REVIEW ARTICLE Open Access

The effectiveness of lumbar stabilisation exercises on pain and functional disability among patients with non-specific low back pain: a systematic review

Shahid Mohd Dar[1]*, Naim Muzaffar Shamsul Muhardzi[2], Siti Salwana Kamsan[1]

[1]*Department of Physical Rehabilitation sciences Kulliyah of Allied Health Sciences, International Islamic University of Malaysia.*
[2]*REGEN Physio and Sports Rehabilitation Center, Petaling Jaya, Selangor, Malaysia.*

Abstract

Core stability exercises have emerged as a crucial intervention for managing and preventing back pain, a pervasive condition affecting millions globally. Back pain frequently arises and persists due to deficiencies or imbalances in core muscles. As a result, engaging in targeted core-strengthening exercises is thought to not only reduce pain but also greatly boost functional capabilities and improve overall quality of life. A systematic search of electronic databases (PubMed, ScienceDirect, and PEDro) was conducted to find experimental studies focusing on the impact of core stability exercises on back pain and functional independence in adults with nonspecific back pain. Out of 250 identified studies, 228 titles and abstracts were reviewed, resulting in the exclusion of 122. Among the remaining 106 articles, 93 full texts were retrieved and evaluated for eligibility. Ultimately, 8 studies met the criteria and were included in the review. Out of the eight studies, two reported no improvement in pain reduction compared to control groups. For disability, six studies assessed the outcome, of which three reported no improvement compared to control groups. The remaining studies demonstrated greater effectiveness of core stability exercises in reducing both pain and disability. These findings highlight the importance of incorporating core stability exercises into treatment plans for NSLBP and emphasize the need for tailored exercise programs to optimize outcomes.

Keywords: *core stability, exercise training, low back pain*

Received:
8 September 2024
Revised:
26 January 2025
Accepted:
2 February 2025
Published Online:
28 February 2025

How to cite this article:
Dar, S. M., Shamsul Muhardzi, N. M., & Kamsan, S. S. (2025). The effectiveness of lumbar stabilisation exercises on pain and functional disability among patients with non-specific low back pain: a systematic review. IIUM Journal of Orofacial and Health Sciences, 6(1), 94–114. https://doi.org/10.31436/ijohs.v6i1.349

Article DOI:
https://doi.org/10.31436/ijohs.v6i1.349

***Corresponding author**
Address:
Department of Physical Rehabilitation Sciences, Kulliyah of Allied Health Sciences, International Islamic University of Malaysia

Telephone: +60169807816

Email address:
shahiddar@iium.edu.my

Introduction

Low back pain is defined as pain in the posterior aspect of the body, extending from the lower margin of the twelfth ribs to the lower glutaeal folds with or without referred pain into one or both lower limbs, lasting at least one day. It has been recognised as one of the leading contributors to global disability (Hoy *et al*., 2014). It is a significant global health issue, affecting millions of people and often leading to disability, reduced quality of life, and substantial economic burden (Wu *et al.,* 2020). According to world health organisation in 2020, low back pain (LBP) affected 619 million people globally, a 60% increase from 1990 and it is estimated that the number of cases will increase to 843 million by 2050, driven largely by population growth and aging (GBD, 2021).

Low back pain may be classified as acute (less than 6 weeks), subacute (6-12 weeks) or more than 12 weeks as chronic (Frizziero *et al.,* 2021). It can be caused by various specific causes, such as muscle strain, poor posture, or degenerative conditions. However, when no specific pathology is identifiable, it is classified as nonspecific low back pain (NSLBP) (Balague F *et al.,* 2012). Management of chronic low back pain has been a topic of discussion among authors of medical fraternity for a long time with physiotherapy playing a vital role in managing the pain and improving functional outcomes through individualized treatment approaches. Research indicates that core musculature activation patterns, particularly in the lumbar multifidi and transverse abdominis, are disrupted in patients with NSLBP. This leads to the abnormalities and puts tremendous load on the stabilisation structures of spine, causing pain and disability (Frizziero *et al.,* 2021). Consequently, clinical approaches now prioritize strategies to restore core muscle function and enhance stability, aiming to alleviate symptoms and minimize the risk of recurrence. Addressing neuromuscular imbalances has become central to the effective management of chronic NSLBP, reflecting a shift toward targeted, evidence-based interventions.

Although core stability exercises are widely used for managing NSLBP, existing research has reported inconsistent findings regarding their effectiveness in reducing pain and functional disability. These inconsistencies may arise from variability in intervention protocols and patient populations. This review aims to systematically analyse existing literature on core muscle activation patterns in NSLBP, identifying gaps in current research and offering evidence-based recommendations for optimizing treatment protocols and tailoring interventions to individual patient needs.

Materials and Methods

Study design

This systematic review was designed using the PICO (Population, Intervention, Comparison, Outcome) framework to formulate the research question (Tawfik *et al.,*2019): *What is the effect of core stability exercises on patients with non-specific low back pain (NSLBP)?* (Table 1). The review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Page *et al.,* 2021)

Search strategy

Online databases, PubMed and Science Direct were accessed for searching without using any filters. The following key words were used: 'Core stabilisation exercises' OR 'Motor Control Stabilization Exercises' OR 'Trunk Stabilization Exercises' OR 'Swiss ball stabilization' OR 'Spinal Stabilization Exercises' AND 'non-specific low back pain' OR 'chronic non-specific low back pain'. A standard search strategy was done in PubMed and was later modified for each database. The search covered studies published from 2008 to 2021.

Table 1. PICOS framework (Tawfik *et al.*, 2019).

Population	Adult patients with NSLBP
Intervention	Core stabilization exercises
Control	Other forms of conventional exercises and treatments or placebo
Outcome	Any reliable and valid outcome measure for pain and/or disability
Study Design	Randomised control trials

Inclusion and exclusion criteria

The studies were reviewed by two reviewers based on the inclusion and exclusion criteria to exclude articles which were Two reviewers manually screened the titles and abstracts, excluding 122 articles that did not meet the criteria not relevant. Following criteria was applied:

Inclusion criteria: 1) original research articles (RCTs) published 2008 onwards and must include patients aged more than 18 years; 2) articles must have patients with NSLBP, with varying pain duration (acute, subacute or chronic); 3) articles using core stability exercises as a principal treatment for an minimum of two weeks; 4) studies must have incorporated outcome measures for measuring pain and disability.

Exclusion criteria: 1) studies published in languages other than English; 2) review articles (including systematic reviews, narrative reviews, scoping reviews, and meta-analyses); 4) case reports.

Study selection

The search results were first screened by reviewing the titles and abstracts. Two reviewers independently screened the abstracts to identify potentially relevant studies. Full-text articles of the selected abstracts were then retrieved and reviewed for eligibility based on the inclusion and exclusion criteria. Any disagreements between the reviewers were resolved through discussion or consultation with a third reviewer.

Data extraction

Data were extracted from the included studies using a standardized data extraction form. Extracted data included Study characteristics: authors, year of publication, study design, number of participants in each group, mean age, details of intervention in each group, and comparison, outcome measures used, and results.

Methodological quality

The selected articles were assessed for the quality in their methodology by two independent reviewers using PEDro scale (Paci *et al.,* 2022). PEDro scale assesses the quality in following domains: 1) Random allocation; 2) concealed allocation; 3) baseline similarity; 4) blinding of assessors, therapists & subjects; 5) measure outcome in more than 85% subjects; 6) intention to treat analysis; 7) between group statistical comparison and 8) point measure and measures of variability.

Results

Figure 1 illustrates the results of the database search process. The systematic literature search identified 250 articles from PubMed (68), ScienceDirect (148), and PEDro (34). After removing 22 duplicates, 228 articles were screened by two independent reviewers based on titles and abstracts, leading to exclusion of 122 articles. Of the remaining 106 articles, 13 could not be retrieved, and 85 were excluded for reasons such as non-English publications (4), reviews/meta-analyses (10), non-relevant outcomes (68), and non-RCTs (3). Ultimately, 8 studies met the eligibility criteria and were included in the review.

Study characteristics

All 8 included studies were RCTs involving 390 participants with NSLBP (Ahmadi *et al.,* 2020; Akhtar *et al.,* 2017; Bhadauria *et al.,* 2017; Ghorbanpour *et al.,* 2018; Kim *et al.,* 2020; Kumar *et al.,* 2009; Shamsi *et al.,* 2020; & Sokunbi *et al.,* 2014). The mean participant age of ranged from 20.9 years (Ghorbanpour *et al.,* 2018) to 47.75 years (Kim *et al.,* 2020). Interventions sessions varied from a minimum of 6 sessions (Akhtar *et al.,* 2017) to a maximum of 18 (Ghorbanpour *et al.,* 2018; Kim *et al.,* 2020).

Most studies compared two groups (core stability vs. control), while three studies used three group designs. Bhadauria *et al.* (2017) compared core stability, Pilates, and strengthening exercises. Kim *et al.* (2020) included groups combining core stability with stretching, strengthening, or sham interventions. Sokunbi *et al.* (2014) compared core stability, acupuncture, and their combination.

Pain and functional disability were consistently reported as primary outcomes using tools like the Visual Analog Scale (VAS), McGill Pain Questionnaire, Oswestry Disability Index (ODI), Roland Morris Disability Questionnaire (RMDQ), and Quebec Low Back Pain Disability Questionnaire. However, Akhtar *et al.* (2017) and Kumar *et al.* (2009) assessed only pain score. Detailed characteristics of the included studies are summarized in Table 2.

Quantified improvements in pain and functional disability

To provide clarity on the effectiveness of core stability exercises, statistical significance was reported using p-values, presented in Table 2. Mean differences and Cohen's d effect sizes were calculated to assess the intervention effects and are presented in Table 3, for pain and Table 4, for disability, each accompanied by the authors' narrative analysis.

To summarize the findings, Ahmadi *et al*. (2020) and Shamsi *et al*. (2020) reported smaller or no significant effects for pain reduction in experimental groups compared to control groups. However, remaining studies demonstrated significant improvements in pain and disability, with moderate to very large effect sizes. For disability, three studies (Ahmadi *et al*., 2020; Shamsi *et al*., 2020; Ghorbanpour *et al*., 2018) found no significant improvements.

Methodological quality

The methodological quality of the included studies is summarized in Table 5. According to the PEDro scale, a score of 4 is considered 'poor', 4 to 5 is considered 'fair', 6 to 8 is considered 'good', and 9 to 10 is considered 'excellent' (Adian *et al*., 2020). All included studies scored within the 'good' range (6-8) except for the study by Shamsi *et al*. (2020), which scored 5 points, indicating 'Fair' quality. Most of the studies failed to blind the subjects and therapists.

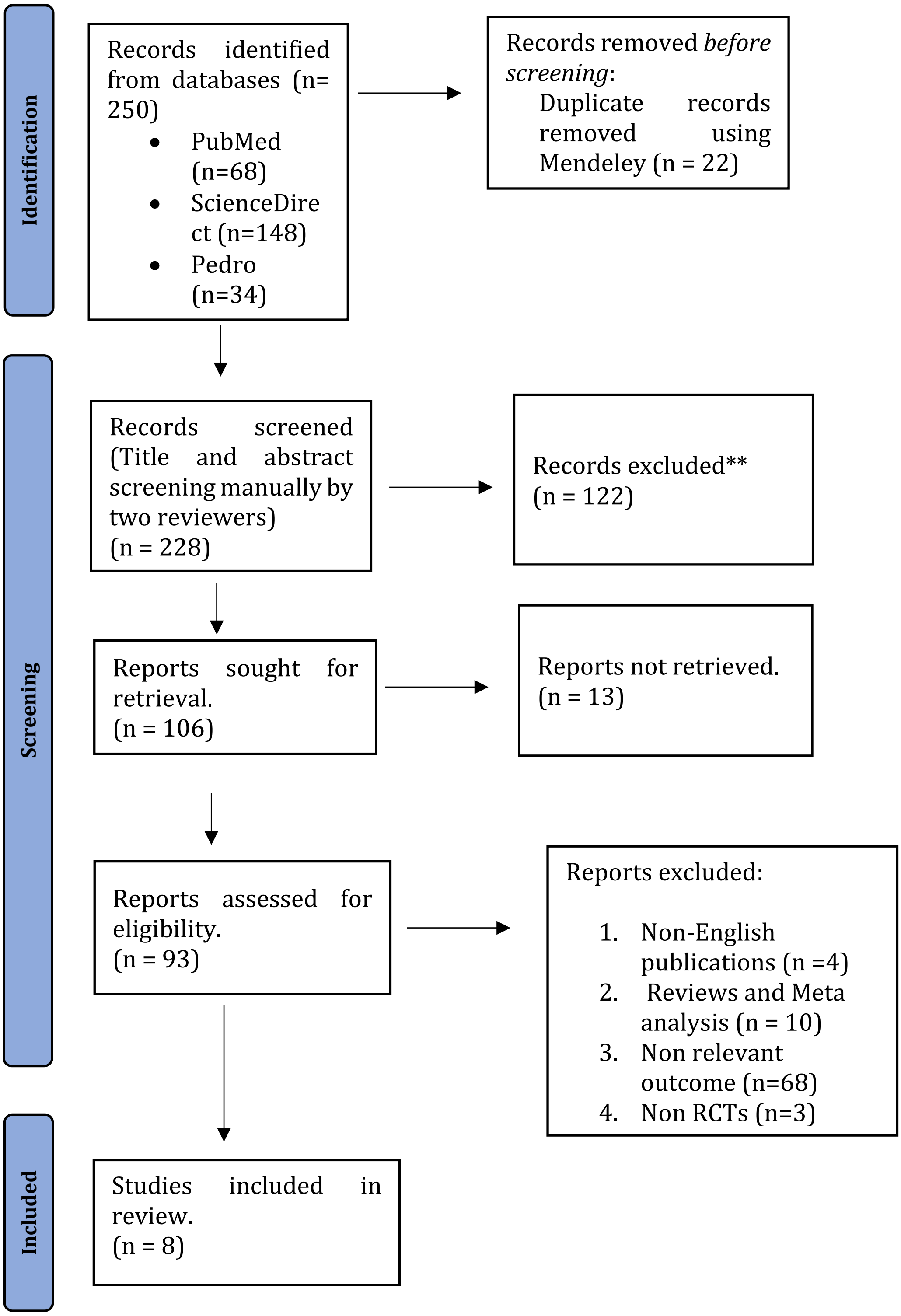

Figure 1. Prisma flow diagram (Page *et al.,* 2021).

Table 2. Characteristics of included studies.

Author/ Year	Study Design	Number of Participants/ Inclusion Criteria	Interventions and mean age	Outcome measures	Findings
Ahmadi *et al.,* (2020)	RCT	n =59 <u>Inclusion Criteria</u> Patients with NSLBP aged between 18-65 years old.	<u>Group A(NCSG)</u> (n= 30, mean age= 42.6± 11.6) This group received therapy utilising the Feldenkrais method. (30-45mins per session/ 2 times per week). <u>Group B (CSG)</u> (n=29, mean age= 38.89.6± 12.52) This group received an educational programme and home-based core stability exercises.	McGill pain questionnaire ODI	Pain score significantly decreased in both groups but there were no significant between group differences (*p*= 0.16). A significant difference between the groups for disability in favour of Feldenkrais method (*p*=0.021).
Akhtar *et al.,* (2017)	Single-blinded RCT	n= 108 <u>Inclusion Criteria</u> Patients with CNSLBP aged between 20-60 years.	<u>Group A (CSG)</u> (n= 53, mean age=46.39 ± 7.43) Participants performed core stabilisation exercises (6 weeks,40mins per session, 1 session per week) and received TENS. <u>Group B(NCSG)</u> (n=55, mean age=45.50 ± 6.61) Participants were given a baseline treatment of US and TENS and conventional exercises. back extensor exercises in prone and hip extensor exercises in prone.	VAS	Both treatment groups displayed statistically significant differences in pain at 2nd, 4th, and 6th week of intervention ($p < 0.05$). However, there was a significant reduction in pain symptoms in intervention group compared to control group (p<0.01).

Bhadauria *et al.*, (2017)	Study Design Single-blinded RCT	n= 36 <u>Inclusion Criteria</u> Patients with CNSLBP aged between 20-60 years.	<u>Group A(CSG)</u> (n=12, mean age= 32.75± 11.73) 16 lumbar stabilisation exercises were prescribed and were performed consecutively for 10 total sessions. <u>Group B(NCSG)</u> (n=12, mean age= 36.67± 10.74) Pilates exercises. Patients were taught to perform isometric contractions of the deep trunk muscles before proceeding with a Pilates programme. <u>Group C(PG)</u> (n=12, mean age= 35.33± 12.88) Dynamic Strengthening. Participants performed 14 exercises targeting the erector spinae and rectus abdominis muscle groups. All participants received hot moist pack and IFT therapies as part of the conventional treatment. Treatment Duration= 3 weeks (60mins per session/3-4 sessions per week).	VAS MODQ	Lumbar stabilisation group reported significant differences in VAS (p=0.0001) and MODQ (p=0.0001) scores within the group and compared to other groups.

Ghorbanpour A *et al.*, (2018)	Study Design RCT	n=30 <u>Inclusion Criteria</u> Patients with CNSLBP aged between 20-40 years.	<u>Group A(CSG)</u> (n=15, mean age= 23.8 ± 3.5) Patients performed core stability exercises such as curl-ups, side-bridge and bird-dog. <u>Group B (NCSG)</u> (n=15, mean age= 20.9 ± 1.2) Exercises for the patients included conventional exercises like single and double knee to chest, prone lying with pillow with one leg sliding, cycling in supine and bridging exercises. All exercises were done for 6 weeks, 3 times per week.	VAS QLBPDSQ	McGill stabilization exercises led to significant improvements in pain ($p<0.05$) and disability ($p<0.05$) in the CSG group, with greater benefits (pain: 15%, disability: 13%) compared to NCSG (pain: 6%, disability: 7%). However, no significant differences were observed between the two groups ($p>0.05$)
Kim & Yim, 2020	RCT	n= 66 <u>Inclusion Criteria</u> Participants with CNSLBP between 30-65 years.	<u>Group A (CSG + stretching)</u> (n=24, mean age= 47.50 ±9.70) Participants underwent core stability exercises followed by 15 minutes of hip muscle (hamstring, iliopsoas, piriformis, TFL) stretching. (30s hold for 3 reps). <u>Group B (CSG+strengthening)</u> (n=22, mean age=47.04± 9.48) Participants underwent core stability exercises followed by 15 minutes of hip strengthening exercises (abductor and extensor strengthening). Positions are held for 30 seconds at maximal isometric contraction and repeated 3 times.	VAS ODI	All groups had significant differences for pain intensity and disability between the baseline and post-intervention ($p < 0.05$). Both the Stretch and Strengthen groups ($p< 0.05$) experienced a greater impact on pain intensity and disability than the Sham group ($p < 0.05$)

			Group C (sham) (n=20, mean age= 47.75± 8.51) Participants underwent Core stability exercises followed by 15 minutes of gentle palpation of skin over lumbosacral spine. All groups performed exercises for 6 weeks (45mins per session/3 sessions per week). All groups carried out core stabilisation exercises (CSE) for 30 minutes followed by different exercises.		
Kumar *et al.,* (2009)	RCT	n= 30 Inclusion Criteria Hockey players with subacute or chronic NSLBP aged 18 -28 years.	Group A (CSG) (n=15, mean age=23.40± 6 3.27) Patients performed lumbar strengthening exercises such as spinal extension and trunk extensor exercises (10 repetitions per exercise) and received ultrasound and diathermy. Group B(NCSG) (n=15, mean age=24.07 ±6 2.89) Core stability exercises in the form of dynamic muscular stabilisation Techniques (DMST) were given in 4 stages (Drawing in of abdomen in supine hook lying, repositioning of limbs while performing drawing in, abdominal hollowing and high-speed phasic exercises)	VAS	The mean levels of pain were significantly lower in the CSG group compared to the conventional treatment group on days 21 and 35 ($p < 0.01$). However, at day 21, the pain levels were similar between the two groups ($p > 0.05$)

Shamsi *et al.,* (2020)	Quasi-randomized controlled trial	n= 46 <u>Inclusion Criteria</u> Adult patients with CNSLBP aged between 18-60 years.	<u>Group A(CSG)</u> (n=22, mean age=38.9±12.2) This group core stabilisation exercises, where patients were first taught the abdominal "drawing in" manoeuvre and progressed to isometric contraction of the muscles in minimally loading positions. Participants then progress to performing light functional tasks while co-contraction stabilising muscles. Finally, participants progress to heavier-load functional tasks. <u>Group B(NCSG)</u> (n=24, mean age=47.0 ± 9.9) Participants performed general exercises which activate the extensor (paraspinal) and flexor (abdominal) muscles. These exercises were performed in the supine-lying position. Treatment duration= 5 weeks (20 mins per session/3 times per week).	VAS ODI	Both groups demonstrated a significant reduction in disability levels ($p < 0.001$) and pain intensity ($p < 0.001$). However, no significant differences were observed between the CSE and GE groups in terms of disability ($p = 0.14$) or pain ($p = 0.72$).
Sokunbi *et al.,* (2014)	Pilot RCT	n=15 (42.1±9.3) <u>Inclusion Criteria</u> Adult patients with acute forms of NSLBP, 18-65 years old.	Participants were divided into 3 groups: Acupuncture Group (ACG), Core stability exercises group (CSG) and exercise with acupuncture group (EACG). <u>Group A (ACG)</u> (n=5, mean age= 40.3±8.2) The participants received acupuncture treatment at selected sites for 20	VAS RMDQ	Pain intensity decreased in all groups. Group C showed significant reductions at both the 6th week and 3-month follow-up ($p < 0.08$), while Group B showed significance only at 3 months ($p < 0.008$). Disability scores

			minutes. Disposable stainless-steel needles were inserted into the muscles to a depth of 10 mm or until the participant feels the acupuncture sensation. <u>Group B(CSG)</u> (n=5, mean age= 42.1±9.3) Participants were shown how to locate and activate the main core stability muscles and exercises were then performed for 20 minutes. <u>Group C(CSG+ACG)</u> (n=5, mean age= 41.4±10.3) Participants received 20 minutes of acupuncture treatment, followed by 20 minutes of core stability exercise treatments. Treatment was given for 6 weeks with 3 months follow up.		decreased in all groups, but only Group C had significant reductions at both time points ($p < 0.008$).

RCT= Randomised control trial, NSLBP= Nonspecific low back pain,ODI=Oswestry disability Index, VAS= Visual analogue scale, MODQ= Modified Oswestry disability questionnaire, QLBPDSQ= Quebec low back pain disability questionnaire, RMDQ= Rolan Morris disability Questionnaire, NCSG= Non-core stability group, CSG= Core stability group, PG= Pilates group, ACG= Accupuncture group, EACG= Exercise with Accupuncture group.

Table 3. Mean differences and effect sizes for pain outcomes following core stability exercises.

Study	Pain measuring tool	Baseline Pain score (Mean & SD)	Post intervention pain score (Mean& SD)	Mean difference in pain within groups	Mean difference in pain between groups	Effect size	Analysis
Ahmadi *et al.,* (2020)	McGill pain questionnaire	CSG = 13.1 ± 6.6 NCSG = 15.3 ± 7.2	CSG = 4.17 ± 4.56 NCSG = 3.63 ± 3.71	-8.93 -11.67	2.74	0.37	The difference between the two groups is small and in favour of NCSG but may not be practically significant.
Akhtar *et al.,* (2017)	VAS	CSG = 5.77 ±1.08 NCSG = 5.40 ± 1.24	CSG = 2.69 ± 0.93 NCSG = 3.69 ± 0.79	3.08 1.71	1.37	0.77	The difference between the two groups indicates moderate to large effect size in favour of CSG, which is substantial and practically significant.
Bhadauria *et al.,* (2017)	VAS	CSG= 7.17± 1.27 NCSG= 6.67± 1.56 PG= 6.42± 1.00	CSG= 1.17± 0.72 NCSG= 2.00± 1.35 PG= 1.33± 0.98	6.00 4.67 5.08	CSG vs. NCSG = 1.33 CSG vs. PG = 0.91 NCSG vs. PG = 0.42	CSG vs. NCSG = 0.79 CSG vs. PG = 0.55 NCSG vs. PG = 0.24	Overall, the CSG group demonstrated the largest improvement, followed by the PG group, and

							then the NCSG group.
Ghorbanpour A *et al.,* (2018)	VAS	CSG = 29.5 ± 4.8 NCSG = 28.3 ± 6.5	CSG = 25.0 ± 4.9 NCSG = 26.5 ± 7.8	4.5 1.7	2.7	0.45	The results indicate moderate effect size in favour of CSG.
Kim & Yim, (2020)	VAS	CSG +stretching= 5.95 ± 1.09 CSG+ strengthening = 6.12± 1.02 Sham= 5.85 ± 1.16	CSG +stretching= 2.37 ± 0.67 CSG+ strengthening = 2.37 ± 0.69 Sham= 2.92 ± 0.61	3.58 3.75 2.93	CSG + Stretching vs. Sham = 0.65 CSG + Strengthening vs. Sham: = 0.82 CSG + Stretching vs. CSG + Strengthening = 0.17	CSG + Stretching vs. Sham = 0.72 CSG + Strengthening vs. Sham = 0.89 CSG + Stretching vs. CSG + Strengthening = 0.19	CSG + Stretching and CSG + Strengthening showed moderate to large pain reductions respectively compared to Sham. The CSG + Strengthening group demonstrated slightly better outcomes.
Kumar *et al.,* (2009)	VAS	CSG = 7.07 ± 0.96 NCSG = 7.00 ±1.07	CSG = 1.47 ± 0.99 NCSG = 4.33 ± 0.82	5.6 2.67	2.93	3.02	CSG showed a substantial reduction in pain group compared to the NCSG group, with a

							very large effect size.
Shamsi *et al.,* (2020)	VAS	CSG = 51.36 ± 9.02 NCSG = 52.86 ±9.02	CSG = 15.09 ± 12.4 NCSG = 15.10 ±13.80	36.27 37.76	1.49	0.09	Result indicates no clinically significant difference between the CSG and NCSG groups.
Sokunbi *et al.,* (2014)	VAS	ACG=62.8±15.7 CSG=60.0±18.5 ACG+CSG= 62.7±17.8	ACG=58.0±22.5 CSG= 50.9±10.4 ACG+CSG=36.6±5.3	4.8 9.1 26.1	ACG vs. CSG = 4.3 ACG vs. ACG+CSG = 21.3 CSG vs. ACG+CSG = 17.0	ACG vs. CSG = 0.16 ACG vs. ACG+CSG = 0.79 CSG vs. ACG+CSG =0.63	The ACG+CSG group showed a large improvement in pain compared to both the ACG and CSG groups.

SD=standard deviation, CSF=core stability group, NCSG= non-core stability group, PG=Pilates group, ACG= Acupuncture group, ODI=Oswestry disability Index, VAS= Visual analogue scale, MODQ= Modified Oswestry disability questionnaire, QLBPDSQ= Quebec low back pain disability questionnaire, RMDQ= Rolan Morris disability Questionnaire

Table 4. Mean differences and effect sizes for functional disability outcomes following core stability exercises

Study	Pain measuring tool	Baseline Pain score (Mean & SD)	Post intervention pain score (Mean& SD)	Mean difference in pain within groups	Mean difference in pain between groups	Effect size	Analysis
Ahmadi *et al.,* (2020)	ODI	CSG =27 ± 8.5 NCSG =27.2 ± 6.5	CSG = 19.31 ± 5.79 NCSG = 14.50 ± 3.38	-7.69 -12.7	5.01	0.79	The NCSG experienced a greater improvement in disability compared to the CSG, with moderate to large effect.
Akhtar *et al.,* (2017)	Did not assess disability						
Bhadauria *et al.,* (2017)	MODQ	CSG= 39.75± 10.11 NCSG= 37.75± 9.27 PG= 28.17± 13.55	CSG= 6.92± 2.47 NCSG= 23.42± 11.01 PG= 8.42± 5.14	32.83 14.33 19.75	CSG vs. NCSG =18.50 CSG vs. PG= 13.08 NCSG vs. PG = 5.42	CSG vs. NCSG= 1.93 CSG vs. PG =1.37 NCSG vs. PG = 0.58	CSG group demonstrated significantly better outcomes in disability compared to the NCSG and PG groups, with very large to large effect sizes.

Ghorbanpour A *et al.*, (2018)	QLBPDSQ	CSG = 25.6 ± 9.7 NCSG = 30.1 ± 11.6	CSG = 22.4 ± 9.0 NCSG = 28.0 ± 10.1	3.2 2.1	1.1	0.10	The results show a small effect size in Favor of the CSG group.
Kim & Yim, (2020)	ODI	CSG +stretching= 57.67± 6.50 CSG+ strengthening =56.91± 6.92 Sham= 58.20 ± 5.27	CSG +stretching= 29.25± 7.66 CSG+ strengthening = 30.18 ± 7.66 Sham= 36.70± 5.12	28.42 26.73 21.50	CSG + Stretching vs. Sham = 6.92 CSG + Strengthening vs. Sham = 5.23 CSG + Stretching vs. CSG + Strengthening = 1.69	CSG + Stretching vs. Sham = 0.68 CSG + Strengthening vs. Sham = 0.51 CSG + Stretching vs. CSG + Strengthening = 0.17	Both CSG + Stretching and CSG + Strengthening groups showed significant improvements in disability compared to the Sham group, with moderate effect sizes. Difference between intervention groups was small.
Kumar *et al.*, (2009)	Did not assess disability						
Shamsi *et al.*, (2020)	ODI	CSG = 50.55 ±12.08 NCSG = 50.67 ±10.41	CSG = 32.77 ±11.0 NCSG = 37.62 ±10.87	17.78 13.05	4.73	0.29	The CSG group showed a small but statistically significant improvement in disability compared to the NCSG group.

Sokunbi *et al.,* (2014)	RMDQ	ACG =8.2±3.7 CSG=8.0 ± 3.1 ACG+CSG= 9.0 ± 4.5	ACG=7.5±2.6 CSG= 4.1 ± 2.4 ACG+CSG= 3.3 ± 0.3	0.7 3.9 5.7	ACG vs. CSG = 3.2 ACG vs. ACG+CSG = 5.0 CSG vs. ACG+CSG= 1.8	ACG vs. CSG = 0.75 ACG vs. ACG+CSG = 1.21 CSG vs. ACG+CSG= 0.45	ACG+CSG showed greater improvement than ACG (moderate-large effect). CSG also improved more than ACG, but with a smaller effect.

SD=standard deviation, CSF=core stability group, NCSG= non-core stability group, PG=Pilates group, ACG= Acupuncture group, ODI=Oswestry disability Index, VAS= Visual analogue scale, MODQ= Modified Oswestry disability questionnaire, QLBPDSQ= Quebec low back pain disability questionnaire, RMDQ= Rolan Morris disability Questionnaire

Table 5. Methodological quality (PEDro scale).

Study	1	2	3	4	5	6	7	8	9	10	11	Score
Ahmadi *et al.*, 2020	√	√	√	√	×	×	×	√	√	√	√	**7**
Akhtar *et al.*, 2017	√	√	√	√	×	×	×	√	√	√	√	**7**
Bhadauri *et al.*, (2017)	√	√	√	√	×	×	√	×	√	√	√	**7**
Ghorbanpour *et al.*, 2018	√	√	√	√	×	×	×	√	√	√	√	**7**
Kim & Yim, 2020	√	√	√	√	√	√	×	√	×	√	√	**8**
Kumar *et al.*,2009	√	√	√	√	×	×	×	√	√	√	√	**7**
Shamsi *et al.*, 2020	√	√	×	√	×	×	×	×	√	√	√	**5**
Sokunbi *et al.*, 2014	√	√	×	√	×	×	√	√	√	√	√	**7**

1: Eligibility criteria, 2: Random allocations 3: Concealed allocation, 4: Comparability at baseline, 5: Patient blinding, 6: Therapist blinding, 7: Assessor blinding, 8: At least 85% follow-up, 9: Intention to treat analysis, 10: Between-group statistical comparisons, 11: Point measures and measures of variability. Item 1 not counted in PEDro score.

Discussion

The present study intended to investigate the effects of core stability exercises on pain and disability among patients with non-specific low back pain. All the studies used pain score as an outcome tool and six studies reported that use of core stability exercises improved the low back pain symptoms significantly among patients with NSLBP. However, Ahmadi *et al.* (2020) reported that both core stability group and Feldenkrais group has a significant reduction in pain scores but there was no significant difference between the two groups. Similarly, Shamsi *et al.* (2020) also reported no significant difference in decreased pain scores between core exercise group and general exercise group, even though both groups showed a significant with-in group differences in pain scores. In rest all the studies core stability exercises were found to be more effective than the other treatments in reducing pain in patients with NSLBP.

In the context of functional impairment, only six out of eight studies (Ahmadi *et al.*, 2020; Bhadauria *et al.*, 2017; Ghorbanpour *et al.*, 2018; Kim *et al.*, 2020; Shamsi *et al.*, 2020; Sokunbi *et al.*, 2014) assessed the subjects in terms of functional disability. These studies utilized various metrics and assessment tools following core stability exercise interventions to measure the degree of functional impairment among the subjects, providing insights into how different conditions or interventions impact daily activities and overall quality of life. However, three studies (Ahmadi *et al.*, 2020; Shamsi *et al.*, 2020; Ghorbanpour *et al.*, 2018) did not report improved functional independence in the core stability exercise group compared to conventional treatment groups.

These findings underscore the dual benefits of core stability exercises, alleviating pain and improving patients' ability to perform daily tasks, thereby enhancing their overall quality of life. The consistent results across the studies (Akhtar *et al.,* 2017; Bhadauria *et al.,* 2017; Ghorbanpour *et al.,* 2018 Kim & Yim, 2020; Kumar *et al.,* 2009; Sokunbi *et al.,* 2014) highlight the effectiveness of core stability exercises in addressing both functional impairment and pain management.

This aligns with the understanding that core muscles are crucial for stabilizing the spine and maintaining proper posture, thereby alleviating the mechanical stress that contributes to pain. The effectiveness of these exercises can be attributed to the targeted strengthening of key muscles, such as the lumbar multifidi and transverse abdominis, which are often weakened or improperly activated in individuals with NSLBP. By improving the activation patterns of these muscles, core stability exercises help to distribute spinal loads more effectively, reducing strain on the lower back and thereby alleviating pain.

A very important observation was made by reviewers was that in two studies, the core stability exercise was combined with other interventions, like stretching, strengthening and acupuncture (Kim & Yim, 2020; Sokunbi *et al.,* 2014). It was observed that when core stability exercises combined with stretching was compared to core stability exercises combined with strengthening exercises, the earlier combination was more effective in reducing pain and improving functional capacity (Kim & Yim, 2020). Similarly, it was reported that core stability exercises, combined with acupuncture therapy demonstrated significant reduction in pain and improvement in functional capabilities compared to core stability exercises alone. These observations underscore the importance of a multimodal approach to treatment. By integrating core stability exercises with other therapeutic interventions like stretching and acupuncture, patients may experience more substantial improvements in pain relief and functional capacity. This comprehensive approach can be particularly beneficial for individuals with chronic pain and functional impairments, offering a more effective pathway to recovery and enhanced quality of life.

The methodological quality of the included studies was generally good, with most studies scoring between 7 and 8 on the PEDro scale. Only one study received a score of 5, indicating fair quality (Shamsi *et al.,* 2020). While all studies lost points due to the lack of blinding of subjects and therapists, the nature of the interventions made blinding of therapist impractical because each study involved different therapists treating each group, which reduces the need for blinding and minimizes the potential bias that could arise from this factor. However, the lack of blinding of the subjects may still have introduced some bias, as participants were aware of the intervention they received. Additionally, assessor blinding could have further reduced bias, and this was implemented in only two studies (Bhadauri *et al.,* 2017; Sokunbi *et al.,* 2014).

One of the primary limitations of this review was the heterogeneity in study designs, which included variability in exercise protocols as well as differences in outcome measures. Variations in the type, duration, frequency, and intensity of core stability exercises made it challenging to compare results across studies and draw definitive conclusions about the most effective protocols. Additionally, discrepancies in sample sizes, with some studies having relatively small populations, may have limited the statistical power and generalizability of the findings. The use of diverse outcome measures for functional disability further complicates the synthesis of results for disability improvement, emphasizing the need for standardized methodologies in future research. Another limitation of this review is the restricted generalizability of the findings, as the inclusion of only English-language studies excluded potentially relevant research published in other languages, which may have provided additional insights or differing perspectives. As a result, the findings may not be fully generalizable to other demographic groups, such as those from non-English speaking regions or different cultural contexts.

The review highlights the importance of personalized exercise programs for NSLBP patients, as variations in core muscle strength, activation patterns, and overall physical condition necessitate tailored approaches to maximize the effectiveness of core stability exercises. Customized programs are better able to target specific neuromuscular imbalances, thereby enhancing treatment outcomes. Future studies should focus on developing standardized protocols for core stability exercises, potentially integrating other therapeutic interventions. Additionally, including studies from diverse populations and non-English-language sources would improve the generalizability of the findings, addressing a limitation in this review and helping refine treatment strategies for a wider range of patients.

Conclusion

This systematic review offers substantial evidence supporting the integration of core stability exercises into the treatment plans of patients with NSLBP. The analysis of studies revealed that core stability exercises significantly improve pain and functional outcomes in individuals with NSLBP. The inclusion of multimodal approaches, combining core stability exercises with other treatments like stretching, strengthening, and acupuncture, demonstrated more promising improvements in pain relief and functional capacity.

Acknowledgement

We would like to express our gratitude to co-authors for their support and encouragement throughout this project. Their feedback and suggestions were greatly appreciated.

Additionally, I acknowledge the department of physical rehabilitation sciences at Kulliyyah of allied health sciences, IIUM for providing the academic environment necessary for the completion of this project.

References

Aidan, G., Cashina, B., James, H. McAuleya. (2020). Clinimetrics: Physiotherapy Evidence Database (PEDro) Scale. *Journal of Physiotherapy.*66(59).

Akodu, A. K., Akindutire, O. M. (2018). The effect of stabilization exercise on pain-related disability, sleep disturbance, and psychological status of patients with non-specific chronic low back pain. *Korean Journal of Pain*, 31(3), 199–205. https://doi.org/10.3344/kjp.2018.31.3.199

Ahmadi, H., Adib, H., Selk-Ghaffari, M., Shafizad, M., Moradi, S., Madani, Z. *et al.* (2020). Comparison of the effects of the Feldenkrais method versus core stability exercise in the management of chronic low back pain: a randomised control trial. *Clinical Rehabilitation*, 34(12), 1449–1457.

Akhtar, M. W., Karimi, H., Gilani, S. A. (2017). Effectiveness of core stabilization exercises and routine exercise therapy in management of pain in chronic nonspecific low back pain: A randomized controlled clinical trial. *Pakistan Journal of Medical Sciences*, 33(4), 1002–1006. https://doi.org/10.12669/pjms.334.12664

Balagué, F., Mannion, A. F., Pellisé, F., Cedraschi, C. (2012). Non-specific low back pain. *The Lancet,* 379(9814), 482-491. https://doi.org/10.1016/s0140-6736(11)60610-7

Bhadauria, E. A., Gurudut, P. (2017). Comparative effectiveness of lumbar stabilization, dynamic strengthening, and Pilates on chronic low back pain: Randomized clinical trial. *Journal of Exercise Rehabilitation*, 13(4), 477–485. https://doi.org/10.12965/jer.1734972.486

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, 37. https://doi.org/10.3390/jfmk6020037

GBD. (2021). Low Back Pain Collaborators. 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 Rheumatology*, 5, e316-29.

Ghorbanpour, A., Azghani M.R., Taghipour, M., Salahzadeh, Z., Ghaderi, F., Oskouei, A.E. (2018). Effects of McGill stabilization exercises and conventional physiotherapy on pain, functional disability and active back range of motion in patients with chronic non-specific low back pain. *Journal of Physical Therapy Science*, 30(4), 481-485. https://doi.org/10.1589/jpts.30.481

Hoy, D., March, L., Brooks, P., Blyth, F., Woolf, A., Bain, C. *et al.* (2014). The global burden of low back pain: estimates from the Global Burden of Disease 2010 study. *Annals of the Rheumatic Diseases*, 73, 968–974. https://doi.org/10.1136/annrheumdis-2013-204428

Kim, B., Yim, J. (2020). Core stability and hip exercises improve physical function and activity in patients with non-specific low back pain: A randomized controlled trial. *Tohoku Journal of Experimental Medicine*, 251(3), 193–206. https://doi.org/10.1620/tjem.251.193

Kumar, S., Sharma, V. P., Negi, M. P. S. (2009). Efficacy of dynamic muscular stabilization techniques (DMST) over conventional techniques in rehabilitation of chronic low back pain. *Journal of Strength and Conditioning Research / National Strength & Conditioning Association*, 23(9), 2651–2659. https://doi.org/10.1519/JSC.0b013e3181b3dde0

Maher, C., Underwood, M., Buchbinder, R. (2017). Non-specific low back pain. *Lancet*, 389(10070), 736–747. https://doi.org/10.1016/S0140-6736(16)30970-9

Majeed, S., Ts, A., Sugunan, A., Ms, A. (2019). The effectiveness of a simplified core stabilization program (TRICCS - Trivandrum Community-based Core Stabilisation) for community-based intervention in chronic non-specific low back pain. *Journal of Orthopaedic Surgery and Research*, 14(1), 1–8. https://doi.org/10.1186/s13018-019-1131-z

Mohammadi, V., Letafatkar, A., Sadeghi, H., Jafarnezhadgero, A. A., Hilfiker, R. (2017). The effect of motor control training on kinetics variables of patients with non-specific low back pain and movement control impairment: Prospective observational study. *Journal of Bodywork and Movement Therapies*, 21(4), 1009–1016. https://doi.org/10.1016/j.jbmt.2016.12.009

Paci, M., Bianchini, C., & Baccini, M. (2022). Reliability of the PEDro scale: comparison between trials published in predatory and non-predatory journals. *Archives of Physiotherapy*, 12(1), 10. https://doi.org/10.1186/s40945-022-00133-6

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D. *et al.* (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*, 372, n71. https://doi.org/10.1136/BMJ.N71

Shamsi, M. B., Mirzaei, M., Hamedirad, M. (2020). Comparison of muscle activation imbalance following core stability or general exercises in nonspecific low back pain: A quasi-randomized controlled trial. *BMC Sports Science, Medicine and Rehabilitation*, 12(1), 1–9.

Sokunbi, O. G., Muhwhati, L., Robinson, P. (2014). A pilot study on using acupunture and core stability exercises to treat non-specific acute low back paun among industrial workers. *South African Journal of Physiotherapy*, 70(2), a268. https://doi.org/10.4102/sajp.v70i2.268

Tawfik, G.M., Dila, K.A.S., Mohamed, M.Y.F., Tam, D.N.H., Kien ND, Ahmed, A.M. *et al* (2019). A step-by-step guide for conducting a systematic review and meta-analysis with simulation data. *Tropical Medicine and Health*,1(47),46. https://doi.org/10.1186/s41182-019-0165-6

Waseem, M., Karimi, H., Gilani, S. A., Hassan, D. (2019). Treatment of disability associated with chronic non-specific low back pain using core stabilization exercises in Pakistani population. *Journal of Back and Musculoskeletal Rehabilitation*, 32(1), 149–154. https://doi.org/10.3233/BMR-171114

Wu, A., March, L., Zheng, X., Huang, J., Wang, X., Zhao, J. *et al.* (2020). Global low back pain prevalence and years lived with disability from 1990 to 2017: estimates from the Global Burden of Disease Study 2017. *Annals of Translational Medicine*, 8(6), 299–299. https://doi.org/10.21037/atm.2020.02.175