Effectiveness of Dynamic Warm-up Protocols in Preventing Lower limb Injuries among Football Players: A Systematic Review

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ABSTRACT

Background: Dynamic warm-ups (DWs) are widely adopted in football as preparatory strategies to boost performance and reduce the chances of injury. However, systematic evidence consolidates their specific effectiveness on lower limb injury prevention.

Objectives: This systematic review aimed to evaluate and synthesis evidence on the effectiveness of dynamic warm-up protocols -incorporating neuromuscular activation, plyometrics, balance training, and sport-specific movement-in reducing lower limb injury incidence(hamstring strains, ankle sprains, and ACL tears) among football players, compared with static stretching and the FIFA 11+ programme, and to identify key protocol design features associated with optimal injury prevention outcomes.

Methodology: Using keywords including "dynamic warm-up," "football injury prevention", "hamstring injury", "ankle sprain" and "ACL injury", a literature search was conducted across the PubMed, Google Scholar, SPORTDiscus, web of science and Cochrane library databases. Studies published between January 2002 and December 2024 were considered, based on predetermined inclusion criteria. A total of 1348 records were identified through database searching and 47 through manual searching . Following title/abstract screening (n= 1011) and full-text evaluation (n= 133),23 studies satisfied all inclusion requirements and were included in the synthesis.

Result : studies systematically show that DW programs that include plyometrics, neuromuscular activation, agility and balance training dramatically reduce lower limb injuries. Up to 50% less ankle sprains occurred as a result of neuromuscular training. FIFA 11 + reduced total injuries and enhanced agility and sprinting through changed DW routines. Elite hamstring injuries increased by 2.3% annually, according to a 13-year study, suggesting that preventive initiative need to be updated on a regular basis.

Conclusion : Football players can reduce lower limb injures by doing dynamic warm-ups, which are supported by study findings. For all levels of play, a well-organized, sport-specific DW program should be carried out fifteen minutes before training or competition.

Keywords: Dynamic Warm-up, Football injury prevention, Hamstring injury, Ankle sprain, Neuromuscular training, Lower limb

INTRODUCTION

Football (soccer) is the most widely played sport globally, with approximately 300 million active participants across all competitive levels. Players are particularly vulnerable to Musculo-skeletal injuries because to the physiological demands of the sport, which include frequent sprinting, quick direction changes, physical contact, and eccentric loading. Football (soccer) is the most widely played sport globally, with approximately 300 million active participants across all competitive levels (Longo et al., 2012). Its physiological demands — characterised by repeated sprinting, rapid directional changes, physical contact, and eccentric loading —

impose substantial biomechanical stress on the lower limbs, making players highly susceptible to musculoskeletal injury (Kirkendall & Garrett, 2002).

Football-related lower limb injuries are a major clinical and performance burden. Nearly one-third of football injuries are caused by muscle injuries, with hamstring strains accounting for nearly 25% of all injury-related absences (Larinier et al., 2024).This load is exacerbated by ankle sprains and anterior cruciate ligament (ACL)

ruptures, which impact athletes of all genders, ages, and competitive levels. (Andersen et al., 2004).

Over the past 20 years, Pré-match and pre-training preparation regimens have changed significantly. Dynamic warm-up (DW) exercise have gradually replaced static stretching, which was originally the norm, due to research indicating that extended static stretching may temporarily decrease neuromuscular function and power production (Behm & Chaouachi, 2011).Football players now prefer DW programs, which include movement-based, sport-specific activities including high knees, lateral shuffles, Butt kicks, plyometric drills, and neuromuscular activation tasks (Daneshjoo et al., 2013); (Li et al., 2023).

FIFA 11+ and other structured injury prevention programmes have been widely used at different competitive levels; nevertheless, there is still conflicting information regarding the effectiveness of generic programmes vs tailored, sport specific DW regimens. Additionally, although if DW activities are becoming more widely used there is still a lack of synthesised information especially addressing their injury-preventive effects on lower limb pathologies in football when compared methodically with FIFA 11+ and static stretching.

In comparison to static stretching and the FIFA 11+ program, the main goal of this systematic review is to assess and synthesise the evidence regarding the efficacy of dynamic warm-up protocols-which incorporate neuromuscular activation, plyometrics, balance training , and sport-specific movement-in lower limb injury incidence (hamstring strains, ankle sprains, and ACL tears)among football players .Additionally, the study aims to identify key protocol design features associated with optimal injury prevention outcomes.

METHODOLOGY

Study Design

The preferred reporting items for systematic reviews and Meta-analyses (PRISMA) standards were followed in the design of this study, which is a systematic review technique was created in advance and adhered to a methodical search, screening ,and data extraction procedure.

Search Strategy

The following Boolean keyword combinations were used to conduct an electronic search across PubMed/MEDLINE, Google Scholar, SPORTDiscus , Web of Science, and Cochrane Library databases.

- "Dynamic warm-up AND Football Injury prevention"
- "Warm-up AND hamstring injury AND soccer"
- "Neuromuscular training AND ACL AND ankle sprain AND football"
- "FIFA 11+ AND injury prevention AND dynamic warm-up"
- "Static stretching versus dynamic warm-up AND lower limb injury"

The five keyword combinations listed above were applied uniformly across all database, with syntax adapted to each platforms search conventions (eg; field tags and Boolean operators specific to each interface).Database-specific controlled vocabulary (eg; MeSH indexing) was not systematically applied, which is noted as a limitation of the search strategy.

The final search across all databases was conducted on (6/7/2026).Duplicate records were identified and removed using Zotero, with automated deduplication followed by manual verification. only studies published in English between January 2002 and December 2024 were considered eligible .Reference lists of included articles were also hand-searched for additional relevant sources.

Eligibility Criteria

The following inclusion and exclusion criteria were applied during the screening process.

Inclusion Criteria	Exclusion Criteria
Peer-reviewed articles (2002-2024)	Non-peer-reviewed sources, theses, books
Studies involving football/soccer players	Studies on non-football sports only
Dynamic warm-up as primary intervention	Studies examining only static stretching
Lower limb injury outcomes reported	Studies without injury outcome data
Published in English	Non-English Publications without translation
Human Participants (any age/sex)	Animal studies or Cadaveric research

Study Selection and Data Extraction

All retrieved titles and abstracts were independently screened by two reviewers (P.P and A.U) to determine eligibility based on the inclusion and exclusion criteria. Full texts of potentially eligible studies were then retrieved and independently assessed by the reviewers; disagreements at both stages were resolved through discussion and consensus , with a third reviewer(N.Y) consulted where agreement could not be reached. Reasons for full-text exclusion were recorded and categorised systematically at the point of screening.The study design, participant characteristics, warm-up intervention parameters (type, duration, components), comparator condition (static stretching, FIFA11+, or no warm-up),injury outcomes, and primary findings were all retrieved from each included study.

Quality Assessment

Risk of bias in included studies was assessed independently by two reviewers according to study design. The Cochrane Risk-of-Bias tool (RoB 2) was used for randomised controlled trails, the risk of Bias in Non-randomized studies of Interventions (ROBINSI)tool for cohort/longitudinal studies , and the AMSTAR 2 checklist for included systematic reviews and meta-analyses. Disagreements in risk-of-bias ratings were resolved by consensus discussion.

RESULT

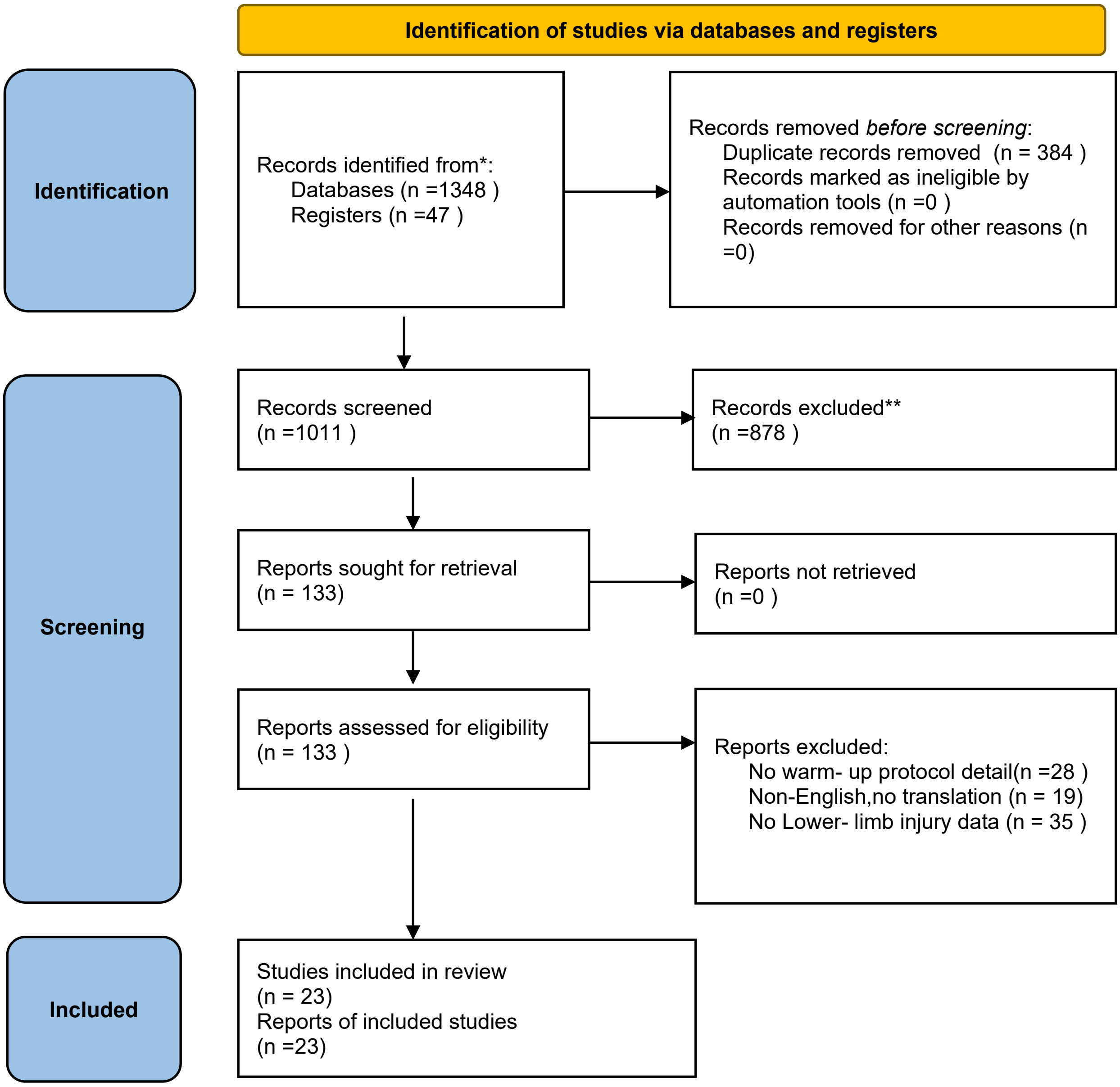
Study Selection

A total of 1348 records were identified through database searching across five databases (PubMed , Google Scholar, SPORTDiscus, Web of Science, and Cochrane Library),with an additional 47 records identified through hand-searching of reference lists. After removal 384 duplicates,1011 distinct records were screened at the title and abstract level. Of these,878 were excluded (non-football/soccer topic, n = 312; no injury outcome data, n = 240;static stretching only, n =187;conference abstracts only, n =139.The remaining 133 full-text articles were assessed for eligibility, of which 110 were excluded (no dynamic warm-up protocol detail, n=28;non-english with no translation available, n = 19;no lower limb injury outcome data, n = 35; duplicate data or same cohort, n = 16; review without primary data , n= 12).A total of 23 studies met the inclusion criteria and were included in the qualitative synthesis. Figure 1 presents the PRISMA flow diagram detailing the study selection process.

Characteristics of Included Studies

The 23 selected studies comprised nine systematic reviews or meta-analyses, six cohort/longitudinal studies, and eight randomised controlled trails. Young football players (U12) and professional elite male and female athletes form several nations were among the study populations. The number of participants in the sample varied from 24 to over 1400.Figure 1 displays the PRISMA flow diagram that shows the study selection procedure.

Figure 1



Effectiveness of Dynamic Warm-Ups on Overall Injury Prevention

DW programs consistently outperformed static stretching and no-warm-up conditions in lower limb injury incidence across all included studies. DW activate the neuromuscular system, raise core temperature, improve joint range of motion, and prime motor recruitment patterns unique to football movements , whereas static stretching may temporarily decrease neuromuscular force production and reflex response times (Woods et al., 2007).when compared to a traditional warm-up control, (Emery & Meeuwisse, 2010) found that a structured neuromuscular DW program (cluster-RCT, n =677) reduced total injury incidence in youth football players by 32%.

In terms of FIFA 11+ comparisons, (Asgari et al., 2022)discovered that a modified DW program performed better that the FIFA 11+ protocol in terms of improving performance and reducing injuries, especially in sprint speed and agility tests. additionally, compared to the regular FIFA 11+ structure (Chiu et al., 2022) found increased cardiorespiratory activity with modified DW procedures. together, our results imply that, although FIFA 11+ offers a verified, scalable framework , especially for settings with fewer resources ,modified , sport-specific DW methods might produce better results in professional and semi-professional contexts.

According to (Weerapong et al., 2004) athletes who used DWS had less muscular sprain, strain, and overuse injuries than those who just used static stretching or no warm-up regimen. The multifaceted advantage of DW procedures is further supported by the Psychological component, which includes enhanced ready perception and decreased felt exertion during activity.

Hamstring Injuries

In professional male football, hamstring injuries are the most common type of muscle injury, making up more than one-third of all injuries and more than 25% of all missed days (Ekstrand et al., 2011).The prevalence of hamstring injuries increased by 2.3 % annually between 2001 and 2014,with an average of 19.7 absence days per 1000 football hours, according to a 13-year longitudinal analysis of the UEFA Elite club injury study (Ekstrand et al., 2016). About 90% of football-related muscle injuries occur in the lower limbs, with the hamstring being the most often injured tissue.

Studies using functional magnetic resonance imaging (fMRI) have shown that deficiencies in eccentric muscle endurance, altered activity distribution, and synergistic neuromuscular coordination between the semitendinosus and biceps femoris are important risk factors for hamstring injuries (Schuermans et al., 2016).The greatest intrinsic risk factor for recurrence was found to be a history of prior hamstring injuries (Engebretsen et al., 2010).In the included research, DW regimens that incorporated progressive loading, neuromuscular engagement , and eccentric strengthening (such as the Nordic hamstring exercise) demonstrated considerable potential in reducing these risk factors ; static stretching comparators did not match these effects.

Ankle Sprains

Although ACL ruptures make up about 5% of football-related time-loss injuries, their individual effects are disproportionately served because of the lengthy recovery times (6-9 months on average) and high risk of re-injury (Faude et al., 2005).According to (Waldén et al., 2011) female football players are two to three times more likely that their male counterparts to sustain an ACL injury, and the injury usually starts four to eight years sooner. ACL injuries are known to be preceded by biomechanical risk factors such as dynamic knee valgus, inadequate neuromuscular control during landing, and imbalances in quadriceps-to-hamstring strength.

Multiple ACL injury risk factors are simultaneously addressed by DW regimens that include progressive plyometrics, single-leg landing mechanics training, and valgus control exercises (Doherty et al., 2017). when compared to static stretching settings, neuromuscular training in a structured DW scenario showed quantifiable gains in knee joint stability, landing mechanics, and hamstring-to quadriceps strength ratios- all characteristics linked to a lower risk of ACL injury (Aguilar et al., 2012).Comparison to hamstring and ankle outcomes, the evidence basis for ACL-specific DW outcomes is considerably weaker. This is due to both the lower base incidence of ACL damage and the limits the literature that is currently accessible.

DISCUSSION

Dynamic warm-up protocols that incorporate neuromuscular activation, plyometrics, balance training, and sport-specific movement are a clinically meaningful, economical , and evidence-based approach for lower limb injury prevention in football , according to this systematic review that syntheses data from 23 studies over a 20-year period. The overall quality of inference is strengthened by the convergence of results from cohort studies, RCTs , and systematic reviews.

The constant superiority DW treatments over static stretching as pre-performance preparation is a key finding. This benefit is based on well-established mechanisms : DWs prime sport

specific motor recruitment patterns , increase core temperature, improve joint range of motion, and activate neuromuscular system (Li et al., 2023); (Woods et al., 2007).static stretching, on the other hand, Amy momentarily reduce neuromuscular reaction times and maximal force output, which is especially detrimental in a sport requiring explosive, high-velocity lower limb activities.

It is especially informative to compare the FIFA 11+ program with modified DW procedures. Evidence from this review indicates that modified, position-specific DW programs may produce better results for sprint performance, agility, and kicking mechanics in higher-performance environments, even though FIFA 11+ offers a standardised, evidence-backed framework that has clearly decreased injury rates in community and semi-elite settings (Reisman et al., 2005) ;Pagaduan et al., 2012).This does not lessen FIFA 11+'s usefulness as a scalable resource for public health; rather, it implies that professional settings with access scientific support can profit from customised DW Programming.

Current DW protocols may not fully addressed all biomechanical and neuromuscular risk factors, as evidenced by the ongoing increase in hamstring injury rates among elite athletes despite the widespread adoption of injury prevention programs (Ekstrand et al., 2016;Hübscher et al., 2010). Individualised strategies using position-specific loading procedures and fMRI-guided muscle profiling (Schuermans et al., 2016) may be beneficial for future programs. The Nordic hamstring exercise has demonstrated promise when incorporated into DW regimens , especially as a progressive eccentric loading stimulus. This calls for more research using randomised designs.

It is necessary to note a few limitations of this review . Formal meta-analysis was not feasible due to differences in study designs, participant ages, competitive levels, DW protocol compositions, and injury categorisation system. Additionally, database-specific controlled vocabulary was not systematically applied during the search, which may have limited retrieval sensitivity in some databases relative to others. Despite evidence suggesting female football players have a disproportionately higher risk of ACL injuries, the included literature's prevalence of male participant samples limits the generalisability of findings to female football players (Waldén et al., 2011).high-quality RCTs in female football cohorts , long-term studies of the dose-response associations between DW frequency and injury outcomes ,and head-to head trials contrasting FIFA 11+ with modified DW protocols across standardised in jury criteria should be the top priorities for future research.

CONCLUSION

This systematic analysis offers substantial evidence that active warm-up regimens can minimise the frequency of lower limb injuries in football players of all ages and skill levels. DWs address the main biomechanical risk factors for hamstring strains, ankle sprains, and ACL injuries by enhancing neuromuscular activation, joint mobility, proprioceptive feedback, and muscle flexibility. Before every training session and competitive match, a 15- to 20minute sport-specific DW program that includes increasing cardiovascular activation, neuromuscular difficulties, plyometric elements, and balance training is advised. The athlete's position ,age, sex, and history of injuries should all be taken into consideration when designing the protocol. Sports scientists, physiotherapists, and coaches must work together continuously to guarantee that DW procedures are routinely implemented , gradually modified, and included into long-term athlete development frameworks.

The adoption of evidence-based DW programs must be viewed as a professional and ethical need at all levels of the game , given the ongoing incidence of lower limb injuries in football and the associated human, financial , and competitive implications.

Conflict of Interest : The authors declare no conflict of interest

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Ethical : Not applicable. This study is a systematic review of previously published literature and did not involve human participants directly.

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