

Review Paper

The Effect of NASM-based Corrective Exercise Interventions on Musculoskeletal Pain Syndromes: A Systematic Review and Meta-analysis

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ABSTRACT

Objectives: This study aimed to synthesize the effects of the National Academy of Sports Medicine (NASM) corrective exercise continuum interventions on pain intensity in individuals with musculoskeletal pain syndromes (MSPS).

Methods: This systematic review and meta-analysis followed the preferred reporting items for systematic reviews and meta-analyses (PRISMA) framework and was prospectively registered in PROSPERO (CRD420261439458). PubMed, Scopus, and Web of Science were searched from inception to June 30, 2026, with Google Scholar used as a supplementary source. Randomized controlled and quasi-experimental studies investigating interventions incorporating the NASM corrective exercise continuum in individuals with MSPS were eligible. Standardized mean differences (SMD) with 95% confidence intervals (CIs) were pooled using a random-effects model.

Results: Twelve studies (n=382) were included in the quantitative synthesis. Overall, interventions incorporating the NASM corrective exercise continuum reduced pain compared with control interventions (SMD=1.057, 95% CI, 0.794%, 1.319%; $P<0.001$). Considerable heterogeneity was observed ($I^2=75\%$). Subgroup analyses demonstrated significant pain reduction for neck pain (SMD=0.904, 95% CI, 0.586%, 1.221%; $P<0.001$) and shoulder pain (SMD=1.311, 95% CI, 0.689%, 1.933%; $P<0.001$), whereas no significant effect was identified for back pain (SMD=0.691, 95% CI, -0.621%, 2.003%; $P=0.302$). The included studies were generally of moderate-to-high methodological quality, and Egger's regression test indicated no evidence of significant publication bias ($P=0.42$).

Discussion: Interventions incorporating the NASM corrective exercise continuum appear to be an effective conservative intervention for reducing pain in individuals with MSPS, particularly those with neck and shoulder disorders. Further high-quality randomized controlled trials with standardized intervention protocols and longer follow-up periods are warranted to establish long-term effectiveness and identify patient populations most likely to benefit.

Keywords:

National Academy of Sports Medicine (NASM), Corrective exercise, Pain, Meta-analysis

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Highlights

- Significant pain reduction was observed in individuals with neck pain.
- Significant pain reduction was also observed in individuals with shoulder pain.
- No significant pain reduction was found for individuals with back pain.

Plain Language Summary

Musculoskeletal pain, including neck, shoulder, and back pain, is a prevalent condition that can interfere with daily activities and negatively affect quality of life. Exercise is widely recommended as a treatment approach; however, the effectiveness of exercise programs may vary depending on their structure and implementation. The National Academy of Sports Medicine (NASM) corrective exercise continuum provides a systematic framework designed to optimize movement patterns and alleviate pain through progressive exercise interventions. This study synthesized the findings of 12 studies involving 382 participants to evaluate whether interventions based on the NASM corrective exercise continuum are effective in reducing musculoskeletal pain. Overall, these interventions resulted in a significant reduction in pain compared with control conditions. The beneficial effects were more pronounced among individuals with neck and shoulder pain, whereas no significant effects were observed for back pain. These findings indicate that NASM-based corrective exercise may represent a safe and non-invasive approach for managing specific types of musculoskeletal pain. Such exercise-based interventions may help individuals improve symptoms, preserve functional abilities, and potentially decrease the need for more invasive treatment options. However, further high-quality studies are required to establish the long-term effectiveness of these interventions and to identify populations most likely to benefit.

Introduction

Musculoskeletal pain syndromes (MSPS) are among the leading causes of disability worldwide [1], imposing substantial clinical, social, and economic burdens across diverse populations [2]. Conditions such as chronic neck pain, low back pain, shoulder pain, patellofemoral pain syndrome, and other overuse-related disorders account for a considerable proportion of healthcare utilization, productivity loss, and diminished quality of life [3, 4]. A growing body of evidence suggests that many MSPS are associated with dysfunctional movement patterns, altered neuromuscular control, muscle imbalances, reduced joint mobility, and impaired postural stability [5, 6]. Despite advances in pharmacological and surgical management, conservative interventions remain the cornerstone of treatment for most musculoskeletal pain conditions because of their favorable safety profile and capacity to address modifiable biomechanical and functional impairments [7, 8]. Among these interventions, exercise therapy has consistently shown benefits for pain [9], function [10], and health-related quality of life [11]. However, considerable variability exists in the type, intensity, and effectiveness of different exercise approaches.

Corrective exercise is one such strategy, and several frameworks have been proposed to guide its implementation [12]. Among these, the model developed by the [National Academy of Sports Medicine \(NASM\)](#) organizes rehabilitation into a four-phase continuum: Inhibit, lengthen, activate, and integrate, to rebalance overactive and underactive muscle groups around a joint [13]. Over the past decade, research on NASM-based corrective exercise has progressively expanded beyond its original focus. Trials have evaluated the model in upper crossed syndrome [14, 15], forward head posture [16, 17], hyperlordosis [18], lower crossed syndrome [19], chronic low back pain [20, 21], and knee osteoarthritis [22], across populations as varied as office employees, university students, military personnel, and elite athletes. Moreover, protocols range from conventional land-based corrective exercise to online-supervised programs [21], aquatic NASM training [22], and modified approaches that integrate taekwondo-based movements [18], with treatment duration and comparator interventions varying considerably across studies. In contrast, NASM-based training outperformed conventional exercise in one trial [14], produced outcomes comparable to alternative rehabilitation approaches in others [17, 20], and was outperformed by an alternative active intervention on all primary outcomes in at least one recent trial [21]. However, existing

evidence syntheses have focused almost exclusively on UCS [23], concluding that corrective exercise appears beneficial but that the available evidence remains methodologically heterogeneous and insufficient to support broader conclusions [24, 25].

What emerges is a body of trials that spans multiple MSPS, employs substantially different protocols, comparators, and outcome measures, and does not consistently favor NASM-based corrective exercise. Therefore, it remains unclear whether the benefits reported in individual trials reflect a reproducible effect of the NASM model itself or simply the broader effectiveness of exercise-based rehabilitation. Existing systematic reviews have not resolved this, since each is restricted either to a single condition, primarily UCS, or to exercise therapy in general, without evaluating NASM as a distinct framework [25-27]. Therefore, a quantitative synthesis across the full spectrum of MSPS is needed to determine whether the effectiveness of NASM-based corrective exercise holds consistently across conditions, populations, protocols, and comparators, and to arrive at a more precise estimate of its overall treatment effect. Accordingly, the present systematic review and meta-analysis aimed to evaluate the effects of interventions incorporating the NASM corrective exercise continuum on pain intensity in individuals with MSPS. The primary outcome of interest was pain intensity, selected because pain is a central and clinically relevant patient-reported outcome across the heterogeneous range of MSPS investigated in the included trials.

Materials and Methods

The conduct and reporting of this systematic review and meta-analysis adhered to the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement [28]. Prior to data collection, the study protocol was submitted and recorded in PROSPERO, the International Prospective Register of Systematic Reviews, with the assigned identifier CRD420261439458.

Search strategy and keywords

A comprehensive literature search was performed in Scopus, Web of Science, and PubMed, covering the period from each database's earliest available records through June 30, 2026, to locate eligible studies. Additional records were identified through a supplementary Google Scholar search. To capture any further relevant literature not retrieved through the initial search, two independent reviewers (Ebrahim Ebrahimi and Mojtaba Khosravi) manually examined the reference lists of in-

cluded articles, with input sought from a subject-matter expert (Rahman Sheikhhoseini) where needed. Search terms were combined using the Boolean operators AND and OR, as detailed below: ([“National Academy of Sports Medicine” OR NASM] AND [“musculoskeletal pain” OR “musculoskeletal disorder*” OR pain OR myalgia OR arthralgia OR “myofascial pain” OR “myofascial pain syndrome*” OR “chronic pain” OR “persistent pain” OR “nociceptive pain” OR “nociceptive pain” OR fibromyalgia OR arthritis OR osteoarthritis OR “hip osteoarthritis” OR “knee osteoarthritis” OR “spine osteoarthritis” OR “back pain” OR backache OR backpain OR “low back pain” OR lumbago OR lumbalgia OR “lumbar pain” OR “lumbar syndrome” OR “lumbar spine syndrome” OR “pelvic girdle pain” OR “sacroiliac pain” OR “neck pain” OR neckache OR neckpain OR cervicgia OR cervicobrachialgia OR “shoulder pain” OR omalgia OR “rotator cuff” OR “rotator cuff disease” OR “rotator cuff tendinopathy” OR “shoulder impingement” OR “subacromial pain syndrome” OR “shoulder-arm syndrome” OR “knee pain” OR gonalgia OR patellalgia OR “patellofemoral pain” OR “patellofemoral pain syndrome” OR “hip pain” OR coxalgia OR “foot pain” OR footache OR “ankle pain” OR plantar fasciitis OR “heel pain” OR metatarsalgia OR podalgia OR “leg pain” OR “arm pain” OR “elbow pain” OR epicondylalgia OR tendinopathy OR tendinitis OR tendinosis OR “muscle pain” OR “muscle ache” OR “muscular pain” OR “musculoskeletal chest pain” OR whiplash OR “whiplash injury” OR “whiplash injuries” OR “thoracic pain” OR thoracalgia OR “pelvic pain” OR “gluteal pain” OR “buttock pain”]).

Inclusion and exclusion criteria

The eligibility criteria were established according to the population, intervention, comparison, outcomes, and study design framework [29]. Eligible studies included individuals of any age or sex with MSPS. The intervention was required to incorporate the NASM corrective exercise continuum as a substantive component of the exercise or rehabilitation program, whether delivered as a stand-alone intervention or in combination with additional exercise or therapeutic components. Comparator groups included no intervention, usual care, sham intervention, conventional therapy, or alternative exercise and rehabilitation programs that did not incorporate the NASM model. Eligible studies were required to report quantitative outcomes related to pain. RCTs and quasi-experimental studies were considered eligible. Moreover, postural deviations or alignment characteristics were not considered eligible conditions and were not used as an independent basis for study inclusion. Stud-

ies were excluded if they did not incorporate the **NASM** corrective exercise continuum as a substantive component of the intervention; enrolled participants without MSPS; evaluated surgical, pharmacological, orthotic, or other non-exercise interventions without a distinct **NASM** component; lacked an appropriate comparison group or sufficient quantitative data for effect-size estimation; or were systematic reviews, meta-analyses, conference abstracts, editorials, commentaries, letters, case reports, study protocols, dissertations, book chapters, or articles published in non-peer-reviewed journals or languages other than English.

Study selection

Titles and abstracts of all identified records were independently assessed for eligibility by two reviewers (Parsa Samaei and Ebrahim Ebrahimi), applying the predefined inclusion criteria alongside PRISMA recommendations; a standardized Microsoft Excel form was used to extract relevant data [30]. Eligibility was restricted to human studies published by June 30, 2026. Where the two reviewers' assessments diverged, a third reviewer (Rahman Sheikhhoseini) was consulted to reach consensus. Prior to screening, all citations retrieved from the search were imported into EndNote 20 (Clarivate Analytics) to detect and eliminate duplicate entries.

Data extraction and quality assessment

Two independent researchers (Parsa Samaei and Ebrahim Ebrahimi) conducted the methodological quality and risk-of-bias assessment using the **Joanna Briggs Institute (JBI)** Critical Appraisal Tools [31]. The specific appraisal checklist was selected according to the research design of each included study, including quasi-experimental and randomized controlled trial (RCT) designs [32]. For quasi-experimental studies, a score of 6 or lower was considered indicative of low methodological quality, whereas for RCTs, studies scoring 9 or lower were classified as low quality [33]. The two reviewers first discussed any disagreements to reach consensus, and the supervising author (Rahman Sheikhhoseini) adjudicated unresolved discrepancies. The same two reviewers independently extracted data using a standardized Microsoft Excel sheet developed for this review. The extracted information included the first author's name and year of publication, study design, participant characteristics, measurement outcomes, assessment methods, data collection instruments, and main findings. Following independent extraction, both reviewers compared their datasets to ensure consistency and accuracy. Any inconsistencies were resolved through discussion and, when necessary, consulta-

tion with the supervising author. The extracted data were subsequently organized and summarized in **Table 1** for further analysis and synthesis.

Data analysis

For each eligible study, the data required for quantitative synthesis, including sample size, means, standard deviations, *P*, and, where applicable, mean differences and their corresponding standard deviations, were extracted. Meta-analyses were performed using Comprehensive Meta-Analysis software, version 4; Biostat, Englewood, NJ, USA). Pooled effect sizes were calculated as standardized mean differences (SMDs) with 95% confidence intervals (CIs) using a random-effects model to account for anticipated between-study heterogeneity. Statistical heterogeneity was assessed using Cochran's *Q* test ($P < 0.05$ indicating significant heterogeneity) and quantified with the *I*² statistic, where values of 25%, 50%, and 75% represented low, moderate, and high heterogeneity, respectively [32]. Publication bias was evaluated using Egger's regression test, with $P < 0.05$ considered indicative of significant small-study effects [34], and was visually inspected using funnel plots. Statistical significance for all pooled analyses was set at $P < 0.05$.

Results

The database search yielded 145 records (**Figure 1**). Following import into EndNote and de-duplication, 43 distinct articles remained eligible for screening. After applying the eligibility criteria during title and abstract review, studies that did not meet these criteria were excluded, leaving 17 articles for full-text assessment. Of these, 10 studies met the predefined criteria upon full-text evaluation. A further 2 eligible studies were located via Google Scholar, bringing the total number of studies incorporated into the systematic review and meta-analysis to 12.

Study characteristics

Table 1 summarizes the characteristics of the included studies. A total of 12 studies were included in the systematic review and meta-analysis, comprising both RCTs and quasi-experimental studies. Most investigations were published between 2020 and 2026, reflecting the recent growth in research on **NASM**-based corrective exercise interventions. Sample sizes ranged from 20 to 50 participants, and the included populations represented a broad spectrum of individuals with MSPS, including UCS [14, 35, 36], chronic non-specific low back pain [20, 21], knee osteoarthritis [22], forward head posture

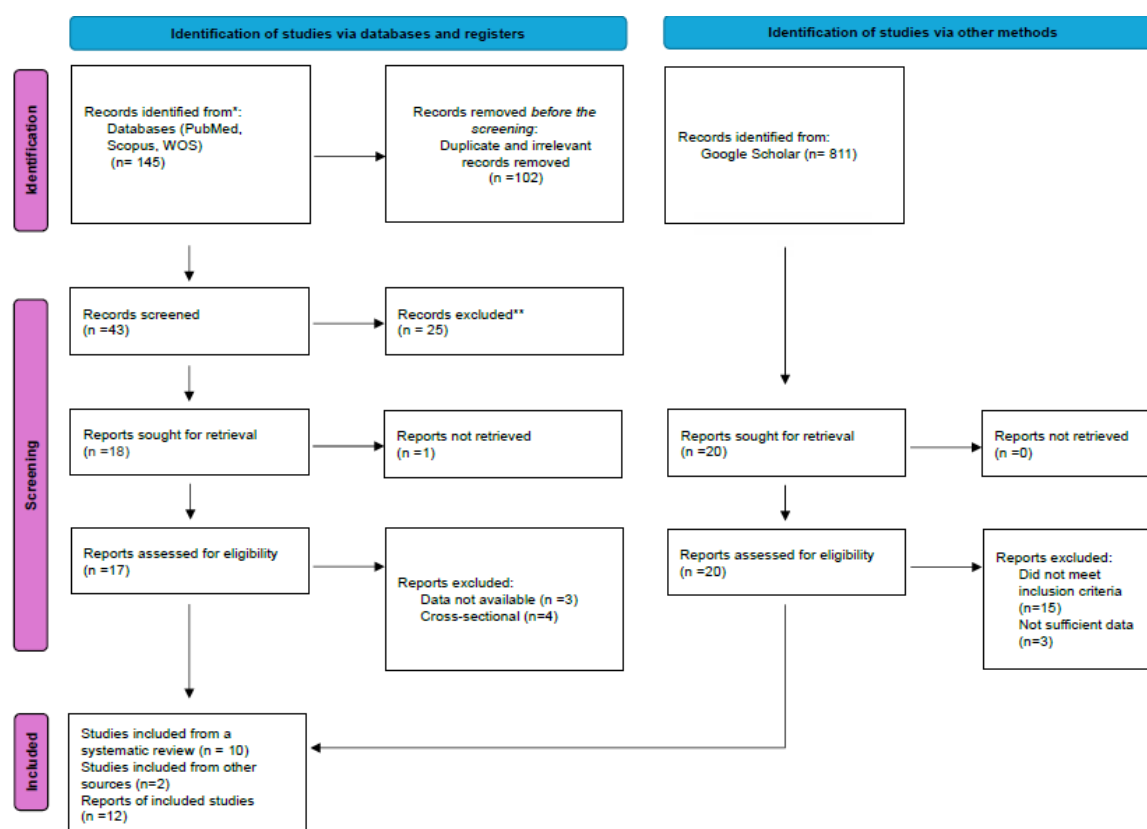


Figure 1. PRISMA flow diagram of the study selection process

[37], lordosis-related pain [18], as well as athletes and university students experiencing pain associated with movement dysfunctions. Participant ages varied widely across studies, from approximately 20 to 57 years, with both male and female participants represented, although several studies included only one sex or did not report sex distribution. The intervention protocols predominantly consisted of NASM-based corrective exercise programs delivered over 8 weeks, while one study implemented a 12-week intervention [15]. Several studies evaluated NASM corrective exercises as a stand-alone intervention, whereas others combined the NASM corrective exercise continuum with complementary rehabilitation approaches, including conventional physiotherapy, foam rolling [15], water-based exercise [22], and Taekwondo training [18]. Comparator groups included usual care, conventional physiotherapy, conventional exercise therapy, core stability training [21], Taekwondo exercise [18], or no additional intervention, depending on the study design. Pain intensity was the primary outcome assessed across all included studies and was most commonly measured using the visual analog scale (VAS) [15, 17, 18, 20-22, 36, 38, 39], although the numeric pain rating scale (NPRS) [35] and the shoulder pain and

disability index (SPADI) [14] were also used in selected studies. Overall, findings consistently favored NASM-based corrective exercise interventions, with most studies reporting statistically significant reductions in pain compared with control interventions.

Data synthesis

A total of 12 studies (n=382) [14, 15, 17, 18, 20-22, 35-39] involving participants with various MSPS were included in the meta-analysis of pain. The pooled analysis demonstrated a significant difference between the effect of interventions incorporating the NASM corrective exercise continuum and the control group (SMD=1.057, 95% CI, 0.794%, 1.319%, $P<0.001$), indicating a greater reduction in pain among participants who received interventions incorporating the NASM corrective exercise continuum compared with those in the control groups (Figure 2). Considerable heterogeneity was observed across the included studies ($I^2=75\%$, $P<0.001$). Therefore, subgroup analyses were performed according to the anatomical location of pain to explore potential sources of heterogeneity. For participants with back pain (4 studies, n=122), the subgroup

Pain

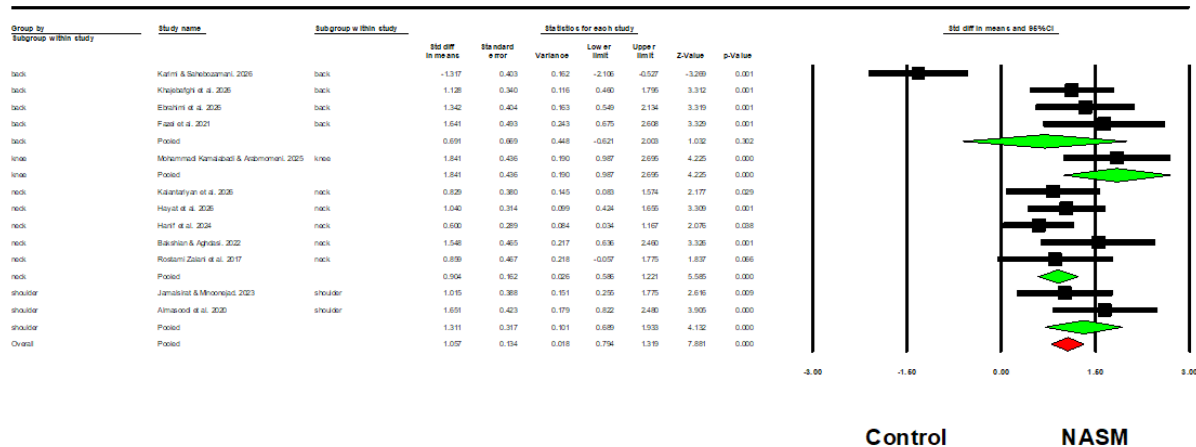


Figure 2. Forest plot summarizing the effect of NASM on pain

analysis showed no significant difference between the NASM intervention and control groups (SMD=0.691, 95% CI, -0.621%, 2.003%, $P=0.302$). In contrast, the neck pain (5 studies, $n=170$) subgroup demonstrated a significant reduction in pain favoring the interventions incorporating the NASM-corrective exercise continuum (SMD=0.904, 95% CI, 0.586%, 1.221%, $P<0.001$). Similarly, a significant treatment effect was observed in the shoulder pain (2 studies, $n=60$) subgroup (SMD=1.311, 95% CI, 0.689%, 1.933%, $P<0.001$), indicating superior pain reduction following interventions incorporating the NASM corrective exercise continuum compared with the control interventions. The knee-pain category was retained in the subgroup display for completeness; however, because it was represented by only a single study [22], its subgroup estimate is equivalent to that study's effect estimate and did not provide an independent estimate of between-study heterogeneity. Therefore, interpretation of the anatomical subgroup findings focused on the regions represented by multiple studies. Publication bias was assessed using Egger's regression test. The results indicated no evidence of significant publication bias for the pain outcome ($P=0.42$).

Methodological quality assessment

Study quality across the included articles was appraised independently using the JBI critical appraisal tools matched to each study design (Tables 2, and 3). For quasi-experimental studies, the corresponding 9-item JBI checklist was applied, while RCTs were evaluated against the 13-item JBI checklist designed for that study type. Responses to each checklist item were categorized as "Yes," "No," "Unclear," or "Not Appli-

cable," and the total quality score was calculated by tallying the number of "Yes" responses. Among the seven quasi-experimental studies, methodological quality was consistently high, with overall scores ranging from 8 to 9 out of 9. Six studies scored 8/9, while one study received the maximum score of 9/9 [17]. The most frequently unmet criterion was adequate follow-up (Q8), whereas all studies clearly defined the intervention, included an appropriate comparison group, used reliable outcome measures, and applied appropriate statistical analyses. The five included RCTs demonstrated moderate-to-high methodological quality, with overall scores ranging from 10-11 out of 13. One trial scored 11/13 [15], whereas the remaining four studies scored 10/13. The principal methodological limitations were the lack of participant and intervention-provider blinding, which was consistently observed across all RCTs. In addition, allocation concealment was reported as unclear in three studies, and one study did not clearly report blinding of outcome assessors. Nevertheless, all RCTs employed appropriate randomization procedures, reported comparable baseline characteristics, used reliable and consistent outcome assessment methods, and performed appropriate statistical analyses. Overall, the risk-of-bias assessment indicated that all included studies were of moderate to high methodological quality, with no study classified as low quality. These findings suggest that the available evidence provides a robust methodological basis for the quantitative synthesis and interpretation of the meta-analysis results.

Table 1. Demographic information from included studies

Author(s), Year	Design	Participants	Gender (M/F)	Age	Experimental Intervention	Control Intervention	Outcomes	Tools	Results
Ebrahimi et al. 2026 [18]	Quasi-experimental	30 lordotic soldiers	30/0	EG: 20.46±2.55 CG: 21±0.3	NASM-based exercises combined with Taekwondo (8 weeks)	Taekwondo exercises	Pain	VAS	Significant differences were observed in the EG group compared to the control.
Kalantariyan et al. 2026 [15]	RCT	30 university students	30/0	EG: 21.5±1.8 CG: 21.9±2.1	NASM-based exercises combined with foam rolling (12 weeks)	Conventional therapy	Pain	VAS	Significant differences were observed in the EG group compared to the control.
Hayat et al. 2026 [35]	RCT	46 individuals with UCS	4/42	EG: 31.56±5.99 CG: 33.13±6.15	NASM-based exercises combined with conventional treatment (8 weeks)	Conventional physiotherapy	Pain	NPRS	Significant differences were observed in the EG group compared to the control.
Karimi & Sahebozamani 2026 [21]	Quasi-experimental	30 elite Taekwondo athletes with CNSLBP	NA	EG: 24.9±3.1 CG: 25.2±2.8	NASM-based exercises (8 weeks)	Core stability	Pain	VAS	Significant differences were observed in the CG group compared to the EG.
Khajebafghi et al. 2026 [38]	Quasi-experimental	40 students	40/0	EG: 20±0.5 CG: 20.2±0.1	NASM-based exercises (8 weeks)	Usual care	Pain	VAS	Significant differences were observed in the EG group compared to the control.
Mohammadi Kamalabadi & Arabmomeni 2025 [22]	Quasi-experimental	30 women with knee osteoarthritis	0/30	EG: 57.1±2.3 CG: 56.2±2.3	Water exercise with the NASM (8 weeks)	Usual care	Pain	VAS	Significant differences were observed in the EG group compared to the control.
Hanif et al. 2024 [36]	RCT	50 individuals with UCS	NA	EG: 30.56±2.48 CG: 29.76±2.89	NASM-based exercises (8 weeks)	Conventional physiotherapy	Pain	VAS	Significant differences were observed in the EG group compared to the control.
Jamalsirat & Minoonejad 2023 [39]	Quasi-experimental	30 elite swimmers	30/0	EG: 26.6±4.82 CG: 27.06±5.18	NASM-based exercises (8 weeks)	Usual care	Pain	VAS	Significant differences were observed in the EG group compared to the control.
Bakshian & Aghdasi 2022 [17]	Quasi-experimental	24 mobile phone Users	24/0	EG: 28.4±4.17 CG: 28.4±9.87	NASM-based exercises (8 weeks)	Usual care	Pain	VAS	Significant differences were observed in the EG group compared to the control.
Fazel et al. 2021 [20]	RCT	22 individuals with CNSLBP	22/0	EG: 45.8±8.8 CG: 40.4±12.2	NASM-based exercises (8 weeks)	Conventional therapy	Pain	VAS	Significant differences were observed between the groups.

Author(s), Year	Design	Participants	Gender (M/F)	Age	Experimental Intervention	Control Intervention	Outcomes	Tools	Results
Almasoodi et al. 2020 [14]	RCT	30 individuals with UCS	30/0	EG: 35.13±5.01 CG: 34.26±5.59	NASM-based exercises (8 weeks)	Conventional therapy	Pain	SPADI	Significant differences were observed in the EG group compared to the control.
Rostami Zalani et al. 2017 [37]	Quasi-experimental	20 individuals with FHP	20/0	EG: 24.12±2.2 CG: 23.31±4.26	NASM-based exercises (8 weeks)	Conventional therapy	Pain	VAS	Significant differences were observed in the EG group compared to the control.

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Abbreviations: EG: Experimental group; CG: Control group; VAS: Visual analogue scale; SPADI: Shoulder pain and disability index; NPRS: Numeric pain rating scale; FHP: Forward head posture; UCS: Upper crossed syndrome; RCT: Randomized controlled trial; CNSLBP: Chronic non-specific low back pain; NASM: National Academy of Sports Medicine.

Discussion

This systematic review and meta-analysis synthesized available evidence on interventions incorporating the NASM corrective exercise continuum for individuals with MSPS. Across 12 studies, the pooled analysis demonstrated greater reductions in pain-related outcomes in NASM-based intervention groups than comparator conditions. However, interpreting this overall effect requires caution because the included interventions and comparators were not uniform. NASM was delivered as a stand-

alone intervention in some studies, whereas other trials combined NASM with additional components such as Taekwondo training, foam rolling, conventional treatment, or aquatic exercise. Comparator conditions also ranged from usual care to active exercise and rehabilitation interventions. Therefore, the overall pooled estimate should be interpreted as an average effect across different NASM-based intervention strategies and clinical comparison contexts rather than as a homogeneous estimate of the isolated effect of NASM.

Table 2. Critical appraisal results of eligible included studies

Author(s)/ JBI Checklists for Quasi-experimental Studies	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Overall Score
Ebrahimi et al. 2026 [18]	Y	Y	Y	Y	Y	Y	Y	N	Y	8/9
Karimi & Sahebozamani 2026 [21]	Y	Y	Y	Y	Y	Y	Y	N	Y	8/9
Khajebafghi et al. 2026 [38]	Y	Y	Y	Y	Y	Y	Y	N	Y	8/9
Mohammadi Kamalabadi & Arabmomeni 2025 [22]	Y	Y	Y	Y	Y	Y	Y	N	Y	8/9
Jamalsirat & Minoonejad 2023 [39]	Y	Y	Y	Y	Y	Y	Y	N	Y	8/9
Bakshian & Aghdasi 2022 [17]	Y	Y	Y	Y	Y	Y	Y	Y	Y	9/9
Rostami Zalani et al. 2017 [37]	Y	Y	Y	Y	Y	Y	Y	N	Y	8/9

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JBI critical appraisal checklist for systematic reviews and research syntheses: Q1. Is it clear in the study what is the "cause" and what is the "effect"? Q2. Was there a control group? Q3. Were participants included in any comparisons similar? Q4. Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest? Q5. Were there multiple measurements of the outcome, both pre and post the intervention/exposure? Q6. Were the outcomes of participants included in any comparisons measured in the same way? Q7. Were outcomes measured in a reliable way? Q8. Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analyzed? Q9. Was appropriate statistical analysis used?

Table 3. Critical appraisal results of the included randomized controlled trials using the JBI checklist

Authors/ JBI Checklists for Randomized Controlled Trials	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Overall Score
Kalantariyan et al. 2026 [15]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	11/13
Hayat et al. 2026 [35]	Y	U	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	10/13
Hanif et al. 2024 [36]	Y	U	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	10/13
Fazel et al. 2021 [20]	Y	U	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	10/13
Almasoodi et al. 2020 [14]	Y	Y	Y	N	N	Y	U	Y	Y	Y	Y	Y	Y	10/13

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JBI critical appraisal checklist for systematic reviews and research syntheses: Q1. Was true randomization used for assignment of participants to treatment groups? Q2. Was allocation to treatment groups concealed? Q3. Were treatment groups similar at the baseline? Q4. Were participants blind to treatment assignment? Q5. Were those delivering the treatment blind to treatment assignment? Q6. Were treatment groups treated identically other than the intervention of interest? Q7. Were outcome assessors blind to treatment assignment? Q8. Were outcomes measured in the same way for treatment groups? Q9. Were outcomes measured in a reliable way? Q10. Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed? Q11. Were participants analyzed in the groups to which they were randomized? Q12. Was appropriate statistical analysis used? Q13. Was the trial design appropriate and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?

The overall findings are consistent with the theoretical rationale underpinning the **NASM** corrective exercise continuum. Unlike conventional strengthening programs that primarily target muscle performance [14], the **NASM** model adopts a sequential approach involving inhibition of overactive tissues, restoration of muscle extensibility, activation of underactive muscles, and integration of coordinated functional movement patterns [40]. This progression aims to correct movement dysfunctions and improve neuromuscular control rather than merely increase muscular strength [19]. Since altered movement patterns, impaired motor control, and muscular imbalance contribute to persistent musculoskeletal pain [41], interventions targeting these mechanisms may reduce abnormal mechanical loading and improve movement efficiency [42], thereby decreasing pain during daily activities. The consistent improvements observed across the included studies support the concept that addressing underlying movement impairments may provide clinical benefits in individuals with MSPS.

Although the pooled effect favored interventions incorporating the **NASM** corrective exercise continuum, subgroup analyses demonstrated that treatment effects differed by anatomical region. Significant benefits were observed for neck and shoulder pain, whereas the subgroup analysis for back pain did not demonstrate a statistically significant advantage over comparator interventions. Several explanations may account for these

differences. First, neck- and shoulder-related disorders, such as UCS and forward head posture, are frequently characterized by predictable patterns of muscular imbalance and postural dysfunction [23], making them particularly suitable for interventions designed to restore muscle balance and movement quality. In contrast, chronic low back pain represents a highly heterogeneous condition influenced not only by biomechanical impairments but also by psychosocial factors [43], central pain sensitization, fear-avoidance beliefs, and lifestyle-related contributors [44]. Consequently, corrective exercise alone may not adequately address the multidimensional nature of chronic low back pain, particularly when compared with active interventions such as core stability training or other structured exercise programs. Furthermore, the back pain subgroup contained relatively few studies and exhibited substantial statistical heterogeneity, reducing the precision of the pooled estimate and limiting definitive conclusions. Although the back pain subgroup did not demonstrate a significant pooled advantage for interventions incorporating the **NASM** corrective exercise continuum, the finding from Karimi and Sahebozamani (2026) warrants particular consideration because the study reported a significant between-group advantage favoring core stability exercise over the **NASM** intervention in taekwondo athletes [21]. This finding indicates that the absence of a significant pooled effect in the back pain subgroup was not simply attributable to a lack of differences between interven-

tions; rather, at least one study demonstrated a clinically meaningful advantage for an alternative active exercise approach. A core stability program may therefore have provided a more direct stimulus to the trunk musculature and neuromuscular control strategies relevant to the functional demands of the Taekwondo population. Also, the superiority of core stability in this individual study should be interpreted within its specific population and intervention context rather than generalized to all individuals with low back pain. The considerable heterogeneity observed across studies ($I^2=75\%$) deserves careful consideration. The included trials varied substantially in participant characteristics, underlying musculoskeletal conditions, intervention duration, exercise intensity, supervision methods, comparator interventions, and outcome assessment tools. Some studies evaluated NASM corrective exercise as a stand-alone intervention [20, 21, 38], whereas others combined it with complementary modalities including aquatic exercise [22], foam rolling [15], or sport-specific training [18]. Such diversity inevitably contributes to variability in treatment effects and suggests that the pooled estimate should be interpreted as an average effect across multiple clinical contexts rather than as a precise estimate applicable to every patient population. From a clinical perspective, this variability may also limit direct translation into practice because the available evidence does not establish a single optimal NASM protocol, dose, or mode of delivery. Additionally, exercise therapy is well established as an effective intervention for many musculoskeletal pain conditions [45]; therefore, demonstrating superiority over another active exercise program is considerably more challenging than demonstrating superiority over minimal intervention or usual care. Consequently, the current meta-analysis suggests that interventions incorporating the NASM corrective exercise continuum should be viewed as one effective rehabilitation framework within the broader spectrum of exercise-based management rather than as a universally superior intervention.

From a clinical perspective, these results have several important implications. Given the increasing emphasis on non-pharmacological management of musculoskeletal pain, interventions incorporating the NASM-corrective exercise continuum may provide clinicians with a structured and clinically applicable framework for rehabilitation. The four-stage continuum offers a systematic method for identifying and addressing movement dysfunctions while progressing patients toward functional integration. Physical therapists, sports rehabilitation specialists, exercise physiologists, and other healthcare professionals may therefore consider incorporating NASM principles into individualized rehabilitation programs,

particularly for patients presenting with posture-related disorders, neck pain, shoulder dysfunction, or movement impairments. Nevertheless, patient assessment remains essential, as not all musculoskeletal conditions respond equally to this approach. For individuals with chronic low back pain or more complex pain presentations, corrective exercise may be most effective when integrated within a comprehensive biopsychosocial rehabilitation program that also addresses education, behavioral factors, functional training, and psychological contributors to pain.

This review has several limitations. First, the number of eligible studies remains relatively small despite the growing interest in interventions incorporating the NASM corrective exercise continuum, particularly within specific musculoskeletal conditions. Second, studies showed considerable clinical and methodological heterogeneity, including differences in intervention protocols, comparator treatments, participant characteristics, and outcome measures. Although a random-effects model and subgroup analyses were used to account for this variability, residual heterogeneity remained substantial. Third, most interventions were limited to approximately eight weeks, with very few studies evaluating long-term follow-up, making it difficult to determine whether pain reductions are maintained over time. Fourth, most studies assessed pain using subjective, self-reported instruments such as the VAS or NPRS, while relatively few simultaneously evaluated objective biomechanical, neuromuscular, or functional outcomes that could help explain the mechanisms underlying clinical improvement. Also, blinding of participants and therapists was generally not feasible because of the nature of exercise interventions, introducing an inherent risk of performance bias despite otherwise acceptable methodological quality. An additional limitation concerns the clinical and demographic diversity of the included populations. The review encompassed participants with different musculoskeletal conditions and movement-related pain presentations, ranging from young university students, soldiers, and athletes to middle-aged individuals with chronic low back pain or knee osteoarthritis. These populations differ in age, underlying pathology, symptom characteristics, physical activity level, and potential mechanisms contributing to pain. Although all eligible studies involved MSPS and evaluated interventions incorporating the NASM corrective exercise continuum, this broad clinical spectrum limits the extent to which the overall pooled effect can be generalized to any specific musculoskeletal condition or patient population. The anatomical subgroup analyses partially addressed this issue by examining pain according to body region; however, the number

of studies within individual clinical categories remained limited. Therefore, the overall pooled estimate should be interpreted as an average effect across diverse clinical contexts rather than as evidence that NASM-based interventions have a uniform effect across all musculoskeletal pain conditions. Finally, only English-language peer-reviewed publications were included, raising the possibility of language and publication bias, although Egger's regression test did not indicate significant small-study effects.

Conclusion

Overall, this systematic review and meta-analysis indicate that interventions incorporating the NASM corrective exercise continuum is associated with significant reductions in pain among individuals with MSPS, particularly in conditions affecting the neck and shoulder. Given the moderate-to-high methodological quality of the available evidence, interventions incorporating the NASM corrective exercise continuum can be considered a valuable component of contemporary musculoskeletal rehabilitation.

Ethical Considerations

Compliance with ethical guidelines

There were no ethical considerations to be considered in this research.

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Authors' contributions

Study design and data collection: Rahman Sheikhhoseini, Parsa Samaei, and Mojtaba Khosravi; Writing Ebrahim Ebrahimi and Parsa Samaei; Final approval: All authors.

Conflict of interest

The authors declared no conflict of interest.

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