INPLASY

Implementation Effectiveness, Barriers, and Real-World Outcomes of Neuromuscular Training Programs for ACL Injury Prevention in Female Athletes: Systematic Review with Narrative Synthesis Using SWiM Framework

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ADMINISTRATIVE INFORMATION

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Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 14 June 2025 and was last updated on 14 June 2025.

INTRODUCTION

Review question / Objective This systematic review with narrative synthesis aims to comprehensively investigate and synthesize the implementation effectiveness, barriers, facilitators, and real-world outcomes of neuromuscular training (NMT) programs for anterior cruciate ligament (ACL) injury prevention in female athletes using the Synthesis Without Meta-analysis (SWiM) reporting framework and implementation science theoretical models.

Rationale Anterior cruciate ligament (ACL) injuries disproportionately affect female athletes, who experience injury rates 3-6 times higher than their male counterparts (Gompels et al., 2024; Silvers-Granelli, 2021). While neuromuscular training (NMT) programs demonstrate significant efficacy in controlled settings, with meta-analyses showing injury reductions of 43.8%-73.4% (D'Emanuele et al., 2021; Sugimoto et al., 2012), their real-world effectiveness remains suboptimal due to implementation challenges.

A critical gap exists between research efficacy and practice. Frank et al. (2015) demonstrated that high coach intent to integrate ACL prevention programs does not translate to effective implementation, revealing a fundamental disconnect between intention and practice. Compliance represents a major barrier, with real-world adherence rates disappointingly low despite dose-response relationships between compliance and injury reduction (Sugimoto et al., 2012). Hägglund et al. (2013) confirmed that superior compliance was associated with fewer ACL injuries, emphasizing that program effectiveness depends on implementation quality. Numbers-needed-to-treat analyses reveal 108-120 athletes must participate to prevent one ACL injury (Sugimoto et al., 2012), highlighting substantial implementation challenges. Despite decades of efficacy research, ACL injury rates have not decreased proportionally

(Benjaminse & Verhagen, 2021), indicating implementation barriers limit public health impact.

Condition being studied This review examines the implementation of neuromuscular training programs designed to prevent ACL injuries in female athletes. ACL injuries disproportionately affect female athletes, occurring 3-6 times more frequently than in male athletes, particularly in sports involving cutting, pivoting, and jumping movements such as soccer, basketball, handball, and volleyball. The focus is on implementation processes, barriers, facilitators, and real-world outcomes rather than intervention efficacy alone.

METHODS

Search strategy We will search four major electronic databases: PubMed, SPORTDiscus, Scopus, and Web of Science. The search strategy will be adapted for each database while maintaining consistency in key terms and concepts.

Participant or population Studies involving female athletes of any age participating in organized sports will be included. This includes: Youth athletes (under 14 years); Adolescent athletes (14-18 years); Young adult athletes (18-25 years) and Adult athletes (over 25 years) Studies involving coaches, trainers, or other program implementers as participants will also be included when they report implementation outcomes related to neuromuscular training programs for female athletes. Exclusion criteria for participants: Studies focusing solely on male athletes; Mixed-gender populations without separate female data; Injured athletes or post-surgical populations as primary participants; Non-athletic populations.

Intervention Neuromuscular training programs designed for ACL injury prevention, including but not limited to: Structured warm-up programs (e.g., FIFA 11+, FIFA 11+ Kids); Comprehensive injury prevention programs (e.g., PEP Program, KLIP Program); Sport-specific prevention programs (e.g., Sportsmetrics); Balance and proprioceptive training programs; Plyometric and strength training programs; and Multi-component neuromuscular training interventions
Program inclusion criteria: Programs must include at least two of the following components: Balance/proprioceptive exercises; Plyometric exercises; Strength training exercises; Agility training; and Sport-specific movement training
Implementation strategy focus: This review will particularly examine different implementation strategies including: Educational workshops and training sessions; Ongoing coaching and support; Technology-assisted delivery; Multi-component implementation approaches; and Organizational policy integration.

Comparator The comparators will include: Standard/usual training practices; Control groups receiving no intervention; Alternative training programs; Waitlist control groups; Different implementation strategies for the same intervention (particularly relevant for implementation research).

Study designs to be included Randomized controlled trials (RCTs); Controlled clinical trials (CCTs); Crossover trials; Controlled before-after studies.

Eligibility criteria
Inclusion Criteria:
Study design: RCTs, controlled clinical trials, crossover studies, or controlled before-after studies
Population: Female athletes of any age in organized sports
Intervention: Neuromuscular training programs designed for ACL injury prevention
Comparator: Any appropriate control condition or alternative implementation strategy
Outcomes: Must report quantifiable implementation outcomes (compliance, adherence, adoption rates) OR qualitative implementation process data (barriers, facilitators, implementation strategies)
Language: English language publications
Publication period: January 1, 2014, to April 30, 2025
Publication status: Peer-reviewed journal articles
Implementation Focus Criteria: Studies must report on at least one of the following:
Process outcomes: Compliance rates, adherence measures, fidelity assessments
Implementation strategies: Description of delivery methods, training approaches, support mechanisms
Contextual factors: Barriers and facilitators to implementation
Sustainability measures: Long-term adoption, maintenance, or continued use
Real-world effectiveness: Outcomes measured in naturalistic implementation settings
Exclusion Criteria:
Studies focusing solely on male athletes or mixed populations without separate female data
Studies involving only injured athletes or post-surgical rehabilitation as primary focus
Studies not reporting implementation-related outcomes or processes

Non-controlled study designs (observational studies, case series, case reports) unless specifically designed for implementation research
Conference abstracts, editorials, commentaries, or reviews
Non-English publications
Studies published before 2014
Laboratory-based studies without real-world implementation context
Studies where implementation data cannot be separated from efficacy results.

Information sources PubMed; SPORTDiscus (via EBSCOhost); Scopus; Web of Science.

Main outcome(s) Primary Implementation Outcomes:
1.Compliance/Adherence Rates
Definition: Proportion of prescribed sessions completed AND quality of exercise execution within sessions
Measurement: Percentage with clear operational definitions for each study context
Analysis: Descriptive statistics with subgroup analysis by implementation strategy
2.Implementation Barriers
Definition: Factors that impede successful program implementation, organized by CFIR domains
Measurement: Frequency and types of barriers reported
Analysis: Thematic analysis with frequency counts where available, organized using Consolidated Framework for Implementation Research (CFIR)
3.Implementation Facilitators
Definition: Factors that promote successful program implementation, organized by CFIR domains
Measurement: Frequency and types of facilitators reported
Analysis: Thematic analysis with identification of key success factors
4.Real-World Effectiveness
Definition: Program outcomes achieved in naturalistic implementation settings compared to controlled trial results
Measurement: ACL injury rates or risk reduction in real-world settings compared to controlled trial settings
Analysis: Narrative comparison with context consideration
1.19.2.Implementation Success Metrics:
Program adoption rates
Sustainability measures (maintenance over time)
Coach/implementer satisfaction scores
Long-term program maintenance rates
Implementation strategy effectiveness.

Quality assessment / Risk of bias analysis Implementation-Appropriate Quality Assessment:
For Implementation-Focused Studies:
1.Primary Tool: Mixed Methods Appraisal Tool (MMAT) for diverse study designs appropriate to implementation research
2.Secondary Considerations: Implementation research quality criteria including clear description of implementation 3.strategy, appropriate measurement of implementation outcomes, adequate sample size for implementation questions.

Strategy of data synthesis Primary Synthesis Approach: SWiM Framework Implementation
This systematic review will employ narrative synthesis following the Synthesis Without Meta-analysis (SWiM) reporting guideline, integrated with implementation science theoretical frameworks.

Subgroup analysis Not applicable in a narrative synthesis.

Sensitivity analysis Not applicable in a narrative synthesis.

Language restriction Only studies published in English will be included in this review.

Country(ies) involved China.

Other relevant information Theoretical Framework: This review is grounded in two complementary implementation science frameworks: Consolidated Framework for Implementation Research (CFIR): Used to systematically categorize and analyze barriers and facilitators across five domains: Intervention characteristics; Outer setting factors; Inner setting factors; Individual characteristics; Implementation process factors
RE-AIM Framework: Applied to structure synthesis of implementation outcomes: Reach: Population coverage and representativeness; Effectiveness: Real-world vs. controlled trial outcomes; Adoption: Uptake by organizations, teams, and individuals; Implementation: Program fidelity, adherence, and adaptation; Maintenance: Sustainability and long-term continuation

Keywords Anterior cruciate ligament; ACL injury prevention; neuromuscular training; implementation science; compliance; barriers; facilitators; female athletes; systematic review; narrative synthesis; real-world.

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