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Pain management interventions for combat sport and martial arts athletes including *pencak silat*: a systematic review

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ABSTRACT

Combat and martial arts, including *Pencak silat*, expose athletes to repetitive high-impact loading that generates acute pain, delayed-onset muscle soreness, and cumulative musculoskeletal strain, yet the evidence base for managing this pain remains fragmented. This systematic literature review synthesised controlled evidence on pain-management and recovery interventions in combat and martial arts athletes. The review followed the PRISMA 2020 framework, searching Scopus, PubMed, and ScienceDirect for records published between 2002 and 2026. A total of 1,444 records were identified; after removing 16 duplicates and screening 1,428 titles and abstracts, 52 reports were assessed in full text and 7 studies met all eligibility criteria. Methodological quality was appraised with the Mixed Methods Appraisal Tool. The included studies evaluated dry needling and manual therapy, cryotherapy and compression, topical pharmacological gels, and neurodynamic mobilisation, consistently reporting raised pressure-pain thresholds, improved perfusion, and attenuated soreness relative to sham or passive control. No study specifically recruited *Pencak silat* athletes, exposing a critical evidence gap. These findings support multimodal, mechanism-targeted pain care while underscoring the urgent need for Pencak-Silat-specific controlled trials. Future research should standardise outcomes and prioritise underrepresented traditional martial arts.

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Introduction

Combat sports and martial arts occupy a prominent place in global sport culture, encompassing Olympic disciplines, professional mixed martial arts, and traditional practices such as *Pencak silat* that carry deep cultural significance across Southeast Asia. Participation in these disciplines is expanding, but so is the associated injury burden, because striking, grappling, and throwing repeatedly load the musculoskeletal system near its tolerance limits (Turnagöl et al., 2021). Epidemiological surveillance shows that a substantial proportion of combat-sport injuries force athletes out of training or competition for more than a week, and that concussive and musculoskeletal presentations are common across disciplines (Bromley et al., 2018; Kiehl et al., 2025). High-performance grappling cohorts likewise report elevated rates of joint and soft-tissue complaints (Nery et al., 2023). This convergence of rising participation and persistent injury risk makes effective pain management a central concern for athlete health.

Pain in combat athletes is not a peripheral inconvenience; it is a recurrent, performance-limiting phenomenon rooted in direct trauma, overuse, and the sustained postural demands of fighting stances (de Souza et al., 2011).

Site-specific data illustrate the problem: hip pain increases with age and experience in karate practitioners (Mack et al., 2022), and judokas with low back pain display measurable deficits in hip–spine flexibility (Tak et al., 2020). Beyond nociception, athletes describe pain as a qualitatively distinct experience shaped by identity, competition, and tolerance norms, which complicates assessment and treatment (Purcell et al., 2024). Managing this pain therefore requires interventions that address both tissue-level drivers and the functional consequences that determine whether an athlete can safely continue to train and compete.

A heterogeneous body of research has examined how musculoskeletal pain in athletes can be treated and rehabilitated. Instructional syntheses have codified graded approaches to low back pain in athletic populations (Sairyo & Nagamachi, 2016), while multidisciplinary sports health-care models increasingly integrate manual and chiropractic care into athlete management (Howitt et al., 2023). Complementary and precision-oriented modalities, including individualised acupuncture, have been modelled for unilateral musculoskeletal pain (Lopes et al., 2023), and observational imaging work suggests that sustained martial arts practice may confer favourable spinal adaptations (Zhang et al., 2023). Despite this breadth, the literature remains dispersed across modalities and populations, offering clinicians little consolidated guidance on which pain-management strategies are effective specifically for combat and martial arts athletes.

Methodological and technological advances are reshaping how pain and recovery are measured and delivered in these sports. Mixed-reality and marker-less motion-tracking systems now support martial arts rehabilitation (Franzò et al., 2023), and machine-learning models estimate joint loading to guide return-to-play decisions after reconstruction (Li et al., 2025). Sideline assessment tools have been refined for rapid neurological triage in striking sports (Twohey et al., 2023), and rigorous trial protocols are being registered to test targeted modalities such as dry needling for discipline-specific fatigue (Aghajani et al., 2025). These developments signal a maturing field, yet they also widen the gap between what can be measured and the still-limited pool of controlled evidence on pain-management effectiveness.

A first and striking gap concerns population coverage. Although combat sports research is growing, traditional Southeast Asian martial arts remain markedly underrepresented, and studies that do address Indonesian traditional martial arts focus largely on injury causation rather than on tested pain interventions (Kusuma, 2023). Person-centred work on injured *Pencak silat* athletes has begun to characterise psychological readiness for rehabilitation (Purnomo et al., 2026), and biomechanical studies of balance and skill in combat sports continue to accumulate (Litwiniuk et al., 2023). Even culturally embedded practices proposed to support rehabilitation and quality of life, such as Capoeira, rest largely on hypothesis rather than controlled testing (Moreira et al., 2022). The near-absence of Pencak-Silat-specific intervention trials is a substantive evidence gap this review foregrounds.

A second gap is methodological. Existing reviews tend to be discipline-narrow or modality-narrow: syntheses have addressed massage in taekwondo practitioners (Mathunjwa et al., 2025) and the historical development of judo in a single region (Hlasho et al., 2024), while primary trials of recovery adjuncts such as wet-cupping are emerging but isolated (Dergaa et al., 2024). Cross-disciplinary comparisons of sensorimotor function between combat and ball sports further highlight inconsistent outcome selection (Kızılay & Cengiz, 2023). No synthesis has yet consolidated controlled pain-management evidence across combat and martial arts disciplines using a transparent PRISMA-based protocol and standardised quality appraisal, leaving practitioners without an integrated, critically appraised evidence map.

These gaps carry urgency because pain and injury directly threaten athletic longevity, return-to-sport success, and career continuity in combat sports (Fares et al., 2025; Santacaterina et al., 2025), and because maladaptive pain-coping is linked to anxiety and aggression in fighters (Glińska-Wlaź et al., 2025). Consolidating the controlled evidence is therefore both clinically and academically necessary. Accordingly, this review addresses three questions. RQ1 (Population–Intervention–Outcome): What pain-management interventions are used to reduce pain among *Pencak silat* and combat sport athletes? RQ2 (Intervention–Comparison–Outcome): How effective are these interventions compared with standard care or alternative recovery methods for reducing pain and improving recovery? RQ3 (Population–Outcome): What outcomes are most commonly reported following pain-management interventions in these athletes, such as pain reduction, functional recovery, and return to sport? By answering these questions, the review offers the first integrated, critically appraised synthesis of pain-management evidence for combat and martial arts athletes and defines a research agenda centred on underrepresented traditional disciplines.

Method

Research Design and Framework

This study was conducted as a systematic literature review (SLR), a design suited to aggregating and critically appraising dispersed empirical evidence to answer focused questions in a transparent, reproducible manner (Tranfield et al., 2003). The review adhered to the reporting standards of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021) and drew on the methodological principles articulated in the PRISMA explanation-and-elaboration guidance (Liberati et al., 2009). The SLR approach was preferred over a narrative review because the pain-management literature in combat sports is fragmented across modalities, disciplines, and outcome sets, and a protocol-driven synthesis was required to minimise selection bias and to expose evidence gaps systematically.

Search Strategy

Prior to constructing the search string, each research question was decomposed using the PICO framework to ensure systematic identification of the core search concepts: Population (P): *Pencak silat*, martial arts, and combat sport athletes; Intervention/Interest (I): Pain-management and recovery interventions (physical, thermal, manual, neurodynamic, and topical/adjunct pharmacological strategies); Comparison (C): Standard care, passive rest, sham, or an alternative recovery method (or no comparator where not applicable); Outcome (O): Pain reduction, muscle-soreness attenuation, recovery, and functional improvement; and Each PICO element was translated into a cluster of synonyms and combined with Boolean operators. The search strings executed in each database were as follows.

Scopus (TITLE-ABS-KEY):

> (("*pencak silat*" OR "combat sport*" OR "martial art*") AND ("pain management" OR "pain relief" OR analgesia OR rehabilitation OR "non-pharmacological intervention*") AND (athlete* OR player* OR competitor*) AND (pain OR recovery OR rehabilitation))

PubMed (Title/Abstract and MeSH):

> ("*Pencak silat*"[Title/Abstract] OR "Martial Arts"[Mesh] OR "martial art*"[Title/Abstract] OR "combat sport*"[Title/Abstract]) AND ("Pain Management"[Mesh] OR "pain management"[Title/Abstract] OR "pain relief"[Title/Abstract] OR Analgesia[Mesh] OR analgesia[Title/Abstract] OR Rehabilitation[Mesh]
>
> OR rehabilitation[Title/Abstract] OR "Physical Therapy Modalities"[Mesh] OR "physical therap*"[Title/Abstract]) AND (Athletes[Mesh] OR athlete*[Title/Abstract] OR competitor*[Title/Abstract]) AND (Pain[Mesh] OR pain[Title/Abstract] OR Recovery[Title/Abstract] OR "return to sport"[Title/Abstract] OR function*[Title/Abstract])

ScienceDirect:

> ("*pencak silat*" OR "martial arts" OR "combat sports") AND ("pain management" OR "pain relief" OR rehabilitation OR "physical therapy") AND (athlete OR athletes)

Truncation and wildcard symbols (e.g., athlete*, martial art*) were used to capture morphological variants such as athlete/athletes and martial art/martial arts. In Scopus the TITLE-ABS-KEY field code restricted retrieval to titles, abstracts, and keywords; in PubMed, Medical Subject Headings (MeSH) were combined with free-text Title/Abstract terms to balance sensitivity and precision. The strings were piloted and refined iteratively: an initial specification that omitted recovery synonyms returned an excess of tangential musculoskeletal records, so the outcome cluster was broadened to include recovery and return to sport to align retrieval with the review objective. The PICO framework here structures the search only and is distinct from the quality-appraisal procedure in Section 3.6.

Database and Information Sources

Three databases were searched as complementary information sources: Scopus (primary, multidisciplinary indexing), PubMed (biomedical coverage with controlled MeSH vocabulary), and ScienceDirect (full-text scientific coverage in sport and health sciences). All searches were executed on the same date and exported for screening. Scopus returned 470 records, PubMed 50 records, and ScienceDirect 924 records, yielding 1,444 records for the identification phase.

Eligibility Criteria

Eligibility criteria were defined a priori and are presented in Table 1.

Table 1. Inclusion and exclusion criteria.

Criterion	Inclusion	Exclusion
Population	Combat/martial arts athletes (e.g., MMA, judo, jiu-jitsu, taekwondo, karate, Sanda, *Pencak silat*)	Non-combat athletes; non-athlete or general clinical samples
Intervention	A defined pain-management or recovery intervention (physical, thermal, manual, neurodynamic, or topical/adjunct pharmacological)	No intervention (purely observational, biomechanical, or performance-only studies)
Outcome	At least one pain, soreness, recovery, or functional outcome	No pain/recovery/functional outcome measured
Study design	Primary studies (RCT, quasi-experimental, crossover, cohort, case report)	Secondary studies (reviews, meta-analyses), protocols, editorials, conference papers
Language	English	Non-English
Publication period	2002–2026	Outside range
Source type	Peer-reviewed journal, final publication stage	Non-journal or non-final records

Study Selection Process

Study selection proceeded in three sequential stages. First, records from the three databases were combined and duplicates were removed. Second, titles and abstracts were screened against the eligibility criteria to exclude clearly irrelevant records. Third, the full texts of potentially eligible reports were retrieved and assessed in detail. Screening and full-text assessment were managed with the Rayyan systematic-review platform (Ouzzani et al., 2016), and disagreements were resolved by discussion and consensus with reference to the eligibility criteria. To establish selection reliability, two reviewers independently screened all titles and abstracts and assessed full texts against the pre-specified eligibility criteria. Inter-rater agreement was calculated using Cohen's kappa; a threshold of $\kappa \geq 0.80$ was set a priori as acceptable reliability. Disagreements at any stage were resolved through discussion and consensus with reference to the eligibility criteria table.

Quality Assessment

Quality appraisal was conducted independently of the PICO-based search formulation described in Section 3.2. Each included study was assessed using the Mixed Methods Appraisal Tool (MMAT), Version 2018 (Hong et al., 2018), which is suited to appraising the heterogeneous designs anticipated in this literature (quantitative randomised, quantitative non-randomised, quantitative descriptive, qualitative, and mixed methods).

For each study, the design category was first classified, after which the corresponding five MMAT criteria were applied and rated *Yes* (1), *Can't tell/Partial* (0.5), or *No* (0). Where a design did not fit the MMAT categories, the equivalent Joanna Briggs Institute (JBI) Critical Appraisal Checklist was applied and the substitution noted; the single-patient case report was appraised in this way. Studies scoring ≥60% (≥3 of 5 criteria) were retained as higher methodological confidence. Consistent with MMAT developer guidance, no study was excluded on the basis of its quality score alone; lower-scoring studies were retained but flagged, and their contribution to synthesis was weighted accordingly (see Section 5.4). The appraisal results are summarised in Table 2.

Table 2. Quality assessment summary (MMAT 2018; JBI for the case report).

Author(s), Year	Study design	Q1	Q2	Q3	Q4	Q5	Total (%)	Quality
Trybulski et al., 2025	Quantitative RCT	Y	Y	Y	CT	Y	90	High
Kużdżał et al., 2024a	Quantitative RCT	Y	Y	Y	Y	Y	100	High
Kużdżał et al., 2024b	Quantitative RCT	Y	Y	Y	Y	Y	100	High
Trybulski et al., 2024	Quantitative RCT	Y	Y	Y	Y	Y	100	High
Wetzel et al., 2002	Quantitative RCT	Y	Y	Y	Y	Y	100	High
Fonseca et al., 2016	Quantitative RCT (crossover)	Y	Y	CT	CT	Y	80	High
Kandakurti et al., 2025	Case report (JBI)	Y	Y	CT	Y	CT	80	Moderate

Note. Y = Yes; CT = Can't tell/Partial. For the case report, JBI case-report items were mapped to the five-column layout; single-case designs carry inherently lower external validity and are interpreted with caution.

Data Extraction Procedure

A standardised extraction form captured the following fields from each included study: author(s) and year, country, study design, sample size and characteristics, intervention and comparator, outcome measures, and principal findings. Extraction was performed by one reviewer and verified by a second against the source article to ensure accuracy and consistency.

Network and Bibliometric Analysis Methodology

Given the small number of included studies, a formal co-authorship or co-citation network analysis was not appropriate. Instead, descriptive bibliometric mapping was performed on the included set, summarising temporal distribution, geographic origin, and intervention category (Figures 2–4). This descriptive approach transparently characterises the evidence base without over-interpreting a limited sample.

Data Analysis and Synthesis

Because the included studies were clinically and methodologically heterogeneous, a meta-analysis was not conducted. Findings were synthesised narratively using thematic synthesis (Thomas & Harden, 2008): extracted findings were coded, grouped into descriptive intervention themes, and organised against the three research questions to identify convergences, contradictions, and gaps across studies.

Reporting and Documentation

The review was planned and reported in accordance with the PRISMA 2020 checklist (Page et al., 2021). The flow of records through identification, screening, eligibility, and inclusion is documented in the PRISMA 2020 flow diagram (Figure 1), and all reported counts are numerically consistent across the Abstract, Methods, and Results.

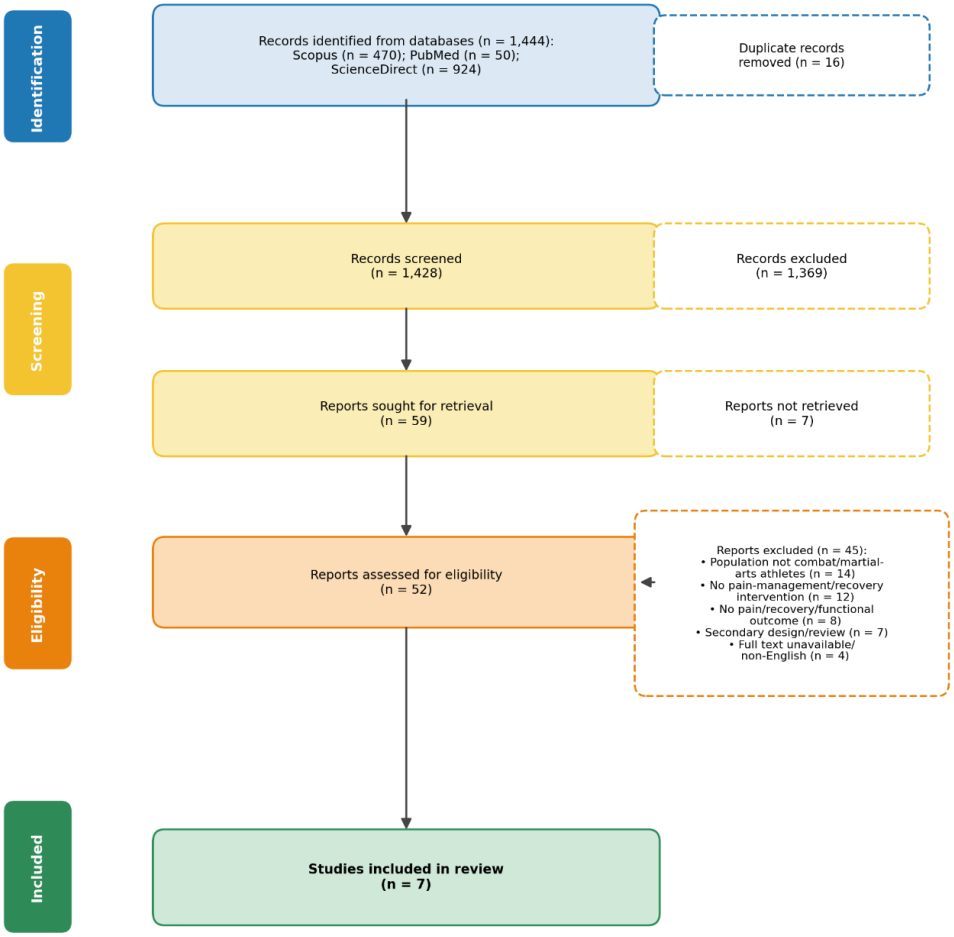

Figure 1. PRISMA 2020 flow diagram of the study selection process (adapted from Page et al., 2021).

Results and Discussions

Study Selection Results

The database searches identified 1,444 records: 470 from Scopus, 50 from PubMed, and 924 from ScienceDirect. After 16 duplicate records were removed, 1,428 records proceeded to title-and-abstract screening, at which 1,369 records were excluded as clearly irrelevant to the review question. Fifty-nine reports were sought for retrieval, of which 7 could not be obtained, leaving 52 reports assessed for full-text eligibility. At this stage, 45 reports were excluded: 14 for an ineligible population (not combat or martial arts athletes), 12 for lacking a defined pain-management or recovery intervention, 8 for reporting no pain, recovery, or functional outcome, 7 for being secondary designs (reviews or meta-analyses), and 4 for inaccessible full text or non-English language. Seven

studies satisfied all eligibility criteria and were included in the synthesis. The complete flow is depicted in Figure 1.

Descriptive Characteristics

The seven included studies were published between 2002 and 2025, with a clear concentration in 2024 (Figure 2). Geographically, the evidence base is dominated by Poland, which contributed four studies, followed by single studies from Brazil, Germany, and the United Arab Emirates (Figure 3). Six studies were randomised controlled trials and one was a single-patient case report. Sample sizes ranged from 1 to 158 participants, and the populations comprised professional and highly trained combat athletes drawn from mixed martial arts, jiu-jitsu, and mixed combat-sport cohorts, together with a mixed-sport impact-injury sample that included karate competitors. Full study-level details are provided in Table 3, and a thematic-methodological classification is provided in Table 4.

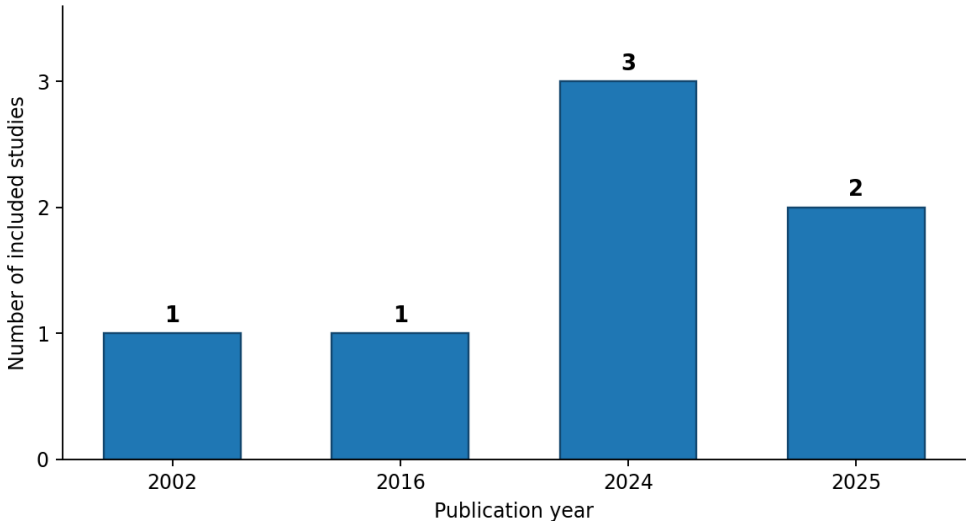

Figure 2. Temporal distribution of the included studies (n = 7).

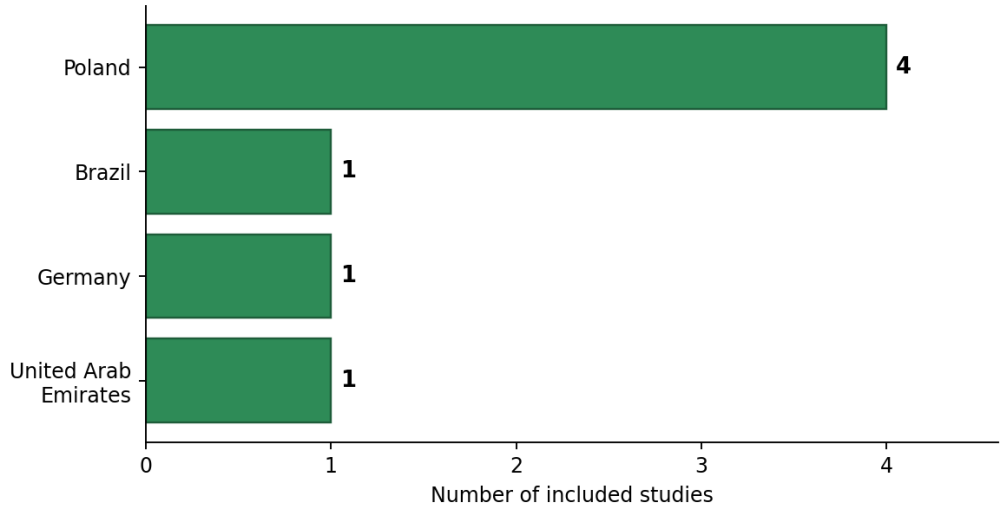

Figure 3. Geographic distribution of the included studies by country of the lead author's affiliation.

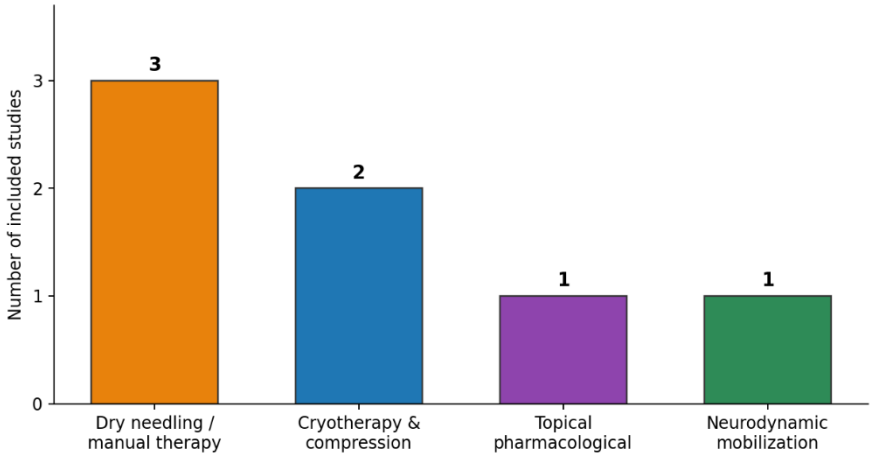

Figure 4. Distribution of included studies by pain-management intervention category (n = 7).

Table 3. Summary of the included studies.

Title	Author(s) (Year)	Country	Method	Key findings
Effect of pneumatic and cold compression on muscle performance and recovery in combat sports athletes	Trybulski et al. (2025)	Poland	RCT, 4 groups, n = 48 professional combat athletes; pneumatic intermittent compression (25/100 mmHg), cryo-compression, or passive rest after a plyometric fatigue protocol	Active compression-especially cryo-compression-enhanced tissue perfusion, restored muscle elasticity, lowered lactate dehydrogenase, and improved reactive strength versus passive rest across 48 h, supporting compression as an effective recovery modality.
Combination of manual therapy and dry needling effectively improves acute neck pain and muscular tone and stiffness in combat sports athletes	Kużdżał et al. (2024a)	Poland	RCT, n = 30 combat athletes with neck pain; manual therapy plus dry needling versus sham-needle plus manual therapy over three sessions	The combined intervention produced significantly lower muscle tone and stiffness and higher pressure-pain thresholds than control after three sessions and at 72 h, indicating reduced pain sensitivity and normalised muscle mechanics.
Comparing the effects of compression contrast therapy and dry needling on muscle functionality, pressure pain threshold, and perfusion after isometric fatigue in forearm muscles of combat sports athletes	Kużdżał et al. (2024b)	Poland	Single-blind RCT, n = 45 combat athletes; compression contrast therapy versus dry needling (with sham conditions) after forearm isometric fatigue	Both therapies improved muscle tension and perfusion after fatigue and raised pressure-pain thresholds; dry needling produced the greater perfusion gains, showing that distinct modalities can each deliver analgesic and recovery benefits.
Acute effects of the dry needling session on gastrocnemius muscle biomechanical properties, and perfusion with latent trigger points: a single-blind RCT in mixed martial arts athletes	Trybulski et al. (2024)	Poland	Single-blind RCT, n = 20 MMA athletes; one dry-needling session versus sham on gastrocnemius latent trigger points	Dry needling increased perfusion, reduced muscle tone and stiffness, improved elasticity, raised the pressure-pain threshold, and increased muscle power, with effects sustained to 24 h, suggesting facilitation of post-exercise recovery and analgesia.
Escin/diethylammonium salicylate/heparin combination gels for the topical treatment of acute impact injuries: a randomised, double-blind, placebo-controlled, multicentre study	Wetzel et al. (2002)	Germany	Double-blind placebo-controlled multicentre RCT, n = 158 competitors (soccer, handball, karate) with acute impact injury; topical escin (1% or 2%) gel versus placebo	Both escin gel concentrations significantly reduced pressure-induced tenderness over six hours compared with placebo, demonstrating effective, well-tolerated topical analgesia for acute blunt-impact injuries in competitive athletes.

Title	Author(s) (Year)	Country	Method	Key findings
Use of cold-water immersion to reduce muscle damage and delayed-onset muscle soreness and preserve muscle power in jiu-jitsu athletes	Fonseca et al. (2016)	Brazil	Randomised crossover trial, n = 8 highly trained jiu-jitsu athletes; cold-water immersion (6 °C, 19 min) versus passive recovery after training	Cold-water immersion lowered lactate dehydrogenase at 24 h and attenuated perceived muscle soreness while helping preserve muscle power relative to passive recovery, supporting its use as a recovery strategy.
Effect of neuromeningeal mobilization and postural re-education exercises for persistent hamstring strain: a case report	Kandakurti et al. (2025)	United Arab Emirates	Case report, n = 1 male martial artist with refractory hamstring strain; slump-based neuromeningeal mobilisation plus postural re-education over three consecutive days	Numeric pain-rating scores fell at rest and with activity and functional scores improved, suggesting neurodynamic mobilisation may relieve refractory strain-related pain, though single-case evidence carries low certainty.

Table 4. Study classification by theme and method

Author(s) (Year)	Year	Country	Research design	Theme/Focus	Intervention	Outcome
Trybulski et al.	2025	Poland	RCT	Cryotherapy & compression	Pneumatic/cryo-compression	Perfusion, elasticity, LDH, reactive strength, pressure pain
Kużdżał et al. (a)	2024	Poland	RCT	Dry needling / manual therapy	Manual therapy + dry needling	Pressure-pain threshold, muscle tone, stiffness, ROM
Kużdżał et al. (b)	2024	Poland	Single-blind RCT	Dry needling / manual therapy	Compression contrast vs dry needling	Pressure-pain threshold, muscle tension, perfusion
Trybulski et al.	2024	Poland	Single-blind RCT	Dry needling / manual therapy	Dry needling (trigger points)	Pressure-pain threshold, perfusion, tone, stiffness, power
Wetzel et al.	2002	Germany	RCT (multicentre)	Topical pharmacological	Escin/salicylate/heparin gel	Pressure-induced tenderness (pain)
Fonseca et al.	2016	Brazil	RCT (crossover)	Cryotherapy & compression	Cold-water immersion	Muscle damage (LDH), soreness, muscle power
Kandakurti et al.	2025	United Arab Emirates	Case report	Neurodynamic mobilisation	Neuromeningeal mobilisation + posture	Numeric pain-rating scale, functional score

Thematic Synthesis

Findings for RQ1 - Pain-management interventions used

Across the included evidence, four coherent intervention categories emerged. The largest cluster used dry needling, alone or combined with manual therapy, to target myofascial trigger points and muscle mechanics in combat athletes (Kużdżał et al., 2024a; Kużdżał et al., 2024b; Trybulski et al., 2024). A second cluster used cryotherapy and compression, including cold-water immersion and pneumatic or cryo-compression, to manage exercise-induced muscle damage and soreness (Fonseca et al., 2016; Trybulski et al., 2025). A third category comprised topical pharmacological treatment of acute impact injuries with an escin-based gel (Wetzel et al., 2002), and a fourth applied neurodynamic mobilisation with postural re-education to refractory strain-related pain (Kandakurti et al., 2025). These categories are quantified in Figure 4.

The interventions share a mechanistic logic even as their techniques diverge. Manual and needling approaches act primarily on local muscle tone, stiffness, and perfusion, whereas thermal and compression approaches target the inflammatory and muscle-damage cascade that drives delayed-onset soreness. The escin gel adds a topical anti-oedematous and analgesic mechanism for blunt trauma, and neurodynamic mobilisation addresses neural mechanosensitivity in persistent pain. Importantly, none of the interventions was tested in a *Pencak silat* cohort; the population base is combat sports broadly, with mixed martial arts and grappling disciplines most represented. This distribution answers RQ1 descriptively while simultaneously exposing the review's central gap: the intervention repertoire for combat athletes is diverse and mechanism-driven, but it has not yet been validated in traditional Southeast Asian martial arts.

Findings for RQ2 - Effectiveness relative to comparators
The controlled studies consistently favoured the active pain-management intervention over its comparator. In the needling and manual-therapy trials, the active conditions produced significantly higher pressure-pain thresholds and more favourable muscle-tone and stiffness profiles than sham or control, with effects that persisted at 24–72 h (Kużdżał et al., 2024a; Trybulski et al., 2024). Where two active modalities were compared directly, both conferred benefit but through partially different pathways, with dry needling generating the larger perfusion response (Kużdżał et al., 2024b). Thermal and compression interventions outperformed passive rest on muscle-damage markers, soreness, and the preservation of muscle power (Fonseca et al., 2016; Trybulski et al., 2025), and the topical escin gel was superior to placebo in reducing impact-injury tenderness (Wetzel et al., 2002).

Two nuances temper this consistency. First, effect durability varied: several benefits were acute and measured within minutes to hours, so the persistence of analgesia across a full training microcycle remains uncertain. Second, comparator choice shaped interpretation-superiority over passive rest or sham is a weaker claim than superiority over an established active standard, which no included study tested. The single-case neurodynamic report showed clinically meaningful pain reduction but cannot support inference about comparative effectiveness (Kandakurti et al., 2025). Answering RQ2, the evidence indicates that targeted pain-management interventions are more effective than passive or sham comparators for short-term pain and recovery outcomes in combat athletes, while head-to-head comparisons against active clinical standards remain absent.

Findings for RQ3 - Outcomes most commonly reported
The included studies converged on a recurring outcome set dominated by mechanistic and perceptual pain measures. The pressure-pain threshold was the most frequently reported pain outcome, appearing across the needling and compression trials as an objective index of pain sensitivity (Kużdżał et al., 2024a; Kużdżał et al., 2024b; Trybulski et al., 2024). Muscle-damage biomarkers, principally lactate dehydrogenase, and perceived muscle soreness were the dominant recovery outcomes in the thermal and compression studies (Fonseca et al., 2016; Trybulski et al., 2025). Muscle mechanical properties-tone, stiffness, elasticity-and tissue perfusion were reported wherever myotonometry and Doppler flowmetry were available, and muscle power or reactive strength recurred as a functional-performance outcome.

By contrast, patient-centred and longer-horizon outcomes were sparse. Only the case report used a conventional clinical pain scale and a functional score to track recovery over time (Kandakurti et al., 2025), and the topical-gel trial used pressure-induced tenderness as a direct pain endpoint (Wetzel et al., 2002). Critically, return-to-sport, re-injury, and pain-related psychological outcomes-dimensions known to matter for athletic longevity-were not captured by any included study. Answering RQ3, the most commonly reported outcomes are objective pain thresholds, muscle-damage markers, soreness, muscle mechanics, perfusion, and power; the near-absence of functional return-to-sport and psychological endpoints represents a notable outcome-selection gap.

Comparative and Critical Analysis
Methodologically, the evidence base is stronger than its size suggests: six of seven studies were randomised controlled trials, several with sham or placebo comparators and blinded outcome assessment, which supports internal validity for short-term endpoints. Yet three limitations recur across studies. Sample sizes were generally small-most below fifty participants and one as low as eight-constraining statistical power and precision (Fonseca et al., 2016). Follow-up windows were short, rarely extending beyond 72 hours, so conclusions about sustained pain relief and recovery are provisional. And outcome selection was narrow and biomarker-heavy, privileging laboratory-measurable indices over athlete-reported and return-to-sport outcomes.

The methodological trajectory over time is informative. The earliest included study was a large, well-powered multicentre pharmacological trial (Wetzel et al., 2002), whereas the recent Polish cluster shifted toward mechanistic single-session designs using myotonometry and Doppler perfusion (Trybulski et al., 2024; Trybulski et al., 2025). This evolution reflects growing methodological sophistication in measuring tissue-level responses, but also a concentration of evidence within a small number of research groups and one national context, which limits external validity. In line with MMAT-informed weighting, the case report was retained for its mechanistic and clinical illustration of neurodynamic mobilisation but was not treated as confirmatory (Kandakurti et al., 2025). Taken together, the field would benefit from larger multi-centre trials, longer follow-up, active-comparator designs, and standardised outcome cores.

Interpretation of findings. The synthesis indicates that pain in combat athletes is most reliably reduced by interventions that simultaneously modify local muscle mechanics and tissue perfusion. The recurring pattern-raised pressure-pain thresholds accompanied by increased perfusion and normalised muscle tone-suggests that

analgesia in these athletes is closely coupled to restoration of local haemodynamics and tissue compliance rather than to a single antinociceptive pathway (Kużdżał et al., 2024b; Trybulski et al., 2024). This mechanistic coherence helps explain why techniques as different as dry needling, compression, and cold-water immersion converge on similar pain and recovery benefits, and why joint- and region-specific presentations-such as the shoulder-motion deficits documented in grappling athletes-may require correspondingly targeted approaches (Castropil et al., 2026).

Theoretical implications. The findings both extend and challenge a purely biomedical model of athletic pain. On one hand, they reinforce tissue-level frameworks by demonstrating measurable, modality-driven changes in nociceptive thresholds. On the other, they under-represent the multidimensional nature of pain that qualitative and trait-based research has emphasised, in which coping style, identity, and affect shape the pain experience (Meyers et al., 2015; Purcell et al., 2024). The disconnect observed between physiological recovery and persistent subjective fatigue in combat athletes reinforces this point, indicating that biomarker normalisation does not guarantee perceptual recovery (Ostapiuk-Karolczuk et al., 2025). A comprehensive theory of pain management for these athletes therefore needs to integrate mechanistic and biopsychosocial dimensions rather than privilege one.

Practical implications. For practitioners, the evidence supports a multimodal, mechanism-matched approach: needling and manual therapy for trigger-point-driven pain and stiffness, compression and cold-water immersion for exercise-induced muscle damage and soreness, and topical agents for acute impact injuries. These core modalities can be complemented by adjuncts under active investigation in combat and striking sports, including fascial therapy (Unalmis & Muniroglu, 2023), wet-cupping (Dergaa et al., 2024), low-dose caffeine for soreness and endurance in kickboxers (Saremi et al., 2025), and nutritional strategies for injury prevention and tissue healing (Turnagöl et al., 2021; Finnegan et al., 2025). Because conditioning load is itself a source of pain and fatigue, integrating pain care with programming decisions-resistance prescription (Nakatani et al., 2024), potentiation strategies (Aydın et al., 2026), occlusion training (Pucsok et al., 2023), structured skill programmes (Wąsacz et al., 2026), and posture and recovery management (T. Liu, 2022)-is advisable. Preventive strengthening, such as neck conditioning to reduce injury exposure, is a further practical lever (J. Liu, 2022).

Comparison with prior reviews. Earlier syntheses in this space have been modality- or discipline-specific rather than integrative. A systematic review of massage therapy in taekwondo practitioners reported recovery and well-being benefits but was confined to one modality and one discipline (Mathunjwa et al., 2025), and a regional historical review of judo did not address pain interventions at all (Hlasho et al., 2024). Adjacent mind–body literature indicates that martial-arts-derived practices can benefit spinal health and low back pain in non-combat populations (Lv & Zhang, 2022; Yang et al., 2024; Niño et al., 2022). The present review advances beyond these efforts by consolidating controlled pain-management evidence across combat disciplines within a single PRISMA-based protocol and standardised appraisal, thereby situating disparate modality findings in one critically appraised map.

Contradictions in the literature. The evidence is not uniformly convergent. While cold-water immersion attenuated soreness and muscle damage in jiu-jitsu athletes (Fonseca et al., 2016), practical internal and external cooling did not meaningfully influence rapid recovery after simulated taekwondo performance (Pariyavuth et al., 2023), indicating that thermal-recovery benefits are conditional on protocol, timing, and outcome. Similarly, the dissociation between recovering biochemical markers and persistent subjective fatigue complicates any simple dose–response reading of recovery (Ostapiuk-Karolczuk et al., 2025). These contradictions likely reflect heterogeneity in fatigue models, cooling doses, and measurement windows rather than genuine incompatibility, and they caution against generalising acute laboratory effects to field recovery.

Research gaps. At least three gaps are evident. First, no controlled pain-management trial has recruited *Pencak silat* athletes, despite emerging attention to their rehabilitation readiness and injury mechanisms (Kusuma, 2023; Purnomo et al., 2026); the review's evidence base is therefore combat sports broadly, not the anchoring discipline. Second, functional and return-to-sport outcomes-and the pain-related psychological factors that influence them, such as injury-related fear and long-term readaptation-are largely absent from intervention studies (Ohji et al., 2021; Savenko et al., 2025). Third, mechanistic characterisation of sport-specific fatigue that could tailor interventions remains preliminary and modality-siloed (Wu et al., 2025).

Limitations of this review. Three limitations warrant acknowledgement. The final included set was small (n = 7), reflecting strict eligibility rather than an exhaustive census, so the synthesis maps-controlled evidence rather than the entire literature. The evidence is geographically concentrated-four of seven studies originated from Poland-which limits cross-cultural generalisability. Finally, restricting inclusion to English-language journal articles may have excluded relevant regional evidence, particularly Indonesian-language studies on *Pencak silat*, potentially underestimating locally available knowledge.

Future research agenda. Three concrete directions follow. First, adequately powered, multi-centre randomised trials should test the leading modalities-dry needling, compression, and cold-water immersion-specifically in *Pencak silat* and other traditional martial arts athletes. Second, trials should adopt a standardised outcome core that pairs mechanistic indices with athlete-reported pain, functional performance, and return-to-sport and re-injury endpoints. Third, comparative-effectiveness designs with active clinical comparators and follow-up spanning a full training microcycle are needed to establish which interventions best sustain analgesia and recovery under realistic competitive loads.

In summary, the review answers its research questions as follows. RQ1: combat athletes are managed with four intervention families-dry needling/manual therapy, cryotherapy/compression, topical pharmacological gels, and neurodynamic mobilisation. RQ2: these interventions are consistently more effective than passive or sham comparators for short-term pain and recovery, though active-comparator evidence is lacking. RQ3: reported outcomes are dominated by pressure-pain thresholds, muscle-damage markers, soreness, muscle mechanics, perfusion, and power, with functional and psychological endpoints underreported.

Conclusions

This systematic review consolidated controlled evidence on pain-management and recovery interventions in combat and martial arts athletes, screening 1,444 records and synthesising seven eligible studies. Four intervention families-dry needling and manual therapy, cryotherapy and compression, topical pharmacological gels, and neurodynamic mobilisation-consistently outperformed passive or sham comparators for short-term pain relief and recovery, most often measured through pressure-pain thresholds, muscle-damage markers, and perceived soreness. The core contribution is an integrated, critically appraised map that transcends single-modality reviews, giving practitioners a mechanism-matched, multimodal framework for athlete pain care. Its principal limitation is a small, geographically concentrated evidence base with no Pencak-Silat-specific trial and few functional or return-to-sport outcomes. Adequately powered, culturally targeted trials with standardised outcome cores and longer follow-up are urgently needed to strengthen and localise this evidence.

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