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Effectiveness of exercise-based, neuromuscular, and multidisciplinary interventions for subacute low back pain: a systematic review

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Abstract

Introduction. Treatments for low back pain (LBP), such as exercise, neuromuscular electrical stimulation (NMES) and multidisciplinary programs, have been proposed, but their effectiveness is uncertain. This review evaluates the exercise-based interventions, NMES, multidisciplinary programs, and their impact on physical performance, pain relief, disability reduction, and muscle endurance in managing subacute LBP.

Methods. This systematic review includes randomised controlled trials (RCTs), cohort studies, and clinical trials evaluating interventions for subacute LBP. A comprehensive literature search was conducted in EMBASE, MEDLINE, Cochrane Library, CINAHL, Scopus, and WOS (from inception until 20 July 2025). The study focused on factors such as participant age, study design, sample size, interventions, functional disability, muscle endurance, and quality of life, and the instruments used to assess them were the ODI (Oswestry Disability Index), RMDQ (Roland-Morris Disability Questionnaire), NPRS (Numeric Pain Rating Scale), and endurance tests. Risk of bias was assessed using Cochrane RoB2, and study quality was evaluated with the PEDro scale and QUIPS tools, by Fleiss-Kappa and Cohen's Kappa.

Results. NMES combined with exercise significantly improves muscle strength and endurance (effect size: 0.5–0.9, $p = 0.002$–0.006). Coordinated care has a 70% recovery rate compared to 50% with normal care ($d = 0.5$). Structured exercise programs showed significant reductions in pain and disability, with the highest SRM (standardised response mean = 2.85). Supervised interventions demonstrated superior outcomes to non-supervised care (Cohen's d of 0.65 (RMQ), 0.47 (ODI) and 0.43 (VAS) pain).

Conclusions. Key findings indicate that NMES combined with exercise significantly improves muscle strength, pain reduction, and disability scores.

Key words: electrostimulation, low back pain, pain measurement, randomised controlled trials, visual analogue scale

Introduction

Low back pain (LBP) is a widespread global condition that significantly impacts the lives of many individuals. Vos et al. [1] identified LBP in the Global Burden of Disease as a major contributor to global disability. The WHO recognised LBP as the leading cause of worldwide activity limitations and work-related restrictions. It is estimated that up to 85% of employed individuals experience LBP at some point [2]. As a result, LBP incurs substantial economic costs for individuals, families, businesses, and governments. In the United States, the direct and indirect costs of LBP are estimated to range from $100 to $200 billion annually, while in Canada, medical expenses related to LBP are projected as being between $6 and $12 billion, excluding lost work time and broader societal costs [3]. LBP is discomfort, tightness, or stiffness in the region between the posterior 12th rib and the gluteal line. NSLBP (non-specific low back pain), as classified by the National Institute for Health and Care Excellence, refers to tension, soreness, and/or stiffness in the lower back area of unclear origin, likely involving joint, disc, and connective tissue contributions. In individuals with NSLBP, the pain cannot be attributed to a specific diagnosis. It is estimated that up to 82% of individuals with isolated LBP do not receive a definitive pathoanatomical diagnosis to explain their symptoms [4, 5]. LBP is managed to improve function, with NSLBP, the most common form, often alleviated through education, comfort measures, moderate rest, activity maintenance, and pharmacological interventions. Non-pharmacological treatments such as physical therapy, targeted exercises, manual therapy, and CBT (cognitive behavioural therapy) can effectively manage subacute and CLBP (chronic low back pain), especially when integrated into a multidisciplinary approach. Subacute LBP (lasting 4–12 weeks) often responds to conservative care, while chronic LBP (lasting over 12 weeks) typically requires more comprehensive treatment due to underlying or persistent issues [6, 7].

Recent research stresses a significant gap in clinical practice guidelines, which often fail to differentiate between subacute and acute LBP. These guidelines typically apply treat-

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ment recommendations for acute pain (lasting no more than six weeks) to subacute cases (persisting six to twelve weeks) [8]. Many reviews aim to identify the most effective treatments for subacute LBP by evaluating clinical guidelines specific to this phase and providing targeted recommendations. These studies seek to understand the factors contributing to subacute LBP's progression to chronic conditions to enhance management strategies and improve patient outcomes. Effective treatments for subacute LBP include physical therapy, targeted exercises, manual therapy, nonsteroidal anti-inflammatory drugs, muscle relaxants, and CBT [9].

NMES is a therapeutic modality used in the management of chronic LBP that delivers electrical impulses through surface electrodes to activate motor neurons, inducing muscle contractions, which enhances muscle strength, augments local circulation, and reduces disuse atrophy, thereby supporting neuromuscular re-education and functional restoration. Low-frequency biphasic pulsed currents (typically 1–100 Hz) are most commonly used in clinical NMES, offering symmetrical or asymmetrical waveforms with pulse durations ranging from 200 to 400 μs; these parameters are effective for selective motor unit recruitment with minimal discomfort. Russian stimulation (also known as Kotz currents) involves medium-frequency sinusoidal bursts (usually 2500 Hz) modulated at a lower frequency (e.g., 50 Hz), delivering more forceful contractions while maintaining greater comfort due to reduced skin impedance and are particularly effective in eliciting high-intensity muscle contractions for strengthening the deep para-spinal muscles. Interferential currents (IFC) utilise two medium-frequency currents (typically 4000 and 4100 Hz) that intersect within tissues, producing a low-frequency amplitude-modulated beat frequency (e.g., 100 Hz). IFC penetrates deeper tissues with less cutaneous discomfort and is primarily used for analgesia but also shows adjunctive benefits in neuromuscular activation [10]. The choice of current is influenced by the treatment goals (whether for pain relief, muscle strengthening, or both) and patient tolerance. In the context of subacute LBP, NMES may exert therapeutic effects through mechanisms such as reactivating inhibited para-spinal muscles, normalising motor control patterns, and reducing nociceptive input, thereby facilitating the transition from acute inflammation to functional recovery [11]. The comparative effectiveness with other complementary therapies such as acupuncture and yoga is also unclear [12]. Addressing these knowledge gaps is essential to inform evidence-based, personalised treatment strategies for improved patient outcomes. This SR assesses interventions for subacute LBP, identifying trends, gaps, and variations in treatment efficacy. Specifically, this review examines the effectiveness of NMES, physical therapy, pharmacological treatments, and CBT in improving patient-reported outcomes, such as pain reduction and functional improvement.

Subjects and methods

Study type and design

This SR adheres to the PRISMA 2020 guidelines (Preferred Reporting Items for SR and Meta-Analyses) [13]. It has been registered in the International Prospective Register of SR (PROSPERO) under the National Institute for Health Research (CRD 42025645610, date of registration: 15 May 2024). The SR evaluated various interventions such as NMES, structured exercise programs, multidisciplinary care, and educational interventions. The primary outcomes assessed included pain severity, functional disability, muscle endurance, and quality of life, measured using validated tools such as the ODI, NPRS and endurance tests. The search was conducted using the PICOS strategy for a population consisting of individuals with subacute LBP, interventions involving exercise-based therapy, NMES, and multidisciplinary programs, and study designs including RCTs, cohort studies, and clinical trials. Articles were screened in stages: title, abstract, and full-text review. Studies were included if they assessed exercise therapy, NMES, or multidisciplinary interventions for subacute LBP, alone or combined with other non-pharmacological treatments. The PICOS framework guided the search, focusing on the effectiveness of these interventions versus standard care in improving pain, disability, muscle endurance, and quality of life. Outcomes were analysed as continuous data due to the varying measurement tools.

Search strategy

Research articles were identified through comprehensive searches of databases from inception to 20 July 2025, including EMBASE, DocOnline, INSPEC, Cochrane SRs, CINAHL, PEDro, SportDiscus, ACP Journal Club, MEDLINE, PsycINFO, Cochrane Controlled Trials Register, and DARE. The MEDLINE and EMBASE searches followed Review Group strategies [14]. Studies on subacute LBP were assessed using the PRISMA flowchart. Screening involved a two-step process: initial title/abstract screening, followed by full-text review. A standardised Excel extraction form was pilot-tested by three reviewers on five studies. Three reviewers independently screened sources as 'included', 'maybe', or 'excluded', resolving discrepancies by discussion or a third reviewer. Peer-reviewed articles, expert opinions, and policy documents were eligible. References were checked to avoid duplication, and authors were contacted for missing data. The search strategy used Boolean operators and key terms such as LBP, disability, NMES, exercise-based interventions, multidisciplinary programs, pain relief, muscle endurance, and personalised management. Combinations like [LBP AND disability], [NMES AND disability reduction], and [opioid use reduction AND functional recovery] explored various treatment outcomes. Comparative terms such as [exercise therapy vs. standard care] and [conservative vs. invasive approaches] were also applied.

Study selection

The selection of studies for this SR adhered to PRISMA 2020 guidelines, prioritising randomised controlled trials, multicentric and double-blind designs, and prospective cohort studies. Full-text availability in peer-reviewed journals was required, while unpublished studies, conference abstracts, and grey literature were excluded.

Inclusion criteria

Only full-text, English-language and peer-reviewed studies were included; unpublished studies, abstracts, and grey literature were excluded. The review also included a pre-post interventional study using the ODI and a non-randomised prospective clinical trial. Outcomes like pain severity and disability were evaluated using validated self-reported tools such as the RMDQ. Studies assessing pain, disability, and overall recovery (as per each study's criteria) were also included. Studies with concurrent leg pain were considered if they met the inclusion criteria. This aligns with recommended core outcome measures for nonspecific LBP trials, ensuring a robust methodology [15].

Exclusion criteria

The study excluded research involving participants with LBP persisting for more than 12 months, as the focus was on understanding the progression of LBP within the first year of onset, which is the critical period during which targeted interventions may yield the most significant benefits [16]. Studies involving mixed populations, such as those including patients with either neck pain or LBP were also excluded, unless LBP-specific data were excluded. Further exclusions included studies recruiting individuals with LBP secondary to other comorbidities (e.g., osteoarthritis), reporting only baseline outcomes or prognostic factors without longitudinal follow-up, and studies exclusively involving participants presenting with both LBP and concurrent leg pain [17].

Risk of bias

Risk of bias was assessed based on the *Cochrane Handbook for Systematic Reviews of Interventions* [18]. The Cochrane RoB 2.0 tool, PEDro, and QUIPS were used to focus outcomes like pain severity, disability, and recovery measured via validated tools such as the RMDQ. RoB 2.0 was applied to evaluate the methodological rigour across domains including randomisation, deviations from intended interventions, missing outcome data, outcome measurement, and selective reporting [19]. Studies meeting these criteria were considered low risk. Inter-rater agreement using Fleiss' Kappa was high ($\kappa = 0.93$). Summary and box plots were generated using the RoB 2.0 tool.

The PEDro scale, an 11-item tool, was used to assess the methodological quality, focusing on the internal validity (criteria 2–9) and statistical reporting (criteria 10–11). Scores range from 0 to 10, with higher scores indicating stronger quality and reduced bias. Three reviewers (KR, APKM, and KSP) independently assessed the studies using the PEDro scale, including inter-rater reliability via Cohen's kappa. For studies not indexed in PEDro, the same scale was applied, and disagreements were resolved by consensus. Scores ≥ 5 were considered high quality, with 9–10 as excellent, 6–8 as good, 3–5 as fair, and < 4 as poor. Risk of bias was independently evaluated by four reviewers (VKJ, VIR, KR, and KSP) using the categories: 'high risk', 'low risk', 'some concerns', and 'unclear'. A fifth reviewer (APKM) resolved unresolved cases. Studies with two or more high-risk items were classified as low quality [20]. This review employed a modified version of the QUIPS tool to better assess the risk of bias, ensuring the prognostic outcomes at follow-up accurately reflected the baseline population [21]. This adaptation was necessary to address the methodological challenges specific to studies tracking health trajectories. The inter-rater reliability for the QUIPS and Altman's criteria (applied to non-RCT and cohort studies) was assessed using Cohen's kappa coefficient, with agreement categorised from slight (≤ 0.20) to almost perfect (≥ 0.81), ensuring consistency in reviewer evaluations.

Data extraction and synthesis

The data items extracted for this systematic review were selected to provide a comprehensive evaluation of each included study. These items included participant age, study design/type of evaluation, sample size, study objective, intervention characteristics, outcome measures, and main results. To facilitate consistent comparison, these data were organised according to demographic profiles, methodological design, and treatment outcomes. A detailed synthesis of the interventions focused on treatment types, session frequencies, dosages, and the randomisation processes employed in subacute LBP studies. The analysis also examined the pain rating scales utilised in the studies and assessed treatment efficacy, comparing randomised versus non-randomised studies to evaluate the consistency of outcomes. A critical appraisal of methodological quality and reporting bias was also performed to contextualise the findings. The synthesised data were summarised in tabular format, highlighting the key outcome measures, effect sizes, and statistical significance for each study. This structured analysis informed the generation of practical, evidence-based recommendations for the clinical management of subacute LBP.

Statistical analysis

Quantitative data synthesis focused on evaluating outcome metrics such as pain intensity, functional disability, muscle endurance, and muscle strength. Descriptive statistics (e.g., means, standard deviations, and ranges) were used to summarise the participant demographics, intervention characteristics, and baseline and post-treatment scores. Where available, inferential statistics reported in the original studies, such as *p*-values, confidence intervals, and between-group comparisons, were extracted to assess the significance of observed treatment effects. To facilitate cross-study comparisons, the effect sizes were either extracted directly from the original studies or calculated using the reported means and standard deviations. The primary measure of effect size was Cohen's *d*, which quantifies the magnitude of between-group differences, and the Standardised Response Mean (SRM), which evaluates within-group change over time. For each calculated or reported effect size, 95% confidence intervals were included to reflect the statistical precision and clinical relevance. Effect sizes were interpreted using conventional thresholds (small: 0.2, moderate: 0.5, large: ≥ 0.8). Comparative analyses were conducted to evaluate the relative efficacy of different intervention types-such as NMES versus PCM, or supervised versus unsupervised exercise, and to identify trends based on LBP subcategories (acute vs. subacute).

Results

Study selection

The PRISMA flowchart below outlines the selection process for studies included in this SR (Figure 1). It details the number of records identified across different databases, the screening process, reasons for exclusion, and the final number of studies included for analysis. This transparent approach ensures reproducibility and highlights the rigorous methodology in study selection.

Risk of bias

The risk of bias assessment for the included studies was conducted using the Cochrane Risk of Bias (RoB V2) tool, evaluating key methodological domains such as randomisation, deviations from intended interventions, missing outcome data, outcome measurement, and selective reporting. The figure below (Figure 2) presents the reviewers' judgements for each criterion across all included studies, categorising them as low risk, some concerns, or high risk of bias. This assessment ensures transparency in study quality and helps interpret the reliability of the findings.

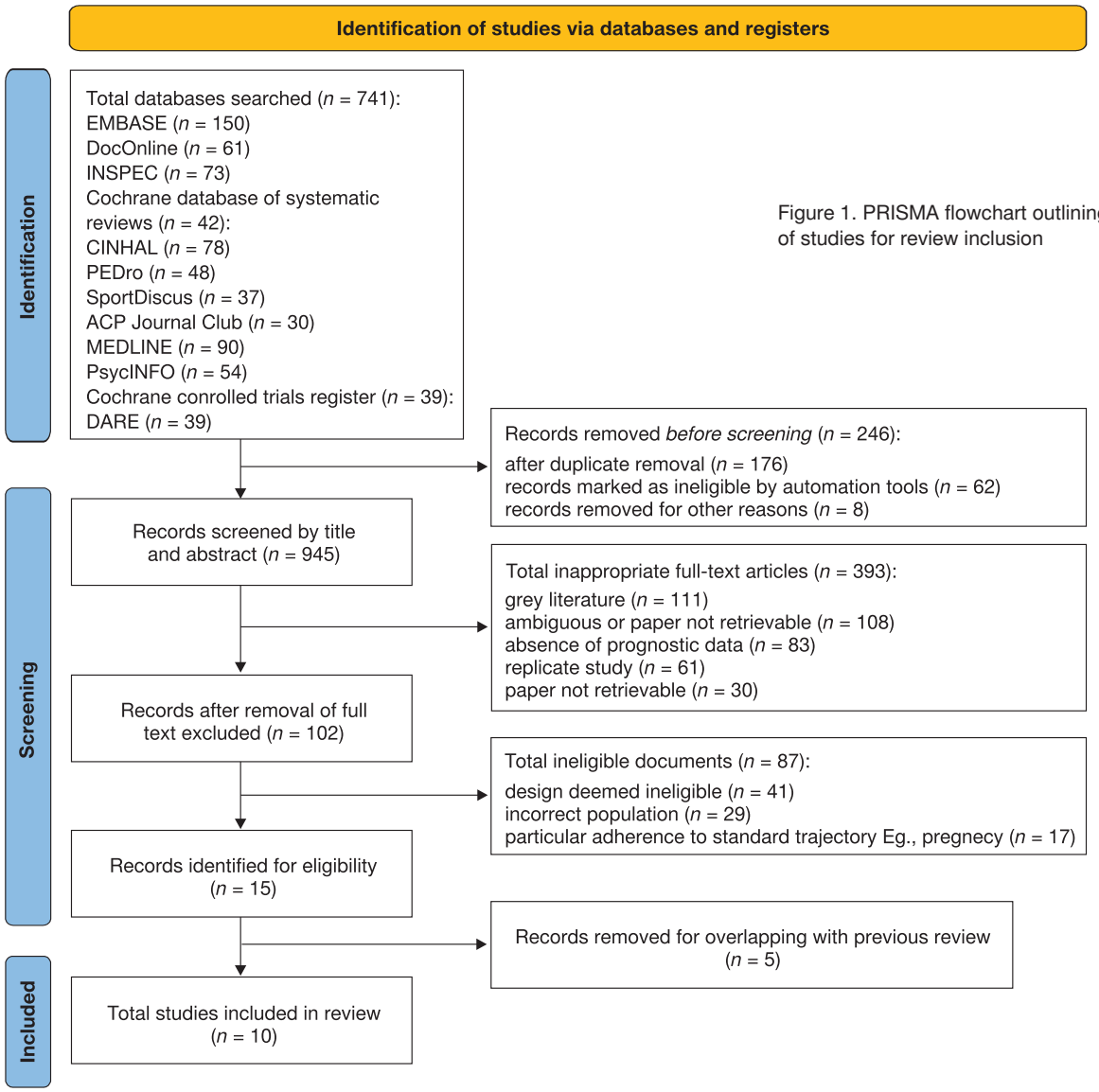

Figure 1. PRISMA flowchart outlining the selection of studies for review inclusion

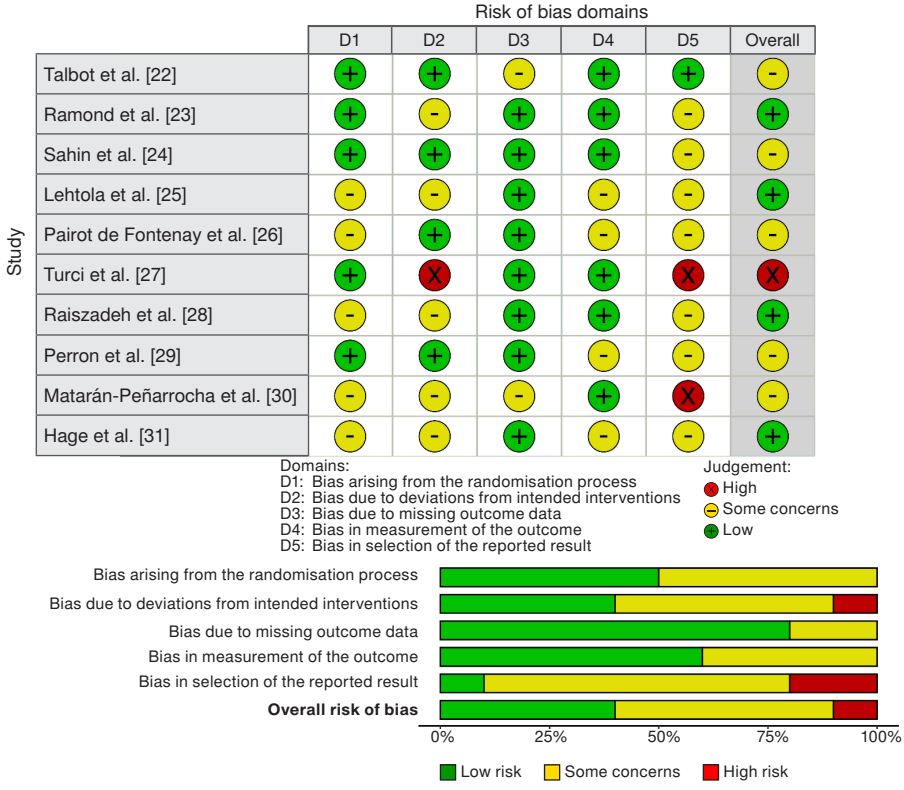

Figure 2. Risk of bias for included studies: reviewers' judgement for each criterion is expressed as a percentage

The RoB V2 assessment showed that most studies had low risk or some concerns, with few exhibiting high risk. A high-risk rating was assigned when there was clear evidence of methodological flaws, such as inadequate randomisation procedures, lack of allocation concealment, or improper blinding. It was also given when a significant proportion of the data was missing without appropriate handling or imputation, when there were major deviations from the intended interventions that could influence the study outcomes, or when there was selective reporting of results, such as omitting pre-specified outcomes, modifying primary endpoints, or presenting incomplete data that could bias the findings. The randomisation and outcome measurement were generally robust, while some concerns arose in deviations from the intended interventions, missing data, and selective reporting. Performance Bias showed almost perfect agreement (0.85), while Selection (0.72) and Detection Bias (0.78) indicated substantial consistency. Reporting (0.55) and Other Bias (0.50) had moderate to fair agreement. These values reflect a reliable and transparent bias assessment, enhancing the credibility of the findings.

PICOS Framework and PEDro Scoring

The PICOS framework was used to optimise the systematic review (SR) search strategy by structuring the study selection around the Population, Intervention, Comparison, Outcome, and Study design. This structured approach improved the precision of database searches and facilitated the identification of relevant studies. After screening titles, abstracts, and full texts, 741 articles met the inclusion criteria from multiple databases, including MEDLINE, EMBASE, Cochrane Database of Systematic Reviews, CINAHL, PEDro, PsycINFO, and others. MEDLINE contributed the highest proportion of relevant studies (14.05%), followed by CINAHL (12.17%), PsycINFO (8.42%), PEDro (7.49%), and the Cochrane Database of SRs (6.55%), highlighting MEDLINE's comprehensive indexing and the methodological rigour of Cochrane's sources. The PEDro scale was applied to evaluate the methodological quality of these included studies (Table 1). Most studies scored above 6, indicating high methodological quality with strong adherence to eligibility specification, random allocation, and appropriate between-group comparisons. However, variability was observed in concealed allocation, assessor blinding, and intention-to-treat analysis, with two studies scoring lower due to methodological limitations. The combined application of the PICOS framework and PEDro scoring ensured that only relevant, high-quality studies were included, thereby enhancing the rigour and reliability of the SR findings.

Database criteria

Study characteristics

A comprehensive database search yielded 2070 records. After removing duplicates, 741 titles and abstracts were screened, and 246 full-text articles were assessed for eligibility. Ten studies met the inclusion criteria for this SR. The PRISMA flow chart (Figure 1) details the selection process,

Table 1. Quality assessment of the included studies using the PEDro scale

Criterion	Studies									
	Talbot et al. [22]	Ramond et al. [23]	Sahin et al. [24]	Lehtola et al. [25]	Pairot de Fontenay et al. [26]	Turci et al. [27]	Raiszadeh et al. [28]	Perron et al. [29]	Matarán-Peñarrocha et al. [30]	Hage et al. [31]
Eligibility criteria specified	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Random allocation	yes	yes	yes	yes	no	yes	yes	yes	yes	no
Concealed allocation	yes	no	yes	no	no	yes	no	no	yes	no
Baseline comparability	yes	no	no	yes	yes	yes	no	no	no	yes
Blinding of subjects	yes	yes	yes	yes	yes	yes	yes	yes	no	yes
Blinding of therapists	yes	yes	yes	yes	yes	yes	yes	yes	yes	no
Blinding of assessors	yes	yes	yes	no	no	yes	no	yes	yes	yes
Measures of at least one key outcome obtained from > 85% of subjects	no	yes	yes	yes	yes	yes	no	yes	yes	yes
Intention-to-treat analysis of at least one key outcome	yes	yes	yes	yes	no	yes	no	no	yes	yes
Between-group statistical comparisons of at least one key outcome	yes	yes	no	yes	no	yes	yes	yes	yes	yes
Point estimates and variability provided at least one key outcome	yes	yes	yes	no	yes	yes	yes	no	yes	yes
Total yes score	10	9	9	8	6	11	6	7	9	8
Mean PEDro score	8.3									
SD	1.53									

yes – criterion was fulfilled, no – criterion was not fulfilled, PEDro – Physiotherapy Evidence

and the study characteristics are summarised in Table 2. Data extracted included study design, sample size, demographics, interventions, outcomes, and results. The included studies were RCTs, cohort studies, and clinical trials-focused on LBP interventions across varied populations. Interventions ranged from physical therapy (NMES, TENS, ultrasound, hot packs) and structured exercises to supervised/home-based rehabilitation, back school programs, passive mobilisations, integrated practice units, and professional training. Results showed improvements in pain, disability, and function. NMES improved physical performance; back school and coordinated care enhanced outcomes; specific exercises offered modest benefits. While trunk endurance tests were weakly responsive, a 6-week program improved disability. Both self-stretching and motor control exercises were effective. Multidisciplinary programs reduced pain, disability, and opioid use. Supervised exercise outperformed non-supervised approaches, and predictive modelling identified outcome-related factors. Peak speed and DidRen Laser Test performance also improved.

In total, ten studies were included in the review. Of these, six were randomised controlled trials (RCTs) [22–25, 27, 30], including one that used a cluster-randomised design [23]. One study was a non-randomised prospective clinical trial [31], and another was a prospective cohort study [28]. Additionally, one study followed a single-arm prospective trial design [26], and one employed a pre-post interventional approach [29]. This categorisation provides a clear overview of the methodological diversity across the included studies. This review incorporated an auxiliary metric derived from the QUIPS tool and Altman's [20] criteria assessment to refine the risk of bias evaluation [29]. Modifications to the risk of bias assessment were crucial in addressing challenges in studies on health-related condition trajectory, enhancing the reliability of the bias evaluation process. The kappa agreement values across all bias criteria demonstrate a generally consistent evaluation process among the reviewers. Performance Bias showed almost perfect agreement (0.85), indicating a strong consensus, while Selection and Detection Bias also reflected substantial agreement (0.72 and 0.78, respectively), suggesting reliable assessments with minor variations. Although Reporting Bias (0.55) and Other Bias (0.50) had moderate to fair agreement, these values still indicate that the reviewers were largely aligned, with only minor discrepancies. Overall, the results suggest a well-controlled bias assessment process, contributing to the study's credibility.

Quantitative outcome of the studies

The reviewed studies highlight the efficacy of targeted rehabilitation strategies in enhancing physical function and reducing disability. Neuromuscular stimulation, multidisciplinary care, back school programs, and motor control exercises significantly improved strength, pain reduction, and disability scores. These findings support structured interventions for optimising musculoskeletal health and functional recovery (Table 3).

The review affirms the efficacy of targeted rehabilitative interventions in improving physical function and reducing disability in subacute and chronic LBP. Talbot et al. demonstrated significant gains in muscle strength and endurance with NMES and PCM, yielding moderate to large effect sizes (0.5–0.9) and enhanced performance in sit-ups ($p = 0.002$) and push-ups ($p = 0.006$). Ramond et al. [23] reported improved recovery rates with coordinated care (70% vs. 50% in usual care; $d = 0.5$), stressing the value of multidisciplinary approaches in-patient rehabilitation. Sahin et al. [24] showed that back school programs significantly reduced pain and disability, indicated by improvements in the Oswestry LBP Disability Index ($p < 0.05$), while Lehtola et al. [25] found that SMCE produced a clinically meaningful decline in disability (RMDQ change = –1.9, $d = 1.9$, $p < 0.01$).

Interventions

The reviewed studies addressed various LBP management strategies (Table 4). Talbot et al. [22] combined PCM, physical activity guidance, and a 9-week NMES program. Ramond et al. [23] used a coordinated-care approach with trained healthcare professionals, unlike the usual-care group. Sahin et al. [24] implemented a low back exercise program, physical therapy (TENS, ultrasound, hot packs), and a back school for education. Lehtola et al. [25] involved five sessions with experienced therapists in a Finnish clinic. Pairot de Fontenay et al. [26] applied a core stability and endurance exercise program. Turci et al. [27] used exercises and breathing patterns to stabilise the lumbar spine. Raiszadeh et al. [28] compared clinic-based (C-IPU) and web-based (O-IPU) rehabilitation models based on participant preference. Perron et al. [29] ran a progressive multi-station exercise program targeting lumbar and hip function. Matarán-Peñarrocha et al. [30] contrasted supervised lumbopelvic strengthening with a home-based program. Hage et al. [31] used passive intervertebral mobilisations for acute-subacute neck pain, focusing on painful sites identified during assessment.

Adequate randomisation reduces bias, supports group comparability, and strengthens the reliability of conclusions regarding subacute LBP therapies. It ensures that outcome differences arise from the intervention itself rather than confounders like age, sex, prior treatments, or comorbidities [32]. Various randomisation methods were used across the studies to enhance the internal validity (Table 5). Talbot et al. [22] employed sealed envelopes post-baseline, with compliance tracked via calls, emails, and texts. Ramond et al. [23] used 1:1 cluster randomisation, stratified by region and study timing, effectively blinding the participants, assessors, and analysts. Sahin et al. [24] combined sealed envelopes with computer-generated allocation and maintained blinding of the researchers and evaluators, further minimising bias [33].

Lehtola et al. [25] found that combining movement control exercises with manual therapy improved outcomes, supporting a multimodal approach. Matarán-Peñarrocha et al. [30] and Turci et al. [27] reported similar benefits from both self-directed and supervised exercise. Raiszadeh et al. [28] highlighted interdisciplinary strategies, noting in-clinic rehab slightly outperformed web-based options. Perron et al. [29] and Pairot de Fontenay et al. [26] emphasised tailored programs for physically demanding roles like military personnel, demonstrating reduced injury rates [34].

Pain Rating Scale (*PRS*)

The Pain Rating Scale (PRS) is a key tool for assessing lower back pain intensity, typically using a 0–10 scale. It enhances patient-provider communication, tracks treatment progress, and guides therapy adjustments [35]. Regular pain monitoring allows for personalised care and improved outcomes. Studies on subacute LBP have used diverse PRSs to evaluate treatment effects. Talbot et al. [22] and Sahin et al. [24] used the VAS for pain, while Ramond et al. [23] and Lehtola et al. [25] employed the RMDQ and PSFS to assess disability and function (Table 8). Pairot de Fontenay et al. [26] used the GRC scale, and Turci et al. [27] applied the ODI

Table 2. Study design and characteristics

Study/author/ year/country	Groups	Gender	Age (years)	Type of study design/evaluation	Sample size	Study objective	Interventions	Outcome measures	Main results	Funding sources
Talbot et al., 2023 [22] USA	group 1: PCM group 2: NEsP, NMES (*n* = 43), PEP (*n* = 42), or PCM (*n* = 43)	M – 60 F – 68	over 40	RCT	128	compared NMES, PEP, and PCM in subacute LBP	PCM + physical activity + 9-week NMES	physical performance, torso strength, pain	NMES improved sit-up/ push-up performance in military personnel	TriService Nursing Research Program, U.S. Govt (Award # HU000l-17-2-TSl0)
Ramond et al., 2023 [23] France	group 1: coordinated-care group (*n* = 200) group 2: usual-care group (*n* = 300)	NR	18 and 60	multicentric, cluster-RCT	500	assessed coordinated primary care for LBP disability over 12 months	training in LBP care, psychosocial factors, collaboration	disability reduction in subacute/ recurrent LBP	coordinated care reduced disability and improved pain management	French Ministry of Health (PREPS-18-0407)
Sahin et al., 2011 [24] Turkey	group 1: back school group (*n* = 70) group 2: control group (*n* = 76)	F – 146	18 and under	RCT	146	evaluated back school program for chronic LBP	exercise + 2-week PT (TENS, ultrasound, hot packs) + back school	pain intensity, disability reduced	programme significantly improved pain and function (VAS, ODQ)	no funding
Lehtola et al., 2016 [25] Finland	group 1: general exercise group (*n* = 31) group 2: movement control group (SMCE *n* = 30)	F – 70	48–51	RCT	70	targeted exercises for individualised LBP care	five therapist-led sessions	PSFS, ODI at 3 and 12 months	SMCE + manual therapy improved function vs. general exercise, but not short-term pain outcomes	no funding
Pairot de Fontenay et al., 2023 [26] Canada	group 1: control group – lower physical activity (*n* = 40) group 2: test group – higher physical activity (*n* = 44)	M – 84	35–40	single-arm prospective trial study	84	assessed trunk endurance tests in LBP	core stability/ endurance program	endurance test responsiveness, modified ODI	weak responsiveness; 6-week program improved ODI	OPPQ, REPAR, FRQS, Sentinelle Nord
Turci et al., 2023 [27] Brazil	group 1: self-stretching group 2: MCE (*n* = 50)	M – 32 F – 68	18–60	prospective, two-arm, randomised trial	100	compared SaSE vs. MCE in chronic LBP	SaSE: limb control + breathing; MCE: spine stabilisation	pain, disability, fear avoidance, global effect	both exercises equally reduced pain and disability	no funding
Raiszadeh et al., 2021 [28] USA	group 1: clinic-based IPU group (*n* = 988) group 2: web-based group (*n* = 102)	M – 449 F – 641	avg. 62	prospective cohort study	1090	on-site vs. web-based multidisciplinary care	C-IPU vs. O-IPU, minimum 2 extra sessions	NPRS, ODI, PSFS, opioid use	both in-clinic and web-based multidisciplinary programs effectively reduced pain and disability; opioid use had better pain relief	Foundation for Physical Therapy Research
Perron et al., 2018 [29] Canada	group 1: standard care (*n* = 45) group 2: experimental exercise program (*n* = 40)	M – 85	avg. 37	pre-post interventional study (ODI)	85	Identified outcome predictors in military LBP	supervised 6-week, multi-station program	ODI, five predictive variables	5 predictors identified; 78% accuracy; improved ODI	OPPQ and REPAR
Matarán-Peñarrocha et al., 2020 [30] Spain	group 1: supervised exercise (*n* = 32) group 2: non-supervised exercise (*n* = 32)	M – 32 F – 32	avg. 53	randomised, double-blind clinical trial	64	supervised vs. non-supervised therapy in non-specific LBP	supervised: lumbopelvic; unsupervised: home exercise	RMQ, ODI, SF-36	both improved, supervised group had better pain reduction	I+D+i of Biomedical and Health Sciences in Andalusia (PC-0185-2017, PC-0267-2017 and PC-0536-2017 by European Regional Development Fund/ European Social Fund
Hage et al. 2021 [31] Belgium	group 1: mobilisation (*n* = 38) group 2: control (*n* = 42)	M – 48 F – 32	avg. 40	non-randomised prospective clinical trial	80	role of head-neck rotation in LBP	PAIVM at painful cervical sites	NPRS, NDI, BQ, TSK, DidRen Laser Test	significant peak speed and DidRen performance improvement in LBP	INTERREG Project FWVl n° 4.7.360

CM – Primary Care Management, NesP – neuromuscular electrostimulation program, RCT – randomised controlled trial, PEP – physical exercise programs, CLBP – chronic LBP, SRM – standardised response mean, MCID – minimal clinical important difference, SaSE – self-administered stretching exercises, MCE – motor control exercises, avg – average, PSFS – Patient-Specific Functional Scale, REPAR – Quebec Rehabilitation Research Network, ICC – intra-class correlation coefficients, OOPQ – Order of Physiotherapy of Quebec, FRQS – Fund Research Quebec-Health, IPU – inpatient unit, BS – body schema, NDI0 – Neck Disability Index, NR – not reported, M – male, F – female

Table 3. Summary of quantitative findings and effect sizes in included studies

Study	Quantitative results		Effect sizes for each relevant variable with 95% *CI*
	primary outcomes	comparative findings	
Talbot et al. 2023 [22]	significant improvements in muscle strength and endurance	NMES group: sit-ups ($p = 0.002$), push-ups ($p = 0.006$) PCM group: 21% strength increase	Cohen's $d = 0.7$ [95% *CI*: 0.18, 1.22] p – not reported
Ramond et al. 2023 [23]	70% of participants receiving coordinated care achieved clinical recovery	coordinated care: 70% improvement; usual care: 50% improvement (12 months)	Cohen's $d = 0.5$ [95% *CI*: 0.22, 0.78] p – not reported
Sahin et al. 2011 [24]	significant pain reduction and improved function	VAS pain reduction ($p < 0.05$) in the back school group compared to the control	Cohen's $d = 0.85$ [95% *CI*: 0.36, 1.34] $p < 0.05$
Lehtola et al. 2016 [25]	significant reduction in disability	SMCE group: mean reduction of 1.9 RMDQ points; 61/70 completed 12-month follow-up	Cohen's $d = 1.9$ [95% *CI*: 1.34, 2.46] $p < 0.01$
Pairot de Fontenay et al. 2023 [26]	significant improvement in trunk endurance and disability reduction	ODI scores decreased from 31.6 to 18.8; SRM = 2.85	SRM = 2.85 [95% *CI*: 1.97, 3.73] p – not reported
Turci et al. 2023 [27]	both groups improved	pain: SSE group 6.3 → 0.8, MCE group 6.2 → 0.9; disability MD at week 13: 1 (95% *CI* –1 to 3); week 26: 0 (95% *CI* –1 to 2)	Cohen's $d = 0.10$ [95% *CI*: –0.29, 0.49] p – not reported
Raiszadeh et al. 2021 [28]	pain improved by 1.02 points; ODI improved by 4.26 points	1090 participants; mean age: 62.3 years; pain: 4.96; disability: 26.92	Cohen's $d = 0.6$ [95% *CI*: 0.48, 0.72] $p < 0.01$
Perron et al. 2018 [29]	significant improvements in ODI	85 military participants; ODI improvement: favourable group 23.9 ± 11.0 vs. unfavourable group 3.4 ± 10.3	Cohen's $d = 0.75$ [95% *CI*: 0.31, 1.19] $p = 0.01$
Matarán-Peñarrocha et al. 2020 [30]	supervised group reported lower pain (2.5 ± 2.1 vs. 3.5 ± 1.5)	supervised group: pain 2.5 ± 2.1; disability lower than non-supervised (pain: 3.5 ± 1.5)	Cohen's $d = 0.65$ [95% *CI*: 0.20, 1.10] p – not reported
Hage et al. 2021 [31]	significant improvements in kinematic measures post-intervention	NDI scores: 22 → 0, pain: 6 → 0, kinematic ICC: 0.57–0.96; average 5 sessions	Cohen's $d = 0.75$ [95% *CI*: 0.18, 1.32] p – not reported

NMES – neuromuscular electrical stimulation, RMDQ – Roland-Morris Disability Questionnaire, VAS – Visual Analogue Scale, LBP – low back pain, SMCE – specific movement control exercise, SSE – self-administered stretching exercises, MCE – motor control exercises, ODI – Oswestry Disability Index, NR – not reported

and NPRS. Raiszadeh et al. [28] combined the NPRS, ODI, and PSFS, and Hage [31] used the VAS. These varied tools capture different aspects of subacute LBP, reinforcing the need for standardised, multidimensional assessments [36].

Acute versus subacute LBP

The studies by Talbot et al. [22] and Ramond et al. [23] highlight the effectiveness of active therapies, such as NMES, PEP, and structured exercise, in subacute LBP, showing superior functional outcomes over standard care. These approaches enhanced strength, flexibility, and endurance, contributing to reduced pain and faster recovery, while Sahin et al. [24] focused on chronic LBP, the benefits of exercise, education, and physiotherapy are relevant across stages, though differing pathophysiological needs must be considered (Table 5). Lehtola et al. [25] further support a multimodal strategy, showing improved outcomes with movement control exercises and manual therapy. Matarán-Peñarrocha et al. [30] and Turci et al. [27] found self-directed and supervised exercise equally effective, enabling individualised care. Raiszadeh et al. [28] demonstrated the benefits of interdisciplinary programs, with in-clinic approaches slightly outperforming web-based models. Lastly, Perron et al. [29] and Pairot de Fontenay et al. [26] emphasised customised exercise interventions for military personnel, noting reduced injury risk and improved function.

Study analysis: key features, global recommendations, and limitations

Talbot et al. [22] reported that NMES combined with PEP produced medium-to-large pain reductions (VAS, $d \approx 0.7$) in subacute LBP compared to PCM, supporting early, multidisciplinary rehabilitation, though COVID-19-related deviations, missing data, and compliance issues were noted. Ramond et al. [23] found that coordinated care moderately improved functional disability (RMDQ, $d \approx 0.5$), recommending collaboration among primary care providers and structured follow-up, though recruitment imbalances may have influenced the results. Sahin et al. [24] demonstrated that back school plus exercise yielded moderate pain reduction (VAS, $d \approx 0.6$), advocating structured programs despite a small sample, homemaker bias, and lack of placebo. Lehtola et al. [25] reported large improvements in disability and function ($d \approx 0.8$) with tailored SMCE and manual therapy for recurrent subacute LBP, but pain intensity tracking was lacking, and the role of MCI as a treatment effect modifier was uncertain. Pairot de Fontenay et al. [26] highlighted supervised full-body exer-

Table 4. Treatments, sessions and dosages

Study	Treatments/ description	Sessions	Dosages/details
Talbot et al. [22]	PCM	weekly communications about pain status and medication use	encouraged physical activity and minimising sedentary behaviour
	NMES	62 sessions (30 min each)	alternating sessions every other day (31 abdominal and 31 back sessions), settings: pulse duration: 250 μs, ramp time: 2 s on, 2 s off – frequency: 55 Hz – duty cycle: 3 seconds on, 5 s off
	PEP	31 sessions (60 min each)	conducted on alternating days, divided into 3 phases, each lasting 3 weeks, with increasing intensity – focused on stretching and strengthening exercises for the lumbar spine
Ramond et al. [23]	GPs and physiotherapists provide written summaries and auto-observation questionnaires	first session: 90 min, second session: 3.5 hours, second session activities: formal presentations on interventional components (psychosocial factors, active reeducation)	two 90-min and one 3.5-hour sessions (over a period of 2–4 weeks)
Sahin et al. [24]	back school group	structured program focusing on LBP education and coping skills 4 sessions total	4 sessions totalling 2 sessions per week for 2 weeks, lasting 1 hour each
	physiotherapy	includes various modalities tailored for pain management	100 Hz, μs, 30 min/session, days a week for weeks therapeutic ultrasound: 1 MHz with an intensity of 1.5 W/cm² for 5 min per session
Lehtola et al. [25]	general exercise	5 sessions	45 min per session manual therapy: 10–15 min per session, home exercises: 3 times per week
	SMCE	5 sessions	45 minutes per session manual therapy: 10–15 min per session, home exercises: 3 times per week
Pairot de Fontenay et al. [26]	multi-station exercise program	2–3 times per week for 6 weeks	45–60 min per session
Turci et al. [27]	SaSE	8 weekly sessions + home sessions	40-min sessions sustained for 10–20 min per posture
	MCE	8 weekly sessions + home sessions	40-min sessions sustained for 10–20 min per posture
Raiszadeh et al. [28]	C-IPU (clinic-based)	high-intensity machine-based core muscle resistance training	prescribed and progressed based on individual needs
	O-IPU (online)	therapist-directed home core strengthening exercises via a web-based platform	12-week program with variable duration based on the patient's needs
Perron et al. [29]	multi-station full-body exercise program	supervised exercise program comprising 7 stations, each with exercises of increasing difficulty	2–3 sessions per week, 45–60 min each
Matarán-Peñarrocha et al. [30]	supervised group	core exercise program/ 3 sessions/week	30–35 min per session
	non-supervised group	home exercise program/ 3 sessions per week/3	10–15 repetitions of each exercise
Hage et al. [31]	PAIVM	mean of 4.7 sessions	mobilisation grades (1–4) are applied based on tolerance, stiffness, and discretion

PCM – Primary Care Management, NMES – neuromuscular electrical stimulation, PEP – physical exercise programs, GP – general practitioner, SaSE – self-administered stretching exercises, MCE – motor control exercises, SMCE – specific movement control exercise, IPU – Inpatient Unit, PAIVM – Passive Accessory Intervertebral Movements

Table 5. Summary of effect sizes grouped by outcome type across included studies

Outcome measure category (average effect size)	Study	Specific outcome tool(s)	Acute/subacute	Effect size	Summary of effectiveness
Pain intensity	Talbot et al. [22]	VAS	subacute	medium–large (e.g., $d = 0.7$)	NMES + PEP > PCM alone in subacute LBP
	Sahin et al. [24]	VAS	chronic → subacute	moderate ($d \approx 0.6$)	back school + exercise improved pain scores
	Matarán-Peñarrocha et al. [30]	VAS	both	small–moderate ($d \approx 0.4$)	home exercise improved acute/ subacute pain
	Hage et al. [31]	NPRS	acute-subacute neck	moderate ($d \approx 0.5$)	manual therapy reduced pain
	Perron et al. [29]	NPRS	acute/subacute	not reported	exercise regimens personalised to patient characteristics
	Turci et al. [27]	NPRS	both	moderate ($d \approx 0.6$)	both SaSE and MCE were effective
	Raiszadeh et al. [28]	NPRS	chronic (not stratified)	moderate ($d \approx 0.6$)	web-based and in-clinic therapy reduced pain
Functional disability	Ramond et al. [23]	RMDQ	subacute	moderate ($d \approx 0.5$)	coordinated care reduced disability
	Lehtola et al. [25]	RMDQ, ODI, PSFS	subacute	large ($d \approx 0.8$)	tailored exercises improved outcomes
	Turci et al. [27]	ODI	both	moderate ($d \approx 0.6$)	exercise effective in acute/ subacute LBP
	Raiszadeh et al. [28]	ODI, PSFS	chronic (mixed)	moderate ($d \approx 0.5$–0.6)	improvements in function reported
Patient-reported outcome	Pairot de Fontenay et al. [26]	GRC scale	subacute/chronic	not quantified	favourable outcomes for full-body supervised exercise
	Lehtola et al. [25]	PSFS	subacute	large ($d \approx 0.8$)*	improved patient-specific function
Movement control / sensorimotor	Hage et al. [31]	sensorimotor tests	acute-subacute	moderate ($d \approx 0.5$)*	improved sensorimotor performance

PSFS – Patient-Specific Functional Scale, VAS – Visual Analogue Scale, RMDQ – Roland-Morris Disability Questionnaire, NPRS – Numeric Pain Rating Scale, SaSE – self-administered stretching exercises, MCE – motor control exercises, RMDQ – Roland-Morris Disability Questionnaire, ODI – Oswestry Disability Index, GRC – Global Rating of Change
* Effect size magnitude interpreted according to Cohen's criteria: small ($d \approx 0.2$), medium ($d \approx 0.5$), large ($d \geq 0.8$)

cise as beneficial for endurance and patient-reported outcomes, recommending individualised exercise with psychological support despite selection bias and test responsiveness concerns. Turci et al. [27] found both SaSE and MCE comparably reduced pain and disability ($d \approx 0.6$), encouraging integration into rehabilitation while acknowledging their unblinded design and limited SaSE evidence. Raiszadeh et al. [28] observed moderate improvements ($d \approx 0.5$–0.6) and opioid reduction with both web- and clinic-based rehabilitation, recommending multimodal, accessible interventions, though selection bias and pragmatic design limited the conclusions. Perron et al. [29] showed that personalised exercise programs reduced pain, emphasising prognostic indicators for tailored interventions, but high dropout, low predictive accuracy, and limited generalisability were issues. Matarán-Peñarrocha et al. [30] found supervised and home-based exercise both reduced pain (VAS, $d \approx 0.4$), with supervised being slightly superior, advocating for personalisation despite a lack of controls and blinding. Lastly, Hage et al. [31] reported that manual therapy reduced neck pain ($d \approx 0.5$) and improved sensorimotor performance, supporting its use with standardised tools, though external validity was limited by the small, non-age-matched samples and exclusions.

Discussion

Subacute LBP, defined as pain persisting for 4 to 12 weeks after an initial injury or strain, represents a transitional stage in the natural healing process and differs from chronic LBP, which lasts beyond 12 weeks and involves ongoing tissue damage, nerve dysfunction, or maladaptive pain mechanisms. Our review highlights the significant role of non-pharmacological interventions, including exercise therapy, neuromuscular electrical stimulation (NMES), cognitive behavioural therapy (CBT), and integrated multidisciplinary rehabilitation, in improving pain, functional outcomes, and recovery rates among patients with subacute LBP.

Exercise-based interventions remain the cornerstone of management, with studies such as those by Sahin et al. [24], Turci et al. [27], and Lehtola et al. [25] demonstrating that structured programs, including back school education, motor control exercises, and personalised training regimens, lead to

substantial improvements in spinal stability, muscle strength, and physical performance.

Similarly, the integration of CBT plays a critical role by addressing maladaptive beliefs such as fear-avoidance, catastrophising, and low self-efficacy, which contribute to prolonged disability [37]. CBT facilitates adaptive coping mechanisms, improves psychological resilience, and, when combined with exercise, enhances functional outcomes while reducing the risk of chronic pain. Neuroimaging studies further support CBT's role in modulating pain pathways by increasing prefrontal activation and reducing limbic system hyperactivity [38], highlighting its neurobiological relevance.

Active rehabilitation strategies not only enhance functional recovery but also promote anti-inflammatory responses, improve circulation, reverse muscle atrophy, and counter central sensitisation, which is particularly beneficial in high-demand populations like military personnel and firefighters [39].

NMES has emerged as a promising adjunct to conventional exercise therapy, demonstrating moderate effectiveness in enhancing deep trunk muscle recruitment, improving lumbar stabilisation, and facilitating neuromuscular reconditioning. Although much of the evidence originates from chronic LBP studies, insights are transferable, with Hicks et al. [40] showing significant improvements in multifidus activation and pain reduction through targeted NMES. Our findings suggest that, particularly in subacute cases, combining NMES with task-specific training accelerates recovery by bridging the gap between initial pain resolution and full functional restoration, potentially preventing progression to chronicity.

Furthermore, multidisciplinary care integrating physical, psychological, and educational components demonstrates superior outcomes compared to unimodal approaches, with studies by Talbot et al. [22], Raiszadeh et al. [28], and Perron et al. [29] underscoring the benefits of combined rehabilitation strategies, including web-based digital platforms that enhance accessibility and long-term adherence. Despite promising findings, several methodological limitations across some of the included studies warrant cautious interpretation, including low compliance rates, missing data, lack of placebo controls, recruitment imbalances, and limited blinding, as reported by Talbot et al. [22], Ramond et al. [23], Sahin et al. [24], Lehtola et al. [25], and Perron et al. [29].

These inconsistencies highlight the need for more rigorously designed randomised controlled trials with standardised protocols and robust outcome measures to strengthen the evidence base for non-pharmacological interventions in subacute LBP. Overall, the synthesis of available evidence suggests that early, targeted, and integrated therapeutic approaches combining active rehabilitation, NMES, CBT, and multidisciplinary strategies are most effective in improving recovery, restoring function, and preventing the transition from subacute to chronic LBP.

Limitations of SR

In the RoBV2 analysis, the kappa agreement was substantial-to-almost perfect across most domains, while the moderate-to-fair agreement for Reporting Bias ($\kappa = 0.55$) and Other Bias ($\kappa = 0.50$) likely reflects the inherent subjectivity in interpreting vague or inconsistently reported data in the primary studies. These domains often lack standardised operational definitions, which increases the variability in individual reviewer assessments, but all discrepancies were resolved through consensus, thereby enhancing the robustness of the final risk of bias evaluations. This methodological step supports the credibility and transparency of our assessment process despite inter-rater variability in select areas. The study's meta-analysis was deemed infeasible due to the significant heterogeneity in the studies, including quantitative outcomes. This led to a rigorous qualitative synthesis to interpret the evidence and account for methodological discrepancies. A formal assessment of publication bias was not performed due to the insufficient studies and data variability. To enhance the methodological robustness, a comprehensive risk of bias assessment was implemented, and the PEDro scale and PICOS framework were used. Future research should employ standardised methodologies, larger sample sizes, and more homogenous study populations for more robust meta-analytical synthesis and evaluation of publication bias.

Conclusions

In conclusion, this systematic review highlights the effectiveness of exercise-based, neuromuscular, and multidisciplinary interventions in managing subacute LBP, with appreciable improvements in pain reduction, functional recovery, and muscle endurance. NMES, particularly in the early subacute phase, showed promise in enhancing muscle activation, while structured exercise and multidisciplinary programs incorporating physical therapy, CBT, and patient education led to superior outcomes compared to unimodal strategies. The findings support a shift from passive or pharmacological strategies towards multimodal, patient-centred interventions for subacute LBP, combining active approaches like exercise and CBT with selective use of NMES where evidence supports its benefit. However, the heterogeneity in intervention protocols and outcome measures stresses the need for greater standardisation in future research. Further studies need to aim for optimal parameters for NMES, clarify the role and timing of CBT integration, and evaluate the long-term efficacy and cost-effectiveness of combined approaches. Future research needs to focus on standardising NMES protocols, evaluating long-term outcomes and the sustainability of combined interventions, optimising CBT integration, and assessing cost-effectiveness. These efforts will help fill existing gaps and strengthen the development of comprehensive, patient-centred treatment models for subacute LBP.

Data availability

The data supporting this study's findings are available on request from the corresponding author.

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Ethical approval

The conducted research is not related to either human or animal use.

Registered in the International Prospective Register of SR (PROSPERO) under the National Institute for Health Research (CRD 42025645610, date of registration: 15 May 2024).

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

Reference

[1] Ciobanu LG, Ferrari AJ, Erskine HE, Santomauro DF, Charlson FJ, Leung J, Amare AT, Olagunju AT, Whiteford HA, Baune BT. The prevalence and burden of mental and substance use disorders in Australia: findings from the Global Burden of Disease Study 2015. Aust N Z J Psychiatry. 2018;52(5):483–90; doi: 10.1177/0004867417751641.

[2] Hoy D, Bain C, Williams G, March L, Brooks P, Blyth F, Woolf A, Vos T, Buchbinder R. A systematic review of the global prevalence of low back pain. Arthritis Rheum. 2012;64(6):2028–37; doi: 10.1002/art.34347.

[3] Mueller J, Niederer D. Dose-response-relationship of stabilisation exercises in patients with chronic non-specific low back pain: a systematic review with meta-regression. Sci Rep. 2020;10(1):16921; doi: 10.1038/s41598-020-73954-9.

[4] Delitto A, George SZ, Van Dillen L, Whitman JM, Sowa G, Shekelle P, Denninger TR, Godges JJ; Orthopaedic Section of the American Physical Therapy Association. Low back pain: clinical practice guidelines linked to the International Classification of Functioning, Disability, and Health from the Orthopaedic Section of the American Physical Therapy Association. J Orthop Sports Phys Ther. 2012;42(4):A1–57; doi: 10.2519/jospt.2012.42.4.A1.

[5] Semwal B, Joshi SJ, Kumar D. Diagnostic imaging vs. pathoanatomical diagnosis in low back pain: a change in approach: a case study. DPUs J Ayurved Homeopath Allied Health Sci. 2023;2(2):31–7; doi: 10.4103/jahas.jahas_14_22.

[6] Gianola S, Bargeri S, Del Castillo G, Corbetta D, Turolla A, Andreano A, Moja L, Castellini G. Effectiveness of treatments for acute and subacute mechanical non-specific low back pain: a systematic review with network meta-analysis. Br J Sports Med. 2022;56(1):41–50; doi: 10.1136/bjsports-2020-103596.

[7] Naragatti S. A comprehensive review of yoga interventions for chronic low back pain: efficacy, mechanisms, and clinical application. Int J Sci Res. 2025;14(1):840–9; doi: 10.21275/SR25120160450.

[8] Costa LD, Maher CG, Hancock MJ, McAuley JH, Herbert RD, Costa LO. The prognosis of acute and persistent low-back pain: a meta-analysis. CMAJ. 2012;184(11):E613–24; doi: 10.1503/cmaj.111271.

[9] Hegmann KT, Travis R, Andersson GB, Belcourt RM, Carragee EJ, Donelson R, Eskay-Auerbach M, Galper J, Goertz M, Haldeman S, Hooper PD, Lessenger JE, Mayer T, Mueller KL, Murphy DR, Tellin WG, Thiese MS, Weiss MS, Harris JS. Non-invasive and minimally invasive management of low back disorders. J Occup Environ Med, 2020;62(3):e111–38; doi: 10.1097/JOM.0000000000001812.

[10] Ward AR. Electrical stimulation using kilohertz-frequency alternating current. Phys Ther. 2009;89(2):181–90; doi: 10.2522/ptj.20080060.

[11] da Silva VZ, Durigan JL, Arena R, de Noronha M, Gurney B, Cipriano Jr G. Current evidence demonstrates similar effects of kilohertz-frequency and low-frequency current on quadriceps evoked torque and discomfort in healthy individuals: a systematic review with meta-analysis. Physiother Theory Pract. 2015;31(8):533–9; doi: 10.3109/09593985.2015.1064191.

[12] Östhols S, Boström C, Rasmussen-Barr E. Clinical assessment and patient-reported outcome measures in low-back pain – a survey among primary health care physiotherapists. Disabil Rehabil. 2019;41(20):2459–67; doi: 10.1080/09638288.2018.1467503.

[13] Tetzlaff J, Page M, Moher D. PNS154 the PRISMA 2020 statement: development of and key changes in an updated guideline for reporting systematic reviews and meta-analyses. Value Health. 2020;23(Suppl 1):312–3.

[14] Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Moher D. Updating guidance for reporting systematic reviews: development of the PRISMA 2020 statement. J Clin Epidemiol. 2021;134:103–12; doi: 10.1016/j.jclinepi.2021.02.003.

[15] Chiarotto A, Boers M, Deyo RA, Buchbinder R, Corbin TP, Costa LO, Foster NE, Grotle M, Koes BW, Kovacs FM, Lin CW, Maher CG, Pearson AM, Peul WC, Schoene ML, Turk DC, van Tulder MW, Terwee CB, Ostelo RW. Core outcome measurement instruments for clinical trials in nonspecific low back pain. Pain. 2018;159(3):481–95; doi: 10.1097/j.pain.0000000000001117.

[16] Itz CJ, Geurts JW, Van Kleef M, Nelemans P. Clinical course of non-specific low back pain: a systematic review of prospective cohort studies set in primary care. Eur J Pain. 2013;17(1):5–15; doi: 10.1002/j.1532-2149.2012.00170.x.

[17] Overås CK, Johansson MS, de Campos TF, Ferreira ML, Natvig B, Mork PJ, Hartvigsen J. Distribution and prevalence of musculoskeletal pain co-occurring with persistent low back pain: a systematic review. BMC Musculoskelet Disord. 2021;22:91; doi: 10.1186/s12891-020-03893-z.

[18] Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA (eds.). Cochrane Handbook for Systematic Reviews of Interventions. Version 6.4 (updated August 2023). Cochrane; 2023. Available from: https://training.cochrane.org/handbook (accessed 15.12.2024).

[19] Nejadghaderi SA, Balibegloo M, Rezaei N. The Cochrane risk of bias assessment tool 2 (RoB 2) versus the original RoB: a perspective on the pros and cons. Health Sci Rep. 2024;7(6):e2165; doi: 10.1002/hsr2.2165.

[20] Riley RD, Moons KG, Snell KI, Ensor J, Hooft L, Altman DG, Hayden J, Collins GS, Debray TPA. A guide to systematic review and meta-analysis of prognostic factor studies. BMJ. 2019;364; doi: 10.1136/bmj.k4597.

[21] Rashed R, Kowalski K, Walton D, Niazigharemakhe A, Rushton A. Physical measures of physical functioning as prognostic factors to predict outcomes in low back pain: protocol for a systematic review. PLOS ONE. 2023;18(12):e0295761; doi: 10.1371/journal.pone.0295761.

[22] Talbot LA, Webb L, Ramirez VJ, Morrell C, Bryndziar M, Enochs K, Metter EJ. Non-pharmacological home therapies for subacute low back pain in active duty military personnel: a randomized controlled trial. Mil Med. 2023;188(1–2):12–9; doi: 10.1093/milmed/usab382.

[23] Ramond-Roquin A, Bègue C, Vizzini J, Chhor S, Bouchez T, Parot-Schinkel E, Loiez A, Petit A, Ghali M, Peurois M, Bouton C. Effectiveness of coordinated care to reduce the risk of prolonged disability among patients suffering from subacute or recurrent acute low back pain in primary care: protocol of the CO. LOMB cluster-randomized, controlled study. Front Med. 2023;10:1156482; doi: 10.3389/fmed.2023.1156482.

[24] Sahin N, Albayrak I, Durmus B, Ugurlu H. Effectiveness of back school for treatment of pain and functional disability in patients with chronic low back pain: a randomized controlled trial. J Rehabil Med. 2011;43(3):224–9; doi: 10.2340/16501977-0650.

[25] Lehtola V, Luomajoki H, Leinonen V, Gibbons S, Airaksinen O. Sub-classification based specific movement control exercises are superior to general exercise in sub-

acute low back pain when both are combined with manual therapy: A randomized controlled trial. BMC Musculoskelet Disord. 2016;17:135; doi: 10.1186/s12891-016-0986-y.

[26] Pairot de Fontenay B, Perron M, Gendron C, Langevin P, Roy JS. Is assessing trunk muscle endurance in military with sub-acute and chronic low back pain clinically meaningful?. Front Sports Act Living. 2023;5:1173403; doi: 10.3389/fspor.2023.1173403.

[27] Turci AM, Nogueira CG, Carrer HC, Chaves TC. Self-administered stretching exercises are as effective as motor control exercises for people with chronic non-specific low back pain: a randomised trial. J Physiother. 2023; 69(2):93–9; doi: 10.1016/j.jphys.2023.02.016.

[28] Raiszadeh K, Tapicer J, Taitano L, Wu J, Shahidi B. In-clinic versus web-based multidisciplinary exercise-based rehabilitation for treatment of low back pain: prospective clinical trial in an integrated practice unit model. J Med Internet Res. 2021;23(3):e22548; doi: 10.2196/22548.

[29] Perron M, Gendron C, Langevin P, Leblond J, Roos M, Roy JS. Prognostic factors of a favorable outcome following a supervised exercise program for soldiers with sub-acute and chronic low back pain. BMC Musculoskelet Disord. 2018;19:95; doi: 10.1186/s12891-018-2022-x.

[30] Matarán-Peñarrocha GA, Palomo ICL, Soler EA, Gil-Martínez E, Fernández-Sánchez M, Aguilar-Ferrándiz ME, Castro-Sánchez AM. Comparison of efficacy of a supervised versus non-supervised physical therapy exercise program on the pain, functionality and quality of life of patients with non-specific chronic low-back pain: a randomized controlled trial. Clin Rehabil. 2020;34(7): 948–59; doi: 10.1177/0269215520927076.

[31] Hage R, Detrembleur C, Dierick F, Brismée JM, Roussel N, Pitance L. Sensorimotor performance in acute-subacute non-specific neck pain: a non-randomized prospective clinical trial with intervention. BMC Musculoskelet Disord. 2021;22:1017; doi: 10.1186/s12891-021-04876-4.

[32] Brea-Gómez B, Torres-Sánchez I, Ortiz-Rubio A, Calvache-Mateo A, Cabrera-Martos I, López-López L, Valenza MC. Virtual reality in the treatment of adults with chronic low back pain: a systematic review and meta-analysis of randomized clinical trials. Int J Environ Res Public Health. 2021;18(22):11806; doi: 10.3390/ijerph182211806.

[33] Strijkers RH, Schreijenberg M, Gerger H, Koes BW, Chiarotto A. Effectiveness of placebo interventions for patients with nonspecific low back pain: a systematic review and meta-analysis. Pain. 2021;162(12):2792–804; doi: 10.1097/j.pain.0000000000002272.

[34] Ashar YK, Gordon A, Schubiner H, Uipi C, Knight K, Anderson Z, Carlisle J, Polisky L, Geuter S, Flood TF, Kragel PA, Dimidjian S, Lumley MA, Wager TD. Effect of pain reprocessing therapy vs placebo and usual care for patients with chronic back pain: a randomized clinical trial. JAMA Psychiatry. 2022;79(1):13–23; doi: 10.1001/jamapsychiatry.2021.2669.

[35] Mogil JS, Pang DS, Dutra GG, Chambers CT. The development and use of facial grimace scales for pain measurement in animals. Neurosci Biobehav Rev. 2020; 116:480–93; doi: 10.1016/j.neubiorev.2020.07.013.

[36] Louw A, Goldrick S, Bernstetter A, Van Gelder LH, Parr A, Zimney K, Cox T. Evaluation is treatment for low back pain. J Man Manip Ther. 2021;29(1):4–13; doi: 10.1080/10669817.2020.1730056.

[37] Yang J, Lo WLA, Zheng F, Cheng X, Yu Q, Wang C. Evaluation of cognitive behavioral therapy on improving pain, fear avoidance, and self-efficacy in patients with chronic low back pain: a systematic review and meta-analysis. Pain Res Manag. 2022;2022:4276175; doi: 10.1155/2022/4276175.

[38] Sheykhangafshe FB, Tajbakhsh K, Niri VS, Asef ZN, Fathi-Ashtiani A. The efficacy of cognitive-behavioral therapy on psychological distress and coping strategies of employees with chronic low back pain. Iran J Health Sci. 2023;11(2):93–101; doi: 10.32598/ijhs.11.2.920.1.

[39] Hoppes CW, Sperier AD, Hopkins CF, Griffiths BD, Principe MF, Schnall BL, Bell JC, Koppenhaver SL. The efficacy of an eight-week core stabilization program on core muscle function and endurance: a randomized trial. Int J Sports Phys Ther. 2016;11(4):507–19.

[40] Hicks GE, Sions JM, Velasco TO, Manal TJ. Trunk muscle training augmented with neuromuscular electrical stimulation appears to improve function in older adults with chronic low back pain: a randomized preliminary trial. Clin J Pain. 2016;32(10):898–906; doi: 10.1097/AJP.0000000000000348.