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EDITORIAL

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The implementation gap in anterior cruciate ligament prevention programs—From evidence to everyday practice

Abstract

Anterior cruciate ligament (ACL) injury remains one of the most impactful injuries in pivoting sports, with non-contact mechanisms accounting for the majority of cases and offering a clear target for prevention. Robust evidence—including multiple Level 1 meta-analyses—demonstrates that structured neuromuscular training (NMT) programs can reduce ACL injury rates by approximately 50%, particularly among youth and female athletes. Effective programs are multi-component, integrate strength, plyometrics, agility, balance and movement-quality feedback, and require adequate training dose and in-season continuity. Despite this well-established evidence base, real-world implementation remains limited. Coaches and sports organisations frequently report barriers such as time constraints, competing performance priorities and low confidence in delivering prevention exercises. This disconnect reflects a broader implementation gap: while we know what works, we are not consistently doing it. Insights from implementation science, including JBI's phased models, facilitation strategies and context-driven frameworks, provide a roadmap for translating evidence into sustained practice. Reframing prevention as performance-enhancing movement training and embedding programs such as the ESSKA 'Prevention for All' initiative into coaching pathways and club standards are essential system-level strategies. The priority is no longer proving efficacy, but achieving widespread, high-fidelity implementation so that ACL prevention becomes a routine component of athlete preparation.

KEYWORDS

ESMA, football, physical therapy, physiotherapy, practice, sports

For a quarter of a century anterior cruciate ligament (ACL) injury remains one of the most serious and costly injuries in pivoting sports. The burden is not only acute and requires mostly surgical reconstruction but results in long-term pain, instability, early osteoarthritis and an increased risk of subsequent knee surgery [6, 9, 22]. Epidemiological work across team ball sports has confirmed that non-contact and indirect-contact mechanisms account for the majority of ACL ruptures, often around two-thirds to three-quarters of all cases, particularly in female athletes. These injuries usually occur during rapid decelerations, cutting manoeuvres or single-leg landings, where unfavourable biomechanics—such as dynamic knee valgus, limited knee flexion, internal tibial rotation and trunk lateral flexion—expose the ACL to high loads [7].

This predominance of non-contact mechanisms is precisely what makes ACL injury such an attractive and important target for prevention. Non-contact ACL ruptures are strongly linked to modifiable risk factors: neuromuscular control deficits, strength imbalances (especially relatively weak hamstrings and hip abductors), poor movement technique and fatigue. Over the last two decades, a large body evidence, including Level 1 meta-analyses has shown that structured neuromuscular training (NMT) programs can reduce ACL injury rates by roughly half, particularly in youth and young female athletes participating in high-risk sports [5, 23, 24]. The approach is continuously taken up, like in the rather new ESSKA-ACL Prevention for all program, which is now being implemented across Europe [15].

Yet, despite this compelling evidence, implementation in everyday sport practice is still limited and inconsistent. The science of what works is well established; the science of how to embed what works into real-world systems is still catching up.

Abbreviations: AASPT, American Academy of Sports Physical Therapy; ACL, anterior cruciate ligament; AOSSM, American Orthopaedic Society for Sports Medicine; CI, confidence interval; ESMA, European Sports Medicine Associates; ESSKA, European Society of Sports Traumatology, Knee Surgery and Arthroscopy; EU, European Union; FIFA, Fédération Internationale de Football Association; IRR, injury rate ratio; JBI, Joanna Briggs Institute (formerly, now just JBI); KSSTA, knee surgery, sports traumatology, arthroscopy; NMT, neuromuscular training; OA, osteoarthritis; RR, risk ratio; US, United States.

NON-CONTACT ACL INJURIES AS THE KEY PREVENTION TARGET

It is broadly accepted, that lower extremity injury risk reduction programmes focusing on neuromuscular control exercises can be used to prevent overall lower extremity injury [16]. Landmark work by Griffin and colleagues already highlighted at the turn of the century that approximately 70% of ACL injuries occur in non-contact situations and laid out risk factors at the environmental, anatomical, hormonal and biomechanical levels [7]. More recent high-quality epidemiological data in team ball sports confirm this picture. It was reported that non-contact ACL injuries represent more than half of all ACL ruptures, with higher incidences in female athletes and during match play compared to training [3]. Högberg et al. similarly found that the most common ACL injury mechanism across a wide range of sports is non-contact, with indirect contact also contributing substantially in some collision sports [8].

Taken together, these data mean that a large proportion of ACL injuries arise from mechanisms that are biomechanically and neuromuscularly modifiable. This is reflected in further meta-analyses of prevention programs: Yoo et al. showed that pre- and in-season neuromuscular training with an emphasis on plyometrics and strengthening significantly reduced ACL injuries in female athletes, with the largest effects in those under 18 years [24]. A clear dose–response relationship was demonstrated, with higher neuromuscular training volumes associated with greater reductions in ACL risk [20]. More recently, it was reported that injury-prevention programs including plyometric components reduced ACL injury rates by about 60% (injury rate ratio 0.40; 95% confidence interval [CI]: 0.26–0.63) [1]. Evidence-based best-practice guidelines from a systematic review and meta-analysis in young female athletes, again concluding that neuromuscular programs can cut ACL injuries roughly in half when implemented with sufficient frequency and quality [12]. The number needed to treat in preventing one ACL rupture is 71 athletes [4].

In other words, if neuromuscular prevention programs were widely adopted and properly executed, many non-contact ACL injuries could realistically be avoided.

WHAT MAKES A GOOD ACL PREVENTION PROGRAM?

The content and structure of an effective ACL prevention program are now reasonably well defined. Across trials and meta-analyses, programs with the greatest protective effect share several core components [24].

First, they are multicomponent. Rather than focusing solely on balance or stretching, effective programs combine lower-limb and trunk strengthening, plyometric training with explicit technique emphasis, agility/change-of-direction drills, balance/proprioceptive training and targeted mobility with regard on situations where restrictions impair safe motion. Strength work often targets the posterior chain (hamstrings, gluteals) and hip abductors/external rotators, supporting better knee control in frontal and transverse planes and avoiding dynamic dnee valgus [17]. Plyometric drills and landing exercises are used to reshape high-risk patterns—reducing stiff, extended, valgus landings and encouraging deeper hip and knee flexion, trunk control and symmetrical loading. Balance and proprioceptive tasks fine-tune neuromuscular responses, while agility drills contextualise these mechanics under sport-specific conditions.

Second, dosage and timing matter. Starting in the pre-season and continuing at least two to three sessions per week during the season is associated with the largest risk reductions, whereas brief or pre-season-only interventions are less protective [24].

Third, feedback on movement quality is crucial. It was emphasised that programs which provide consistent feedback on technique—verbal, visual or video-based—are more effective [12]. Athletes need to know not only *what* to do, but *how* to do it safely.

Fourth, integration into existing routines is a major facilitator. Many of the most successful programs, such as the FIFA 11+, were packaged as warm-ups of approximately 15–20 min. In collegiate male soccer it was shown that the FIFA 11+ reduced overall injury rates by roughly 46% and significantly decreased ACL injuries when teams adhered to the prescribed warm-up [19].

From a content perspective, we therefore know quite precisely what a ‘good’ prevention program looks like. The challenge lies less in designing the program and more in achieving consistent, high-fidelity implementation at scale [15].

THE IMPLEMENTATION GAP: WHERE EVIDENCE GETS LOST

There is a lack of awareness regarding injury prevention concepts among sports medicine professionals [21]. Despite robust evidence, many youth and community teams do not implement these programs regularly. Implementation research in sport has shown that coaches frequently cite perceived lack of time, competing priorities, doubts about performance relevance and limited confidence in delivering neuromuscular exercises as reasons for poor uptake. Therefore, broad implementation of prevention programs (ensuring student-athletes receive proper training), high-quality education (increasing awareness across all relevant stakeholders), equitable access (making sure every high school athlete—regardless of school resources—can benefit from injury-prevention measures), and strong stakeholder alignment (bringing together schools, sports clubs, parents,

coaches, and other groups toward a common goal) is crucial to facilitate the general implementation [18].

Still, in practice, adherence often drops sharply after the first weeks of the season.

This pattern is highly familiar from other clinical and public-health domains and fits squarely into what JBI and others describe as the implementation gap: the distance between what we know and what we do. JBI has contributed significantly to conceptualising and addressing this gap. A 7-phase process model for JBI's approach to evidence implementation, emphasising context assessment, audit and feedback, facilitation and iterative evaluation was developed [13]. This was complemented by a paper that provides a scaffold for selecting and applying theoretical frameworks in evidence-implementation projects as exemplified for ACL prevention in Figure 1, highlighting that different contexts may require different combinations of theories and strategies [11].

Lizarondo and colleagues subsequently synthesised facilitators' experiences in a qualitative systematic review, showing that facilitation is complex, relational and resource-intensive. Effective facilitators need protected time, skills in communication and relationship-building, and strong organisational support to optimise implementation outcomes [10]. Allu and colleagues sufficiently illustrated how collaborative implementation science can bring diverse stakeholders together, create practical implementation tools and support sustained practice change [2].

These insights are directly relevant for ACL prevention. Simply publishing an exercise protocol or running a one-off workshop is unlikely to achieve lasting change. Instead, sports organisations should approach ACL prevention as a structured evidence-implementation project: assessing local context and barriers; engaging coaches, physiotherapists, athletes and club leaders; appointing and training facilitators or 'prevention champions'; and establishing audit, feedback and monitoring systems.

FROM PREVENTION TO PERFORMANCE: CHANGING THE NARRATIVE

One of the most potent levers in practice is how prevention is framed. If neuromuscular programs are presented as 'extra' injury drills competing with 'real' training, they will lose out whenever time or attention is tight. However, the same program can be framed as performance-oriented movement training: enhancing jump-landing quality, agility, stability, fatigue resistance and long-term availability for selection.

This reframing aligns properly with the JBI emphasis on context and stakeholder engagement. Athletes and coaches care deeply about performance and player availability. When they see that neuromuscular training improves both, prevention becomes more relevant to reach their primary goals rather than a competing agenda. The 'Prevention for All' ACL initiative from ESSKA explicitly adopts this approach, presenting neuromuscular training as simple, accessible and performance-supporting for all levels, from schools to elite sport [15].

SYSTEM-LEVEL STRATEGIES: LEARNING FROM EVIDENCE IMPLEMENTATION

The 2025 Editorial 'Prevention of ACL injury is better than repair or reconstruction—Implementing the ESSKA-ESMA 'Prevention for All' ACL programme', is a clear call

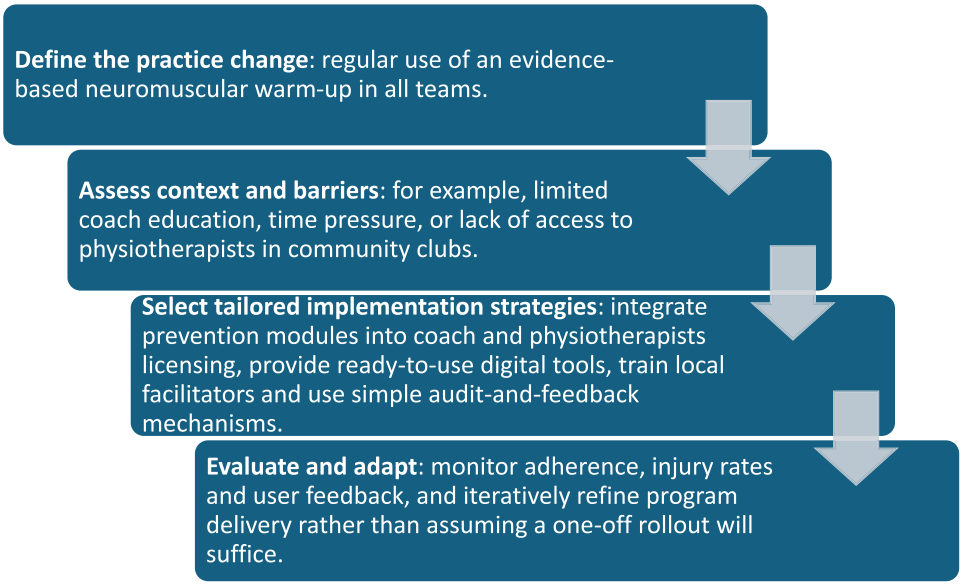

FIGURE 1 Anterior cruciate ligament (ACL) prevention: an approach of getting research into practice.

to move from rhetoric to system-level action. It highlights the need for national and international bodies to embed ACL prevention into coaching curricula, club standards and youth development pathways, and not to leave implementation to isolated enthusiasts.

Collaborative implementation science also reminds us of the value of multi-stakeholder and team-based partnerships [14] clinicians, researchers, coaches, athletes and administrators working together rather than in silos.

CONCLUSION FROM KNOWING TO DOING

The key facts are no longer in doubt. Non-contact mechanisms account for most ACL injuries in pivoting sports. Well-designed neuromuscular training programs, delivered with adequate dose and quality, can reduce those injuries by about half. The components of an effective program are well described, and widely available in open resources and guidelines. The real challenge is implementation: getting these programs off the page and into the warm-up of every high-risk team, season after season.

Here, sports medicine can and should draw on the broader evidence-implementation literature, from phased process models and theoretical scaffolds to detailed insights into facilitation and collaborative implementation. A KSSTA Editorial on ACL prevention is squarely within this implementation agenda, calling for the 'ESSKA-prevention for all' program to be adopted at scale.

For clinicians, researchers and sports organisations, the message is clear: we no longer need to prove that many ACL injuries can be prevented. Our task now is to use the available implementation science to organise prevention—to align systems, incentives and daily routines so that effective neuromuscular training becomes an unquestioned part of how we prepare athletes to perform.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

ETHICS STATEMENT

The authors have nothing to report.

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