Core Stabilization Exercises for Managing Non-Specific Low Back Pain in Adults: A Narrative Review of Their Efficacy Alone or with Multidisciplinary Approaches.

Author Information: Joseph Aubrey Comerford BSc (Chiro)

Email: joe.comerford2@gmail.com

Abstract:

Background: Non-specific low back pain affects people of all ages and is a leading contributor to disease burden worldwide. Estimates from the Australian Bureau of Statistics 2017–18 National Health estimate about 4.0 million Australians have back problems. The management of NSLBP has proven very challenging, as evidenced by its mounting socioeconomic burden. Core stability treatment procedures aim to improve pain and disability by increasing spinal stability in the lumbar spine. The purpose of this review is to examine the effect enhancing core stability through targeted core stabilisation exercises has on reducing the symptoms of NSLBP in combination with or independent of general exercise programs and/or conservative treatments.

Methods: A structured search of relevant articles was performed using the PubMed, Elsevier, and Cochrane databases. The search provided a total of 608 articles. Twenty-two articles met the inclusion criteria, and 586 articles were excluded.

Results: Core stability provides excellent therapeutic effects in NSLBP patients by reducing pain intensity and functional disability. Evidence suggests that core stability is more effective than rest or no/minimal intervention and, when used in combination with other types of exercise for NSLBP, can have even greater efficacy.

Conclusion: Core stability exercises should be used as part of a comprehensive treatment approach for non-specific low back pain (NSLBP), combined with other modalities such as therapeutic exercise and allied health conservative treatment plans. When used in conjunction with other modalities in a multidisciplinary approach, these treatments have demonstrated significant improvements in both pain levels and functional status, as compared to a placebo.

Keywords:

Non-specific low back pain, core stability, exercise, adults, conservative therapies, physiotherapy.

Introduction:

Non-specific low back pain (NSLBP) has become a major public health problem worldwide and affects people of all ages.[1] The Australian Bureau of Statistics 2017–18 National Health estimate about 4.0 million Australians (16% of the population) have back problems, with low back pain deemed the most frequent musculoskeletal condition that presents to general practice in Australia.[2] It is estimated that 70–90% of people will suffer from NSLBP at some point.[2]

NSLBP is a complex multifactorial phenomenon that is not attributed to a recognisable pathology or symptom pattern but instead develops as a result of the interaction of several risk factors, including constitutional risk factors, occupational risk factors, behavioural and environmental factors and psychosocial factors.[3] It is defined as localised pain between the 12th costal margin and above the inferior gluteal folds, with or without leg pain.[3]

The term “core stability” is commonly used to refer to the ability of the core muscles to stabilise the lumbar spine and pelvic girdle during static postures and dynamic movements. The theoretical foundation of improving core stability is to reduce pain and disability by recreating normal muscle function to increase spinal stability, improve neuromuscular control within the lumbopelvic region, induce inter-segmental stiffness and prevent shear force that causes injury to the lumbar spine.[1] The universal consensus on the pathophysiology of non-specific low back pain (NSLBP) is thought to involve a complex interplay between different structures and systems in the body, including the muscles, ligaments, discs, and nerves in the lumbar spine region. When the deep spinal muscles are affected, this can lead to alterations in the biomechanics of the lumbar spine, such as decreased stability and increased stress on certain structures resulting in pain and discomfort. In addition, it is believed that alterations in the central nervous system (CNS) may contribute to the emergence of NSLBP, given that individuals with chronic NSLBP often exhibit altered pain signal processing, leading to heightened pain sensitivity.

Furthermore, the psychological and emotional factors, such as stress, anxiety, and depression, can also play a role in the development and persistence of NSLBP.[6,7]

The management and treatment of NSLBP has proven very challenging, as evidenced by its mounting socioeconomic burden.[1] As NSLBP is not a homogeneous condition, the healthcare fraternity has a difference in opinions regarding its evolution. Some postulate it's due to a torso muscle endurance imbalance.[8] In contrast, others believe it's due to the cumulative stresses placed on the lumbar spine over time, such as repeated flexion cycles under load which in turn can create a "spine flexion bending intolerance".[5] There are multiple reasons for the lack of evidence-based information on the aetiology of non-specific low back pain (NSLBP). One reason is the complexity of the condition, as it can be caused by a variety of factors and involve multiple structures and systems in the body. This can make it challenging to identify the specific underlying causes of NSLBP and develop effective treatments. Additionally, NSLBP is often diagnosed based on subjective symptoms reported by the patient, such as pain and discomfort in the lower back region, rather than objective measures. This can make it difficult to accurately assess the severity and underlying causes of the condition. Furthermore, research on NSLBP has been limited by a lack of standardised diagnostic criteria and a lack of consensus on the best methods for assessing and treating the condition. This has made it challenging to conduct large-scale, high-quality research studies on NSLBP and develop evidence-based guidelines for diagnosis and treatment. All of these factors have contributed to the lingering uncertainty surrounding the aetiology of NSLBP and the need for further research to better understand the condition and develop effective treatments.[9]

A plethora of core stabilisation exercises are endorsed in clinical practice as the gold standard for patients with NSLBP, ranging from Pilates to specific core stabilisation exercise regimes. However, uncertainty in the literature exists as there is currently only low-quality evidence to support using one exercise approach over another since the relative effectiveness of different approaches has been shown to be generally

comparable.[1,10] A liability of NSLBP as a diagnosis is the vast majority of research done on this broad topic generically categorises the NSLBP population regardless of age, demographic and socioeconomic status. This creates a gap in the knowledge on the effects sub-categorising the NSLBP population based on factors in their history, and physical examination may have treatment wise.

A systematic review conducted by van Middelkoop et al.[11] aimed to investigate the clinical effectiveness of physical and rehabilitation interventions for NSLBP. The review included 110 randomized controlled trials, which evaluated a range of physical and rehabilitation interventions, including exercise, manual therapy, and various modalities such as electrotherapy and ultrasound. The results of the review were mixed, with inconclusive evidence to support the idea that core stabilisation exercises are a more effective treatment on their own for NSLBP compared to being incorporated as part of a global treatment plan. The heterogeneity differences between the populations, interventions, and comparison groups of the reviewed articles were cited as a factor in the lack of conclusive evidence. Overall, they noted that the evidence was generally of low to moderate quality, and highlighted the need for further high-quality research to confirm the effectiveness of these interventions.[11]

The aim of this review is to narrow the search focus and evaluate the effectiveness of core stability in addressing non-specific low back pain (NSLBP), whether as a standalone treatment or in combination with general exercise routines and/or conservative therapies. This may involve analysing traditional exercises in isolation or in conjunction with manual medical techniques and/or manually administered physical therapy. The review will conduct an appraisal of the tabulated data on core stability pertaining to NSLBP to help conclude whether core stability exercises are a more effective intervention when used in isolation or when they are incorporated as part of a multimodal approach, including but not limited to, general exercise routines and allied health interventions such as physiotherapy.

Methodology

A comprehensive and structured literature search of relevant articles was completed using the PubMed, Elsevier, and Cochrane databases. Key search terms included “core stability” or “core stabilisation” or “lumbar stabilisation” or “core strengthening” combined with the terms “low back pain” or “non-specific low back pain” and exercise* and “physiotherapy”. The Boolean operator’s AND and OR were used to combine the following search terms: “non-specific low back pain”, “core stability”, “exercise*”, “adults” and “physiotherapy”. The truncal symbol * was used to include exercise and exercising and exercises. The search criteria were limited to full-text online articles that included randomised control trials, systematic reviews, and meta-analyses with the publication date of 2006-2022. The initial searches were identified using the following PICO formats “non-specific chronic low back pain and core exercises” which returned 31 results. Other PIO combinations included “non-specific low back pain and lumbar musculature” (136 results), “non-specific low back pain and core muscular strength” (23 results) and “non-specific low back pain and adults” (418 results). The combined search on the electronic databases provided a total of 608 articles. Articles were screened by title and abstract. Studies deemed unclear from their title or abstract were reviewed according to the selection criteria through full text. Studies had to be full randomised controlled trials (RCTs) to be included within the final review. Twenty-two articles met the inclusion criteria, and 586 articles were excluded (Table 1). In total, with the 22 articles combined, 1456 participants were included in these studies. Characteristics of the 22 RCTs ranging from 2006 to 2022 participant breakdown and demographic are shown in Table 2 below.

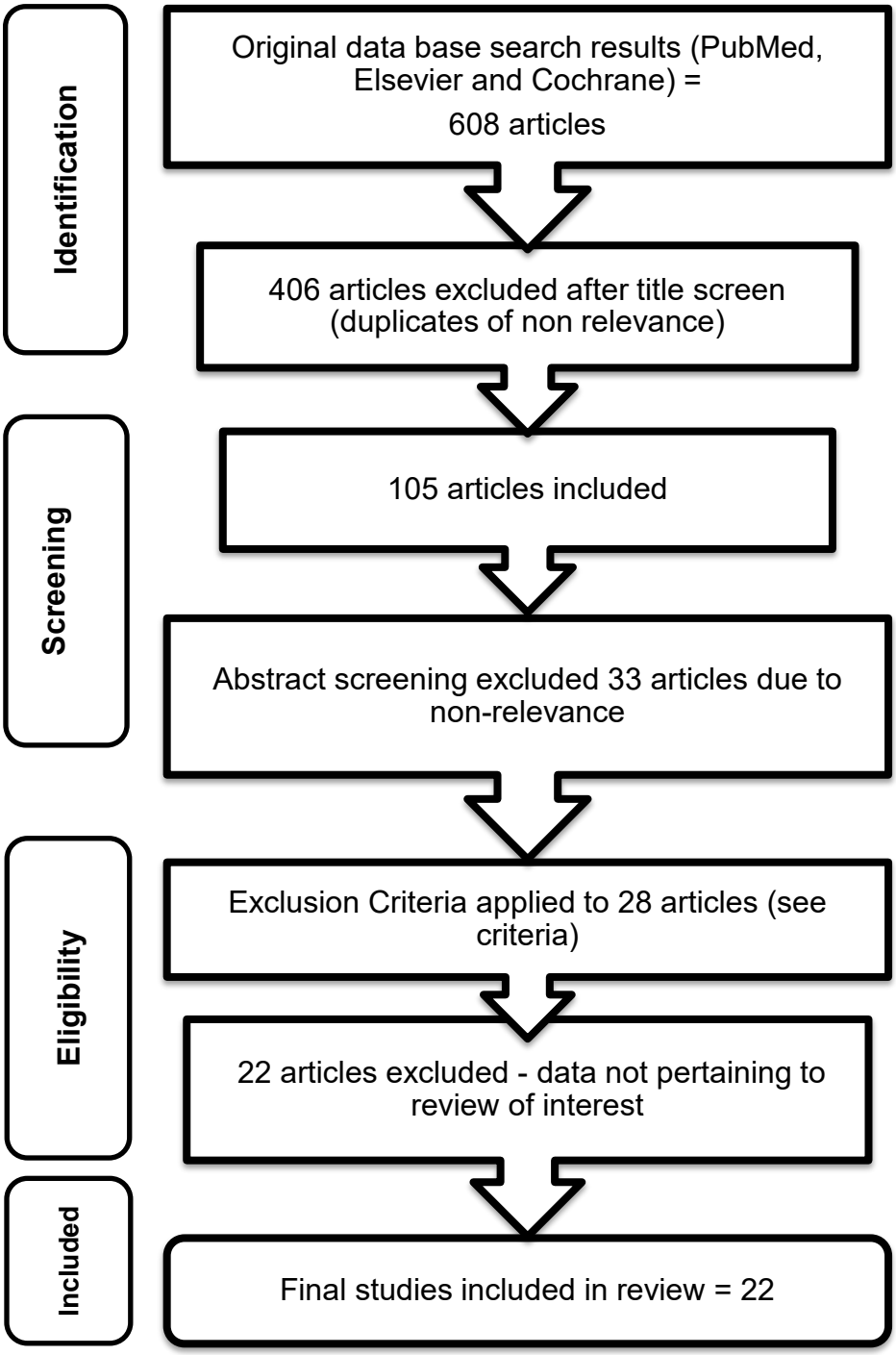
Inclusion Criteria:

Inclusion Criteria included articles that investigated core stability exercises individually, in contrast, or combination with ‘physical therapy’ ‘pharmacological approach’ or no intervention/control group. The included studies had to be peer-reviewed and in the English language, with the study population refined to adults of either gender in the 18-80 age bracket.

Exclusion Criteria:

Exclusion criteria included articles not in the English language; population groups that included injured/diseased participants or children; LBP with specific aetiologies; LBP in pregnant women.

Table 1: Literature search flow diagram



Outcome measures

The following self-reported outcome measures were assessed in this review: pain intensity (e.g., visual analogue scale (VAS), McGill pain questionnaire), back-specific disability (e.g., Roland Morris, Oswestry Disability Index), perceived recovery (e.g., overall improvement), return to work (e.g., return to work status, sick leave days), and side effects. The primary outcomes for this overview were pain and physical functional status. Secondary outcome measures included an improved low back range of motion, flexibility, and quality of life surveys.

Table 2. Characteristics of included studies

Reference, Year	Study Aim/Group Allocation	Study Design/ PEDro Score	Sample Description/ Sample Size	Outcome Measures	Statistically Significant Findings	Study/Bias/ Limitations
Bae et al.[12], 2018	Compare the effect of assisted sit-up exercise (SUE) using a new training device, has on strengthening core muscles and improving non-specific low back pain (NSLBP) compared to conventional core stabilisation exercise (CSE). The trial subjects were allocated into two groups a sit-up exercise group and a core stabilisation exercise group. There was no control group allocated.	RCT PEDro = 5/10	N=36 SUE (n=18) Mean age 32.7 ± 6.1 CSE (n=18) Mean age 32.4 ± 10.7	VAS for pain intensity, Oswestry Disability Index for functional status.	Significant improvements were seen in both groups with a ($p < 0.05$). However, all measurements for pain and disability showed no statistical difference between the experimental group or the control.	The applied exercise could not be quantified. The sample size was small and the mean age in both groups was relatively young. Medium quality study.
Cairns et al.[13], 2006	Evaluate the effect adding specific spinal stabilisation exercises to conventional physiotherapy for patients with recurrent low back pain (LBP) has on improving movement outcomes. The trial subjects were allocated into two, a conventional physiotherapy treatment group and a core stabilisation exercise group with conventional physiotherapy. There was no control group allocated.	Single-blind RCT, with a 12-month follow-up PEDro = 7/10	N=97 Stabilisation (n=47) Mean age 37.5 ± 9.5 Conventional (n=50) Mean age 39.9 ± 11.3	VAS for pain intensity, Rolland Morris Disability Questionnaire and the Oswestry Disability Index for functional status	No statistical or clinical difference between the 2 treatment groups was seen in the pain or functional outcome measure.	Compliance was not formally measured, making it not possible to fully evaluate the effect compliance had on the outcome. Literature > 10 years old Moderate quality.
Costa et al.[6], 2009	Investigate the efficacy motor control exercise of specific low back muscles has on chronic low back pain versus a placebo intervention The trial subjects were allocated evenly into two groups a spinal stabilisation group and a placebo exercise group.	RCT Pedro = 9/10	N=154 Exercise Group (n=77) Mean age 54.6 ± 13.0 Placebo Group (n=77) Mean Age 52.8 ± 12.7	Pain numerical rating scale (NRS) for pain intensity, Roland-Morris Disability Questionnaire (RMDQ), Patient-Specific Functional Scale (PSFS) for activity.	The study provides evidence that motor control exercise was better than placebo with the exercise intervention demonstrating improvements in patient activity and patient's global impression of recovery. However, pain intensity was only minimally reduced	Blinding of clinicians was not possible. Adherence to home exercises was not monitored.

Reference, Year	Study Aim/Group Allocation	Study Design/ PEDro Score	Sample Description/ Sample Size	Outcome Measures	Statistically Significant Findings	Study/Bias/ Limitations
Cruz-Díaz et al.[14], 2017	To assess the effectiveness of 12 weeks of Pilates practice in disability, pain, kinesiophobia and transversus abdominis activation in patients with chronic nonspecific Low Back Pain. The trial consisted on three groups, a Pilates Mat group (PMG), an equipment based Pilates with apparatus group (PAG) and a no treatment control group.	RCT PEDro = 7/10	N=98 PMG (n=34) Mean age 36.94 ± 12.46, PAG (n=34) Mean age 35.5 ± 11.98, Control group (n=30) Mean age 36.32 ± 10.67	VAS for pain intensity, Rolland Morris Disability Questionnaire and the Oswestry Disability Index for functional status.	Results suggest that Pilates Mat and equipment-based Pilates were both effective in NSLBP management with observed improvement on pain, disability, deep trunk muscles activation and kinesiophobia. Equipment based Pilates seems to provide faster and better results in comparison with mat Pilates especially in the short term. Improvement was observed in both intervention groups in all the included variables at 6 and 12 weeks ($p < 0.001$). Faster enhancement was observed in the equipment-based Pilates group ($p = 0.007$).	Dropout rate in the control group was a limitation. Many factors could be the responsible for differences in outcomes between the PMG and PAG groups such as the study population, instructor performance, patient motivation or accuracy of the given instructions during the transversus abdominis activation.
Demirel et al.[15],2019	To determine whether spinal stabilisation exercises or yoga influences pain, functional status and quality of life in non-specific low back pain sufferers The trial subjects were allocated evenly into two groups, a spinal stabilisation group (SG) and a yoga exercise group (YG).	RCT PEDro = 6/10	N=77 SG (n=37) Mean age 45.59 ± 12.32, YG (40) Mean age 44.25 ± 8.71	VAS for pain intensity, Back Performance Scale (BPS) and the Oswestry Disability Index for functional status.	The results were conflicted with the YG reported decreased pain during activity, but the SG reported superior improvements in disability status.	The major limitation is the assessor was not blinded to the groups and some subjects did not want to join yoga classes due to religious beliefs
Ghorbanpour et al.[16], 2018	To compare the effects of "McGill stabilisation exercises" and "conventional physiotherapy" has on pain, functional disability and active back flexion and extension range of motion in patients with chronic non-specific low back pain. The trial subjects were allocated evenly into two groups, a McGill spinal stabilisation group and a conventional physiotherapy group.	RCT PEDro = 5/10	N=34 McGill stabilisation group (n=17) Mean age 23.8 ± 3.5, Conventional physiotherapy group (n=17) Mean age 20.9 ± 1.2	VAS for pain intensity, Quebec Low Back Pain Disability Index for functional status.	McGill stabilisation exercises and conventional physiotherapy provide approximately similar improvement in pain, functional disability, and active back range of motion in patients with CNSLBP. However, it appears that McGill stabilisation exercises provide an additional benefit to patients with NSCLBP, especially in pain and functional disability improvement.	This study had several limitations, including a short intervention period and a small sample size making it difficult to determine if the outcomes are true findings.
Hlaing et al.[17], 2021	To compare the effects of two different exercise regimes, Core stabilization exercises (CSE) and Strengthening exercise (STE), on proprioception, balance, muscle thickness and pain-related outcomes in patients with subacute non-specific low back pain (NSLBP). The trial subjects were allocated evenly into two groups, a CSE group and a STE group.	RCT PEDro = 7/10	N=36 CSE group (n=18) Mean age 35.06 ± 9.55 STE group (n=18) Mean age 35.50 ± 8.83	The visual analogue scale (VAS) was used to assess pain, The Modified Oswestry Disability Questionnaire (MODQ) was used to measure functional disability.	The CSE group demonstrated significantly more improvement than the STE group after 4 weeks of intervention. Although both exercise groups gained relief from pain, the CSE group demonstrated greater reduction of functional disability [effect size: 0.61, ($p < 0.05$)] and fear of movement [effect size: 0.80, ($p < 0.01$)].	Only patients with sub-acute NSLBP were included. Exercise compliance was not tested and as such may be different between the CSE and STE groups, introducing a bias.
Hosseinifar et al.[18], 2013	To determine and compare the effectiveness of stabilization and McKenzie exercises on pain, disability and TrA and MF muscle thickness in resting and	RCT PEDro = 5/10	N=30 Stabilisation group (n=15) Mean age 40.1 ± 10.8	The visual analogue scale (VAS) was used to assess pain, The Functional Rating Index (FRI)	Stabilization exercises proved to be more effective than McKenzie exercises in improving the intensity of pain and function score in nonspecific CLBP subjects.	Moderate quality study

Reference, Year	Study Aim/Group Allocation	Study Design/ PEDro Score	Sample Description/ Sample Size	Outcome Measures	Statistically Significant Findings	Study/Bias/ Limitations
	contracting states in patients with nonspecific CLBP. The trial subjects were allocated evenly into two groups, a stabilisation exercise group and a Mckenzie exercise group.		Mckenzie exercise group (n=15) Mean age 36.6 ± 8.2	questionnaire was used to measure functional disability.		
Inani et al.[19], 2013	To evaluate if there is any difference between whether core stabilisation exercises or conventional exercises improve the pain and functional status of adults with non-specific low back pain (LBP). The trial subjects were allocated evenly into two groups, a core stabilisation exercise group and a conventional exercise group.	RCT PEDro = 5/10	N=30 Core stabilisation group (n=15) Mean age 27.8 ± 7.34 Conventional exercise group (n=15) Mean age 32.93 ± 6.43	VAS for pain intensity, Modified Oswestry Disability Index for functional status.	The study's outcome suggests that core stabilisation exercises reduce pain and improve functional status in patients with non-specific LBP by a difference of (p0.001) compared to the conventional exercise regime.	Small sample size, Absence of a true control group, Moderate quality study.
Kim et al.[20], 2020	To establish if core stability exercise (CSE) in conjunction with hip muscle stretching exercises would result in more significant improvements in pain and functionality outcomes for non-specific low back pain (LBP) sufferers. The trial consisted of three groups. The Stretch group (n = 24) performed exercises for hip muscle stretching for maximal motion; the Strengthen group (n = 22) performed exercises for hip muscle strengthening while maintaining the maximal isometric contraction. The Sham group (n = 20) received gentle palpation of the skin.	RCT PEDro = 6/10	N=66 Stretch Group (n=24) Mean age 47.50 ± 9.70 Strengthen group (n=22) Mean age 47.04 ± 9.48 Sham Group (n=20) Mean age 47.75 ± 8.51	VAS for pain intensity, Oswestry Disability Index for functional status.	There were significant within-group changes for all measurements (P<0.05). The Stretch and Strengthen groups had greater improvements in pain intensity, disability level, balance ability, and quality of life than the Sham group. Lower back instability and hip muscle flexibility had the greatest improvement in the Stretch group. In conclusion, CSE and hip muscle stretching are effective at improving physical function and activity in NSLBP patients.	Short intervention period, lack of objective assessments. Moderate quality.
Koumantakis et al.[21], 2005	To investigate whether stabilisation exercises are a useful supplement to general trunk exercises in patients with recurrent nonspecific LBP. The trial subjects were allocated evenly into two groups, a general exercise group combined with specific core stabilisation exercises and a group that received general exercise only.	RCT PEDro = 7/10	N=55 Stabilisation-Enhanced exercise group (n=29) Mean age 39.2 ± 11.4 General exercise only group (n=26) Mean age 35.2 ± 9.7	Short-Form McGill Pain Questionnaire for pain perception, VAS for pain intensity, Roland-Morris Disability Questionnaire for functional status.	A statistically significant difference was observed between the 2 groups for the reduction in RMDQ scores (mean difference=2.55, P=.027) in favour of the general exercise–only group for the RMDQ data acquired immediately posttreatment. Both groups made a clinically significant improvement based on a 4-point within- group change; however, the improvement in the stabilisation–enhanced exercise group was suboptimal compared with the general exercise–only group for the immediate post exercise comparison.	There was no means of verifying appropriate muscle recruitment and contraction, with the subjects having to be corrected until at least 3 sessions had passed. The Back Book supplied for patient education may have influenced patients' beliefs with LBP.
Lopes et al.[22], 2017	To evaluate the immediate effects of Pilates based therapeutic exercises session on postural sway, dynamic balance and pain in young adults with NSLBP.	RCT PEDro = 7/10	N=46 Pilates Group (n=23) Mean age 21.8 ± 3.2	VAS for pain intensity' Oswestry Disability Index for functional status.	Pain decreased significantly after the Pilates exercises (VAS change: − 29.5 ± 10.5%), while no changes were observed in the control group (VAS change: 3.0 ± 16.4%). In the Pilates group 44.4% (n = 12) of the	The study population was young with minimal disability and pain that is not generally representative of the chronic LBP population.

Reference, Year	Study Aim/Group Allocation	Study Design/ PEDro Score	Sample Description/ Sample Size	Outcome Measures	Statistically Significant Findings	Study/Bias/ Limitations
	The trial subjects were allocated evenly into two groups, a Pilates group and a control group.		Control group (n=23) Mean age 22.8 ± 3.6		participants had a minimum decrease of 50%, and 48.1% (n = 13) had a decrease above 30% in the VAS, which is a decrease clinically relevant.	Only immediate effects were measured.
Macedo et al.[23], 2012	To compare the effectiveness of motor control exercises of the superficial and deep trunk stabilisers to graded activity exercises which includes addressing pain-related fear, kinesiophobia, and unhelpful beliefs and behaviours about back pain while correcting physical impairments such as reduced endurance, muscle strength, or balance for patients with chronic nonspecific low back pain. The trial subjects were allocated evenly into two groups, a motor control group, and a graded activity exercise group.	RCT PEDro = 8/10	N=172 Motor Control Exercise Group (n=86) Mean age 48.7 ± 13.7 Graded Activity Group (n=86) Mean age 49.6 ± 16.3	NRS for pain intensity, Patient-Specific Functional Scale and Roland-Morris Disability Questionnaire for functional status.	The estimates of treatment effects from the linear mixed models revealed that there were not statistically significant, or clinically important, differences between treatment groups for any of the outcomes at any of the time points.	Clinicians could not be blinded to the interventions. Lack of a true control group. Functionality was only measured with self-reported outcome measures.
Marshall et al.[24], 2013	To compare the effect of 8 weeks of specific trunk Pilates exercises to stationary cycling for patients with chronic non-specific low back pain. The trial subjects were allocated evenly into two groups, a specific trunk Pilates exercise group (SEG) and a general exercise group (CEG).	RCT PEDro = 7/10	N=64 Specific Trunk Pilates Exercise Group (n=32) Mean age 36.2 ± 8.2 General Exercise Group (n=32) Mean age 36.2 ± 6.2	VAS for pain intensity, Oswestry Disability Index for functional status.	The 8-week supervised group-based program of Pilates had better short but not long-term statistical outcomes compared with stationary cycling. At 8 weeks, disability was significantly lower in the specific trunk exercise group compared with the stationary cycling group (d = 0.62, P = 0.018). Pain was reduced from baseline in both the groups after training (P < 0.05) but was lower for the SEG (P < 0.05).	Baseline scores for pain and disability were moderate. Participants had a positive attitude towards exercise. Study supervisors were unable to be blinded.
Matarán-Peñarrocha et al.[25], 2020	To compare the effectiveness of supervised physical therapy program versus non-supervised on pain, functionality, fear of movement and quality of life in patients with non-specific chronic low back pain. The trial subjects were allocated evenly into two groups, a supervised exercise group and a non-supervised exercise group (CEG).	RCT PEDro = 8/10	N=64 Supervised Exercise Group (n=32) Mean age 54.3 ± 7.9 Non-supervised Exercise Group (n=32) Mean age 53.2 ± 8.0	The visual analogue scale (VAS) was used to assess pain, The Oswestry Disability Questionnaire and the Roland-Morris Disability Questionnaire were used to measure functional disability.	Although analysis of variance (ANOVA) test showed statistically significant differences between groups for pain (P = 0.028; supervised: 2.5 ± 2.1; non-supervised: 3.5 ± 1.5) and disability for Roland–Morris Disability Questionnaire (P = 0.004; supervised: 3.1 ± 2.2; non-supervised: 5.1 ± 3.0) and for Oswestry Disability Index (P = 0.034; supervised: 14.5 ± 7.1; non-supervised: 19.2 ± 10.0) at 8 weeks immediately posttreatment, there were no differences between the groups in patient-rated pain, functionality, fear of movement and quality of life at six months of follow-up.	Blinding was lacking for both the study subjects and physical therapists. There is no true control group.
Ozsoy et al.[26], 2019	To evaluate the effects of Myofascial Release Technique (MRT) with a roller massager combined with core stabilization exercises (CSE) in elderly	RCT PEDro = 6/10	N=45 CSE Group (n=23) Mean age 68.14 ± 2.57	The visual analogue scale (VAS) was used to assess pain, The Oswestry Disability	It was found that the improvement in core stability endurance (p=0.031) and spinal mobility (in the sagittal plane) (p=0.022) was greater in the CSE+MRT	A MRT group should have been included to demonstrate the effectiveness of each treatment.

Reference, Year	Study Aim/Group Allocation	Study Design/ PEDro Score	Sample Description/ Sample Size	Outcome Measures	Statistically Significant Findings	Study/Bias/ Limitations
	with non-specific low back pain (NSLBP). The trial subjects were allocated evenly into two groups, a CSE group and a CSE + MRT group.		CSE+MRT Group (n=22) Mean age 68.04 ± 2.97	Questionnaire was used to measure functional disability.	group compared to the CSE group. There was no significant difference between the two groups in terms of pain, low back disability, lower body flexibility, kinesiophobia, gait characteristics and quality of life (p>0.05). The current study suggests that myofascial release technique with a roller massager combined with core stabilization exercises can be a better choice in the treatment of NSLBP in elderly.	
Paungmali et al.[27], 2018	To investigate the effects 3 group exercise interventions, have on the levels of plasma β-endorphin (PB) and plasma cortisol (PC) after lumbar core stabilisation exercise (LCSE), placebo (automated passive cycling training), and control (rest)—in patients with chronic nonspecific low back pain. The trial consisted of three groups. The LSCE group who performed lumbopelvic core stabilisation exercise; the placebo group who performed automated passive cycling exercises on an automatic bicycle. The control group who was made to relax completely on the Pilates power gym in the similar supine crook lying position.	RCT PEDro = 5/10	N=24 Mean age 33.76 ± 14.51 The study was a double cross over, so all participants performed each type of exercise intervention during the trial.	The visual analogue scale (VAS) was used to assess pain.	A significant difference in PB level was identified before and after the LCSE condition (P< .05), whereas no significant differences were noted in control and placebo exercise conditions. The findings of this study indicate that LCSE could possibly influence PB levels among patients with chronic nonspecific low back pain. The mechanism of action of the pain-relieving effect of LCSE might be related to an endogenous opioid mechanism as part of its effects and might not be involved with a stress-induced analgesia mechanism.	The present study did not directly investigate the changes in pain intensity in relationship to changes in the levels of PB and PC during LCSE. Therefore, it was not possible to comment on the direct pain inhibition effects by the levels of PB and PC identified during the study after the LCSE. The smaller sample size could be considered as another limitation.
Paungmali et al.[28], 2017	The main objective of this study was to investigate the immediate effects of lumbopelvic core stabilisation exercise (LPST) has on pain perception and pain sensitivity among chronic low back pain patients. All the participants received 3 different types of experimental interventions, which included LPST, the passive automated cycling intervention, and the control intervention randomly, with 48 hours between the sessions.	RCT PEDro = 4/10	25 Mean age 33.33 ± 14.37 The study was a double cross over, so all participants performed each type of exercise intervention during the course of the trial.	The visual analogue scale (VAS) was used to assess pain.	The pain intensity under the LPST condition was significantly better than that under the passive automated cycling intervention and controlled intervention (P < 0.001). Lumbopelvic stabilisation training may provide therapeutic effects by inducing pain modulation through an improvement in the pain threshold and reduction in pain intensity.	Only the immediate effects of LPST on pain perception were considered. The study did not account for the different subtypes of chronic low back pain.
Shamsi et al.[29], 2016	To compare core stability and general exercises (GEs) in chronic low back pain (LBP) patients based on lumbopelvic stability (LPS) assessment through three endurance core stability tests. The trial subjects were allocated evenly into two	RCT PEDro = 4/10	N=48 CSE Group (n=24) Mean age 39.2 ± 11.7 GE Group (n=24) Mean age 47.9 ± 10.2	The visual analogue scale (VAS) was used to assess pain, The Oswestry Disability Questionnaire was used to measure functional disability.	CSE is not more effective than GE for improving endurance core stability tests and reducing disability and pain in chronic non-specific LBP patients.	Mean age between groups was moderately higher which could be considered a drawback of the sampling method.

Reference, Year	Study Aim/Group Allocation	Study Design/ PEDro Score	Sample Description/ Sample Size	Outcome Measures	Statistically Significant Findings	Study/Bias/ Limitations
	groups, a CSE group and a GE group.					
Shamsi et al.[30], 2020	To investigate whether there was a difference in the pattern of muscle activation in chronic nonspecific low back pain sufferers following core stability exercise (CSE) and general exercise (GE). The trial subjects were allocated evenly into two groups, a CSE group and a GE group.	RCT PEDro = 4/10	N=43 CSE Group (n=27) Mean age 38.9 ± 12.2 GE Group (n=24) Mean age 47.0 ± 9.9	The visual analogue scale (VAS) was used to assess pain, The Oswestry Disability Questionnaire was used to measure functional disability.	Both exercise programs reduced pain and disability. The effects of two exercises on pain, disability, and antagonist coactivation or imbalance ratios were not statistically different.	The participants were not randomly allocated to the study arms, which can be considered as a drawback of our study. Minimize systematic bias or confounding could not be achieved using the quasi-randomized trial design.
Waseem et al.[31], 2019	To compare the effects of core stabilisation workouts to routine physical therapy exercise training for the treatment of disability caused by chronic low back pain. The trial subjects were allocated evenly into two groups, a CSE group and a routine physical therapy group.	RCT PEDro = 4/10	N=120 CSE Group (n=60) Mean age 46.39 ± 7.43 Routine Physical Therapy Group (n=60) Mean age 45.50 ± 6.61	The Oswestry Disability Questionnaire was used to measure functional disability.	A larger reduction in disability was observed for subjects treated with core stabilisation exercises in comparison to those treated with routine physical therapy. The mean reduction in disability as measured by ODI score was 39.44 ± 14.64 for CSE Group and 31.91 ± 12.31 for The Physical Therapy Group.	There was no proof of patient compliance.
Zhang et al.[32], 2015	To determine whether Chinese massage combined with core stability exercises may exert greater improvement on non-specific low back pain (LBP) than massage therapy alone. The trial subjects were allocated evenly into two groups, a Chinese massage combined with a core stability exercise group and a control group that used stand-alone Chinese massage.	RCT PEDro = 5/10	N=92 Chinese massage Group with core stability exercises (n=46) Mean age 48.71 ± 3.89 Control Group (n=46) Mean age 51.62 ± 4.03	The visual analogue scale (VAS) was used to assess pain, The Oswestry Disability Questionnaire was used to measure functional disability.	Core stability exercises may improve the therapeutic effect of Chinese massage in treating non-specific low back pain with both the VAS ($p < 0.05$) and ODI ($p < 0.05$) scores significantly lower in the experimental group than those in the control group.	Difficulty blinding the therapists and a lack of objective measurements of function or physical activity post-intervention.

Legend: Non-specific Low Back Pain (NSLBP); Visual analogue scale (VAS); Pain numerical rating scale (NRS); Roland-Morris Disability Questionnaire (RMDQ); Patient-Specific Functional Scale (PSFS); Chronic low back pain (CLBP); Pilates Mat Group (PMG), Pilates Apparatus Group (PAG); Back Performance Scale (BPS); Lumbopelvic stability training (LPST); Sports massage therapy (SMT); Pain Intensity (PI); Pain Pressure Threshold (PPT); Tissue Blood Flow (TBF); Modified Oswestry Disability Questionnaire (MODQ); Transverse abdominis (TrA); Multifidus (MF); Patient-Specific Functional Scale (PSFS); Core Stability Exercise (CSE); General Exercise (GE);

Results

Description of studies:

There is a great deal of literature about patients with NSLBP, but information related to the most effective treatment regime is limited. The aim of this review is to summarise the findings and to discuss certain perspectives regarding the implementation of the most effective lumbar core stabilisation strategies that may be relevant to prescribe for adults encountering this complaint.

The 22 RCTs selected involved 1456 patients in representing this review, investigated lumbar core stabilisation exercises individually, in contrast, or in combination with 'physical therapy' 'pharmacological approach' or no intervention/control group. The experimental groups consisted of a range of stabilisation exercises that varied from study to study, which emphasises that significant heterogeneity exists between articles being reviewed.

Quality of evidence:

The PEDro scale was used to assess and critically analyse the methodological quality of the included 22 RCTs. Based on this comprehensive assessment, the quality of evidence for each outcome ranged from 4 to 9, with specific details provided in Table 2.

Effects of interventions on pain and functional status:

Specific spinal stabilisation exercise therapy versus minimal or no intervention;

Five studies compared spinal stabilisation exercises to a control group that received no treatment or sham therapy. Three out of 5 studies reported a statistically significant improvement in average pain intensity for their core stability intervention group.[6, 14, 20, 22, 27] Clinically meaningful differences in average pain intensity and/or functional status were observed in 3 of the five studies at the completion of the trial compared to the control. One study reported improved core stability released increased the amounts of endogenous opioids associated with relieving CLBP symptoms at a biochemical level.[25] While the evidence suggests that improving stabilisation of the core musculature may

have a positive effect on NSLBP symptoms, analysis of this data is difficult to pool because of the heterogeneity between the types of interventions.

Specific spinal stabilisation exercise therapy versus other forms of exercise therapy:
Eleven studies compared specific core stability exercises to another exercise intervention as the control group. Each study compared a core stability exercise regime to different general strengthening and/or stretching exercise routines with varying trial timelines. A total of six of the eleven studies did not find any statistically significant differences between the various exercise interventions at the completion of the trial.[11, 21, 23, 25, 29, 30]

One study reported conflicting results with the extrapolated data signifying that the experimental group improved pain outcomes but not functional status, while the control group reported superior improvements in disability status but nothing statistically significant in pain improvements.[15] While five studies demonstrated that improving core stability can have a therapeutic effect on decreasing NSLBP symptoms, based on the heterogeneity of the populations, interventions, and comparison groups in these articles, there is insufficient data to draw a firm conclusion on the clinical effect of which is the best approach to use.

Spinal stabilisation exercises as an adjunct therapy to another treatment versus the other treatment alone:
Two studies compared the effects of adding core stabilisation exercises in accordance with a physical therapy approach and compared it to the stand-alone physical therapy.[13, 32] Results were mixed with the outcomes with the study that used core stabilisation exercises in conjunction with standard physiotherapy care found no difference in pain or functional status to the control group that used just standard physiotherapy treatment.[13] The study that used core stabilisation exercises in combination with Chinese massage had better results than the stand-alone Chinese massage did.[32]

Spinal stabilisation exercises versus various conservative care treatments;
One study compared spinal stabilisation exercises in addition to another treatment versus the stabilisation exercises alone.[26] Results favoured the combination over the exercises in isolation.[26] Three studies compared spinal stabilisation exercises in addition to another conservative treatment approach. All three studies' results

favoured the core stabilisation exercises over the other treatment control group, with significant improvements in pain and functional status seen at the completion of the trials.[16, 28, 31]

Discussion

The intention of this review is to develop a synthesis on the available scientific data in relation to exercise and conservative care rehabilitation programs and the affects they have on the perturbations caused from NSLBP. In this review, 22 RCTs were included that evaluated the effectiveness of core stabilisation exercise as a conservative care rehabilitation intervention for NSLBP individually, in contrast, or in combination with 'physical therapy' 'pharmacological approach' or no intervention/control group.

In general, core stabilising exercises have emerged as popular topics related to the rehabilitation of painful and dysfunction backs.[11] Previously published trials have suggested that core stabilization exercises are more effective in treating non-specific low back pain (NSLBP) than conventional exercises which targeted the more superficial musculature. In contrast, core stability exercises focus on retraining motor skills and activating local spinal stabilization muscles, including the deep abdominal muscles, back muscles, and pelvic floor muscles. This unique focus is thought to be the reason for the superior effectiveness of core stability exercises in managing NSLBP, as compared to conventional exercises.[11]

This review reinforced the knowledge of the above concept, with all the studies that trialled core stabilisation exercises against a placebo/control group finding the improvements in the experimental group were statistically significant when compared to the placebo, without any adverse events reported throughout the trial. The core exercise programs for the experimental groups primarily emphasised maintaining a neutral lumbar spine and excluded exercises such as traditional sit-ups, which are known to generate excessive compressive forces in the lumbar spine. [6, 14, 20, 22, 27]

The results varied between the RCTs that compared core stability exercises with other interventions, that being conservative care or exercise therapy. The collaborated data shows that less than half of the studies found statistically significant differences in pain

and functional status improvements to the comparator intervention at the trial completions. It's important to note that core stabilisation exercises should not be dismissed as a treatment, as all studies have found that they can decrease the effects of NSLBP. However, when compared to a multimodal approach, the differences in effectiveness must be regarded as small and not clinically relevant. This is because the observed clinical differences may not be significant enough to make a meaningful impact on every individual patient's experience. Therefore, it's generally recommended that a multidisciplinary approach be used for treating NSLBP to address the complex nature of the condition and provide the best possible outcomes for the patient. For these reasons, it is generally recommended that a multidisciplinary approach be used for treating NSLBP to address the complex nature of the condition and provide the best possible outcomes for the patient.

During the review process, it became apparent that there is disagreement among authors about making non-specific low back pain (NSLBP) an official diagnosis. McGill et al.[5] argue that in the absence of serious medical issues, most cases of back pain can be traced to a particular motion, posture, or load, and a NSLBP diagnosis simply indicates

that the assessment has not been thorough enough to identify the underlying cause of the pain. According to McGill et al.[5], the concern with treating NSLBP as a diagnosis is that the exercise programs available lack clarity due to the heterogeneous nature of the condition. Without a precise diagnosis, an approach that works well for one patient may not be effective or may even exacerbate the pain in another patient. To address this issue, McGill et al.[5] suggest using specific predictors to group patients and tailor the prevention and rehabilitation approaches accordingly. For instance, patients with "spine flexion bending intolerance" may not benefit from conventional sit-up exercise regimes, as they involve repeated bending of the spinal discs which can be harmful. In short, according to McGill et al.[5], there is no such thing as non-specific back pain, and a thorough understanding of the underlying cause is essential to guide appropriate treatment interventions.

Limitations

The studies included in this review on non-specific low back pain (NSLBP) have moderate limitations stemming from the variations in regulation, testing procedures,

data acquisition, and analysis. For instance, spine stabilization exercises for participants differ between studies based on varying inclusion and exclusion criteria. The patient populations studied are highly heterogeneous, with significant age and socioeconomic variations, leading to differing underlying causes of pain across subpopulations. For example, the aetiology of discogenic pain is more likely in patients between 20 and 40 years of age, while stenosis pain origins are more common in those over 60. NSLBP heterogeneity presents a significant challenge when attempting to summarise the current evidence. As NSLBP is a complex condition with multiple underlying mechanisms, it is difficult to pinpoint a single cause of pain across the entire patient population. A future study design proposal would be to classify NSLBP patients into sub-categories based on their history and physical examination findings to identify which specific motions, postures, and loads trigger their pain, rather than relying solely on self-reported outcome

measures. Without this detailed information, future similar study designs are unlikely to produce significantly different results. Therefore, sub-categorisation of back pain patients based on their intolerance to specific movements, postures, and loads should be the foundation for designing prevention and treatment plans.

Conclusion

In conclusion, this review found there is low-to-moderate evidence supporting the effectiveness of core stability exercises for reducing pain and disability in NSLBP patients. However, this review cannot recommend core stabilisation exercises as a standalone exercise modality for NSLBP, as the outcomes did not show a significant statistical difference when compared to general exercise therapy, manual physical therapy or a combination of both. Alternatively, better improvements in pain and disability were noted when a comprehensive inclusive treatment approach was used, one which encompasses therapeutic exercise and allied health conservative treatment plans together, instead of such a focusing solely on one therapeutic modality, that being a targeted therapeutic exercise or manual therapy.

Based on these findings McGill [33], advises against conducting any further research on non-specific low back pain (NSLBP) as it does not provide any insight into the prevention or treatment programs for the larger study population. Instead, McGill

recommends that future research should sub-categorize the NSLBP population into more specific homogeneous sub-groups based on specific factors in their history and physical examination, such as spine flexion-intolerant patients rather than subjective outcome measures. By sub-categorizing NSLBP patients in terms of painful motions, postures, and loads using provocative testing, the rehabilitation program could be tailored to the specific assessment findings of the study population.[33] This fundamental approach would provide clear clinical guidance for developing a pain-free foundation and eliminating the unhelpful non-diagnosis of "non-specific back pain."[33]

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