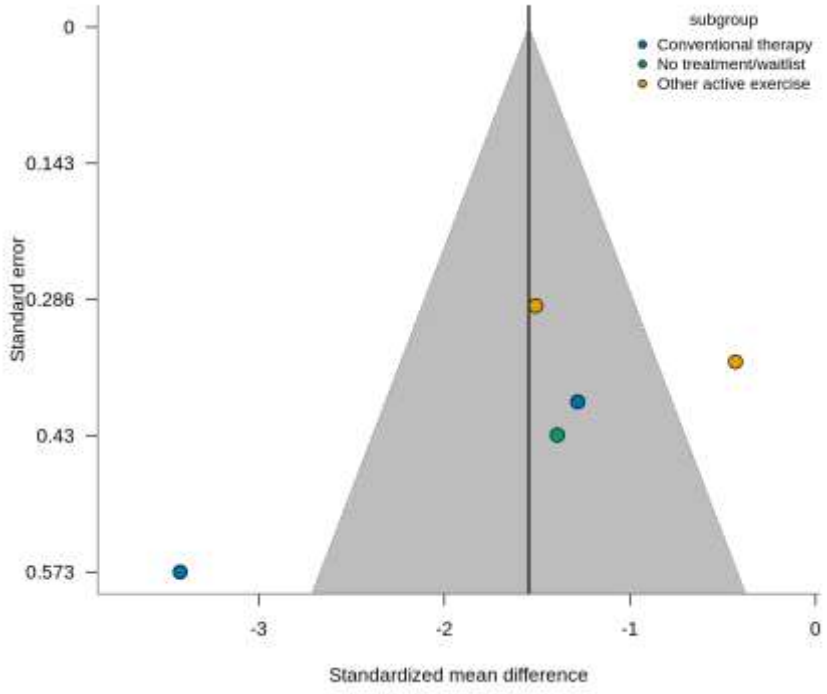


Figure 7. Funnel plot corresponding to the functional-disability analysis.

3.6 Sensitivity Analyses

After excluding Khan (2024) (SMD = -0.91, 95% CI -1.74 to -0.07, I-squared = 52.1%) and Wang et al. (2022) (SMD = -1.41, 95% CI -2.37 to -0.44, I-squared = 58.8%), statistical significance was preserved,

according to a leave-one-out analysis of pain. On the other hand, confidence intervals crossed zero when Khaledi and Gheitasi (2024), Guler et al. (2025), or Xu et al. (2024) were excluded. Only when Khan (2024) was eliminated did the pooled impact for disability remain significant (SMD = -1.15, 95% CI -1.95 to -0.36, I-squared = 50.6%); excluding any other trial resulted in a confidence interval that included zero. Influence diagnostics indicated that Khan (2024) had a substantial effect on both pooled outcomes, with Cook's distances of 0.64 for pain and 0.75 for disability and studentized residuals of -2.21 and -3.12, respectively. Wang et al. (2022) also influenced the pain model (Cook's distance = 0.46; studentized residual = 1.86). Khan (2024) reported particularly large standardized effects (SMD = -2.36 for pain and -3.42 for disability), which may partly reflect the substitution of baseline SDs when post-treatment SDs were unavailable. Excluding this study reduced I-squared from 73.1% to 52.1% for pain and from 80.2% to 50.6% for disability, while the pooled estimates still favored CSE and remained statistically significant.

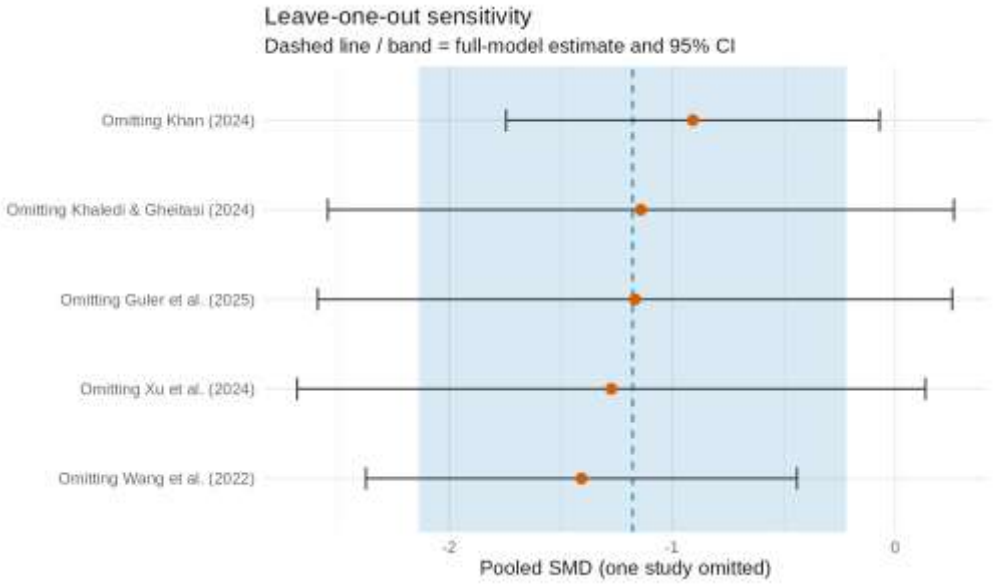


Figure 8. Sensitivity analysis for the pain result using leave-one-out.

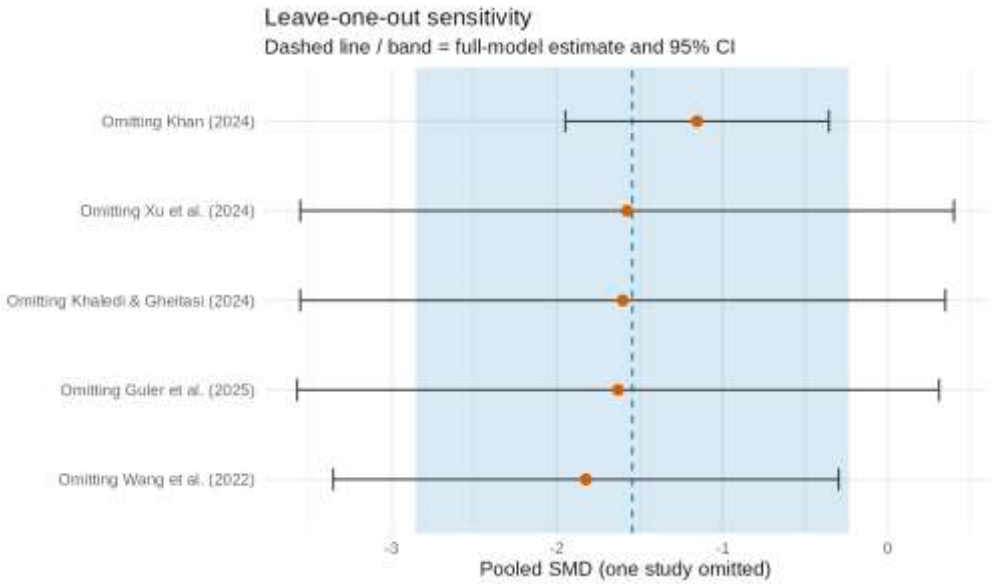


Figure 9.The disability outcome's leave-one-out sensitivity analysis.

3.7 Small-Study Effects

Egger's regression was applied to both primary outcomes, although the results are difficult to interpret because only five studies were available and the test is underpowered when k < 10. The pain analysis gave z = -1.73 and p = 0.084, whereas the disability analysis gave z = -2.03 and p = 0.042. With so few trials, these statistics neither establish nor exclude publication bias with confidence. The corresponding funnel plots are shown in Figures 5 and 7.

3.8 Certainty of Evidence (GRADE)

GRADE assessment began at High certainty because all included studies were RCTs, after which potential downgrading domains were considered. No downgrade was applied for risk of bias because each trial received an overall judgment of "Some concerns" and none was rated High risk. Inconsistency was considered serious because I-squared exceeded 50% for both outcomes and both prediction intervals crossed the null. Imprecision was also judged serious because the evidence base consisted of only five studies and 181 participants, confidence intervals were broad, and the prediction intervals included the possibility of no benefit. Indirectness was not considered serious because the studied populations, interventions, and outcomes broadly matched the review question. Publication bias could not be evaluated reliably because too few trials were included. Consequently, certainty was rated Low for both pain and functional disability (Table 3).

Table 3. GRADE evaluation of certainty for the primary outcomes.

Outcome	k	N	RoB	Inconsist.	Indirect.	Imprecision	Pub. bias	Certainty	Pooled SMD (95% CI)
Pain (VAS)	5	181	Not serious	Serious (I^2=73%)	Not serious	Serious (wide CI; PI crosses 0)	Undetected (k<10)	LOW	-1.18 (-2.14 to -0.22)
Disability (ODI)	5	181	Not serious	Serious (I^2=80%)	Not serious	Serious (wide CI; PI crosses 0)	Undetected (k<10)	LOW	-1.54 (-2.85 to -0.24)

Table 4. Summary of pooled meta-analytic estimates for pain and functional disability.

Outcome	k	N	Pooled SMD (95% CI)	p-value	I-squared	tau-squared	95% prediction interval	Q between (p-value)
Pain (VAS)	5	181	-1.18 (-2.14, -0.22)	0.027	73.1%	0.43	-3.22, 0.87	4.33 (0.115)

Outcome	k	N	Pooled SMD (95% CI)	p-value	I-squared	tau-squared	95% prediction interval	Q between (p-value)
Disability (ODI)	5	181	-1.54 (-2.85, -0.24)	0.031	80.2%	0.86	-4.41, 1.32	1.27 (0.53)

4. Discussion

4.1 Summary of Findings

CSE was linked to statistically significant decreases in pain intensity (SMD = -1.18, 95% CI -2.14 to -0.22) and functional impairment (SMD = -1.54, 95% CI -2.85 to -0.24) in young people with chronic non-specific LBP in five randomised studies with 181 participants. Both values are considerable (Cohen's d > 0.8) and may indicate a clinically significant shift under standardised effect standards. However, due to the substantial heterogeneity (I-squared = 73-80%) and low GRADE certainty rating, there is little confidence in the exact magnitude of these effects.

4.2 Comparison with Prior Reviews

Overall, the findings align with earlier meta-analyses performed in broader adult CLBP populations. Dimitrijevic et al. (2025) pooled 23 studies and reported an SMD of -0.88 for pain following stabilization exercise [18], compared with -1.18 in the present analysis. The larger estimate observed here may partly relate to the focus on younger adults, who may have greater neuromuscular adaptability and a larger contribution from potentially reversible motor-control deficits. Liu et al. (2026) found smaller pooled estimates of approximately -0.56 for pain and -0.81 for disability across several forms of core-muscle training [19]. Smrcina et al. (2022), based on five studies, concluded that evidence supporting superiority of CSE over other exercise approaches was limited [17]. That conclusion is compatible with the current subgroup result, where the smallest effect on pain was seen when CSE was compared with another active exercise program (SMD = -0.58).

Several aspects of the evidence may explain why the pooled effects in this review appear relatively large. The analysis was restricted to young adults, a group that may respond more readily to neuromuscular retraining. Most interventions were also supervised and fairly intensive, typically delivered three times per week over 6-8 weeks. In addition, some standardized effects had to be reconstructed from change scores and p-values rather than calculated from directly reported post-treatment means and SDs, introducing extra uncertainty. A further contributor was Khan (2024), which reported unusually large effects for pain (SMD = -2.36) and disability (SMD = -3.42) and exerted a marked influence on the pooled results.

4.3 Mechanisms of Action

The benefits of CSE are likely to arise from several interacting physiological and motor-control mechanisms. Stabilization training emphasizes deep trunk muscles that support segmental control of the spine, especially the transversus abdominis and lumbar multifidus. Individuals with CLBP may exhibit delayed activation of the transversus abdominis, deterioration in multifidus muscle quality through atrophy or fatty infiltration, and altered anticipatory motor control. CSE is designed to improve the timing and coordination of recruitment, enhance proprioceptive regulation, and support more stable spinal positioning during functional activity.

Evidence from the included trials offers physiological support for this explanation. After 8 weeks of CSE, Guler et al. (2025) observed an increase in lumbar multifidus cross-sectional area and a reduction in fatty infiltration compared with conventional physiotherapy [8]. Xu et al. (2024) reported greater surface EMG activity in the rectus abdominis, erector spinae, and multifidus, together with improved trunk strength and endurance after core stability training [9]. These muscular and neuromuscular adaptations provide a plausible pathway through which CSE could reduce pain and improve disability.

4.4 Clinical Implications

From a clinical perspective, the pooled findings indicate that CSE is a reasonable treatment option for young adults with chronic non-specific LBP. Benefits were observed against no treatment, conventional physiotherapy, and alternative active exercise programs. This pattern suggests that stabilization-focused exercise may offer advantages over passive treatment or less specifically targeted activity. Nevertheless, the pain effect was smallest against another active exercise intervention (SMD = -0.58), indicating that CSE may provide only a modest additional benefit when compared with other structured exercise approaches.

The protocols used in the included trials suggest a practical program consisting of progressive, supervised CSE for 6-8 weeks, typically three sessions per week lasting about 40-60 minutes. Some studies incorporated Swiss balls and gradually increased exercise difficulty to raise trunk-muscle demand and potentially support adherence. Because treatment effects differed substantially between trials, clinicians should monitor individual response rather than expect the same outcome in every patient. CSE may be most appropriately delivered as one component of broader rehabilitation that also includes education and graded return to usual function.

4.5 Limitations

The findings need to be considered alongside several limitations. Only five RCTs with 181 participants were available, restricting statistical power and preventing a dependable assessment of publication bias. Screening was completed by a single reviewer, which increases the possibility of selection error or reviewer bias. The search relied on LiteratureSearch and WebSearch rather than a full systematic search of established bibliographic databases such as MEDLINE, Embase, CINAHL, and PEDro. The protocol was also not prospectively registered in PROSPERO, creating additional potential for bias in the retrieval and review process.

Methodological weaknesses in the primary trials further reduce confidence in the pooled results. Every trial received an overall RoB 2 judgment of "Some concerns." Blinding of participants and therapists was generally impractical, randomization methods were insufficiently described in four trials, and four studies lacked protocol registration. Between-study heterogeneity remained substantial (I-squared = 73-80%), and the planned comparator subgroup analysis did not explain it. Khan (2024) had a disproportionate influence on the meta-analysis, and its standardized effects may have been inflated because baseline SDs were substituted for unavailable post-treatment SDs.

Additional uncertainty results from the way some effect estimates were derived. Several effects were reconstructed from change scores and p-values instead of directly reported post-treatment means and SDs. Guler et al. [8] enrolled adults aged 18-65 years, which exceeded the prespecified young-adult age range, even though most participants were considered likely to be younger adults. No included trial reported outcomes beyond the immediate end of treatment, so it is not possible to determine whether benefits persisted. Finally, both pain and disability were rated Low certainty by GRADE, meaning that future evidence could materially alter confidence in the estimates and potentially change their magnitude.

4.6 Future Research

Future randomized trials should strengthen methodological rigor by clearly reporting random-sequence generation and allocation concealment, registering protocols before recruitment, and using blinded outcome assessment wherever feasible. Sample sizes should be based on formal power calculations, and post-treatment means with SDs should be reported to allow more reliable quantitative synthesis. Follow-up periods of 3-12 months are needed to determine whether treatment gains are maintained. Future studies should also evaluate broader patient-centered outcomes, including quality of life and return to work, and directly compare CSE with clearly specified alternative exercise programs to establish their relative value for young adults.

5. Conclusions

The available evidence from five randomized trials indicates that CSE is associated with improvement in pain intensity (SMD = -1.18, 95% CI -2.14 to -0.22) and functional disability (SMD = -1.54, 95% CI -2.85 to -0.24) among young adults with chronic non-specific LBP when compared with several control conditions. Although pooled effects were large and consistently favored CSE, confidence in their magnitude is limited because heterogeneity and imprecision resulted in a Low certainty rating. Comparator category did not explain the between-study variability, and Khan (2024) substantially influenced the pooled estimates. Larger, well-designed RCTs with stronger methodological safeguards and longer follow-up are needed to confirm the extent and durability of benefit and to define the most effective CSE protocols for this population.

References

1. Ferreira ML, de Luca K, Haile LM, et al. 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. Lancet Rheumatol. 2023;5(12):e716-e728. doi:10.1016/s2665-9913(23)00098-x
2. Zhang Y, Yang C, Bai J, et al. Changing burden, risk factors, and projections of low back pain in adolescents and young adults. Spine. 2025. doi:10.1097/brs.0000000000005447
3. Wang L, Zou X, Zi X, She M, Duan C. Trends in the global burden of low back pain and neck pain in individuals aged 15 to 49 years, 1990 to 2021, and projections through 2036. Medicine. 2025. doi:10.1097/md.0000000000044006
4. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71. doi:10.1136/bmj.n71
5. Sterne JAC, Savovic J, Page MJ, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ. 2019;366:l4898. doi:10.1136/bmj.l4898
6. Guyatt GH, Oxman AD, Vist GE, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ. 2008;336(7650):924-926. doi:10.1136/bmj.39489.470347.AD
7. Wang H, Fan Z, Liu X, Zheng J, Zhang S, Zhang S, Yu Q, Lo WLA. Effect of progressive postural control exercise versus core stability exercise in young adults with chronic low back pain: a randomized controlled trial. Pain Ther. 2023;12(1):293-308. doi:10.1007/s40122-022-00458-x
8. Guler MA, Demirdel E, Gezer IA, Nayman A, Tezcan EA. Effect of core stabilization exercises on lumbar multifidus morphology and functional outcomes in chronic non-specific low back pain: a

randomized controlled trial. BMC Musculoskelet Disord. 2025;26(1). doi:10.1186/s12891-025-09433-x

9. Xu S, Wang R, Ma S, He B. Interventional effect of core stability training on pain and muscle function of youth with chronic non-specific lower back pain: a randomized controlled trial. Heliyon. 2024;10(6):e32818. doi:10.1016/j.heliyon.2024.e32818
10. Khaledi A, Gheitasi M. Isometric vs isotonic core stabilization exercises to improve pain and disability in patients with non-specific chronic low back pain: a randomized controlled trial. Anesthesiol Pain Med. 2024;14(1):e144046. doi:10.5812/aapm-144046
11. Khan AR. Efficacy of core-strengthening and intensive dynamic back exercises on pain, core muscle endurance, and functional disability in patients with chronic non-specific low back pain: a randomized comparative study. J Clin Med. 2024;13(2):475. doi:10.3390/jcm13020475
12. Hlaing SS, Puntumetakul R, Khine EE, et al. Effects of core stabilization exercise and strengthening exercise on proprioception, balance, muscle thickness and pain related outcomes in patients with subacute nonspecific low back pain: a randomized controlled trial. BMC Musculoskelet Disord. 2021;22(1):548. doi:10.1186/s12891-021-04858-6
13. Akodu AK, Adedeji AR, Zibiri R, et al. Effect of telerehabilitation-based core-stability exercise on pain-related disability in patients with chronic low back pain. Bull Fac Phys Ther. 2024;29(1). doi:10.1186/s43161-024-00193-8
14. Zheng F, Zheng Y, Liu S, et al. The effect of m-health-based core stability exercise combined with self-compassion training on pain-related disability in patients with chronic low back pain. Pain Ther. 2022;11(4). doi:10.1007/s40122-022-00358-0
15. Nayel N, Ezzat H, Ahmed S, Saleh H. Effect of core stability exercises and Russian electrical stimulation on nonspecific low back pain: a single-blinded randomized controlled trial. Sci Rep. 2025;15. doi:10.1038/s41598-025-28313-x
16. Elgendy MH, Khalifa MH, Kentiba E, et al. Core stability exercises versus intermittent traction in management of nonspecific chronic low back pain: a randomized controlled trial. Eur J Appl Physiol. 2025. doi:10.1007/s00421-025-05931-x17. Smrcina Z, Woelfel S, Burcal C. A systematic review of the effectiveness of core stability exercises in patients with non-specific low back pain. Int J Sports Phys Ther. 2022;17(5). doi:10.26603/001c.37251
17. Dimitrijevic V, Raskovic B, Jevtic N, Nikolic S, Viduka D, Obradovic B. Pain and disability therapy with stabilization exercises in patients with chronic low back pain. Healthcare. 2025;13(9):960. doi:10.3390/healthcare13090960
18. Liu Y, Yu Y, Lu F, Liu J. Comparative effectiveness of different core muscle training regimens for chronic low back pain. Front Med. 2026;13:1814834. doi:10.3389/fmed.2026.1814834