

Prevención de lesiones deportivas basada en evidencia en la población general: programas eficaces, estrategias de implementación y políticas de salud pública

Evidence-Based Sports Injury Prevention in the General Population: Effective Programs, Implementation Strategies, and Public Health Policies

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RESUMEN

Las lesiones relacionadas con el deporte y el ejercicio representan un desafío relevante para la salud pública debido a que pueden disminuir la participación en actividad física, afectar la capacidad funcional e incrementar la utilización de servicios de salud. El presente estudio analizó la efectividad de los programas de prevención de lesiones deportivas sustentados en evidencia y su posible integración en políticas de promoción de la salud dirigidas a la población general. Se realizó una revisión estructurada de la literatura basada en el Método Científico, incluyendo revisiones sistemáticas, metaanálisis, ensayos clínicos aleatorizados, declaraciones de consenso y guías internacionales. El análisis se centró en entrenamiento de fuerza, ejercicios neuromusculares, equilibrio y propiocepción, programas estructurados de calentamiento, manejo de cargas, adherencia, implementación y estrategias a nivel de políticas públicas. La evidencia revisada mostró reducciones consistentes en la incidencia de lesiones mediante intervenciones estructuradas basadas en ejercicio, con resultados especialmente favorables para el entrenamiento de fuerza, la propiocepción, los programas neuromusculares y los calentamientos preventivos. Una mayor adherencia se asoció con una mayor efectividad preventiva, lo que destaca la importancia de una implementación constante. La mayor parte de la evidencia disponible se concentró en intervenciones a nivel individual, mientras que las estrategias comunitarias, organizacionales y de políticas públicas estuvieron menos representadas. Los hallazgos respaldan un enfoque multicomponente y multinivel en el que la preparación física se combine con educación, progresión adecuada de las cargas, apoyo organizacional, entornos seguros y estrategias de salud pública. La integración de estas medidas en escuelas, centros deportivos, programas recreativos, servicios de salud y espacios comunitarios puede contribuir a reducir lesiones prevenibles sin limitar la participación en actividad física. Por lo tanto, la prevención de lesiones deportivas debe incorporarse a políticas más amplias de promoción de la salud orientadas a generar oportunidades seguras, sostenibles y equitativas para mantener una vida activa.

PALABRAS CLAVE

lesiones deportivas, prevención de lesiones, actividad física, entrenamiento neuromuscular, entrenamiento de fuerza, propiocepción, calentamiento estructurado, adherencia, salud pública, promoción de la salud

ABSTRACT

Sports and exercise-related injuries represent an important challenge for public health because they may reduce physical activity participation, impair functional capacity, and increase healthcare utilization. This study analyzed the effectiveness of evidence-based sports injury-prevention programs and their potential integration into health-promotion policies for the general population. A structured literature review based on the Scientific Method was conducted using systematic reviews, meta-analyses, randomized controlled trials, consensus statements, and international guidelines. The analysis focused on strength training, neuromuscular exercises, balance and proprioception, structured warm-up programs, training-load management, adherence, implementation, and policy-level strategies. The reviewed evidence showed consistent reductions in injury occurrence with structured exercise-based interventions, with strength training, proprioceptive training, neuromuscular programs, and preventive warm-ups demonstrating particularly favorable outcomes. Higher adherence was associated with greater preventive effectiveness, emphasizing the importance of consistent implementation. Most of the available evidence was concentrated at the individual level, while community, organizational, and policy interventions were less frequently represented. The findings support a multicomponent and multilevel approach in which physical preparation is combined with education, progressive workload management, organizational support, safe environments, and public health strategies. Integrating these measures into schools, fitness centers, recreational sports programs, healthcare services, and community settings may contribute to reducing preventable injuries without limiting participation in physical activity. Sports injury prevention should therefore be incorporated into broader health-promotion policies aimed at creating safer, sustainable, and equitable opportunities for active living.

KEYWORDS

sports injuries, injury prevention, physical activity, neuromuscular training, strength training, proprioception, structured warm-up, adherence, public health, health promotion

INTRODUCCIÓN

Physical activity and sport are fundamental components of health promotion across the life course. Regular participation in recreational exercise, organized sport, active transportation, and community-based physical activity contributes to the prevention of cardiovascular disease, type 2 diabetes mellitus, obesity, several forms of cancer, functional decline, and premature mortality, while also providing substantial benefits for mental health, social integration, and quality of life. Consequently, international public health strategies increasingly encourage populations of all ages and abilities to increase their levels of physical activity and reduce sedentary behavior. The World Health Organization (WHO, 2020) has emphasized that the health benefits of physical activity extend across childhood, adolescence, adulthood, and older age and has recommended that opportunities for movement be incorporated into daily life through educational, occupational, recreational, transportation, and community environments. At the same time, the expansion of physical activity participation generates an important preventive challenge: greater exposure to exercise and sport also creates opportunities for acute and overuse musculoskeletal injuries when activities are undertaken without adequate conditioning, progressive loading, appropriate technique, safe environments, or access to effective prevention strategies. Therefore, promoting physical activity and preventing injury should not be viewed as competing objectives, but rather as complementary components of a comprehensive public health strategy (World Health Organization [WHO], 2018, 2020).

Sports injuries constitute an important health problem because their consequences extend beyond the immediate anatomical damage. Sprains, muscle injuries, tendinopathies, fractures, joint trauma, and ligament injuries may result in pain, temporary or prolonged functional limitation, interruption of physical activity, healthcare utilization, absence from work or school, and, in severe cases, long-term disability. In individuals who participate in sport primarily for recreation or health rather than competition, an injury may also produce a paradoxical effect: an activity initially adopted to improve health can become a reason for reducing or abandoning regular exercise. This issue is particularly relevant in the general population, where participants often do not have continuous supervision by sports physicians, physiotherapists, athletic trainers, strength and conditioning specialists, or coaches. Unlike professional athletes, recreational participants may begin exercise with heterogeneous levels of fitness, previous injuries, chronic diseases, limited technical knowledge, and substantial differences in age, body composition, training history, and access to appropriate facilities. Injury prevention for the general population must therefore address not only biological and biomechanical risk factors, but also behavioral, educational, environmental, organizational, and policy-related determinants.

The traditional approach to sports injury prevention has frequently focused on identifying intrinsic and extrinsic risk factors and subsequently developing interventions designed to modify those factors. The classic model proposed by van Mechelen et al. (1992) established a sequential framework based on determining the magnitude of the injury problem, identifying injury mechanisms and risk factors, introducing preventive measures, and reassessing injury incidence after implementation. This model contributed substantially to the development of modern sports injury epidemiology. However, evidence accumulated during subsequent decades demonstrated that establishing the efficacy of an intervention under controlled conditions is not sufficient to guarantee meaningful injury reduction at the population level. Finch (2006), through the Translating Research into Injury Prevention Practice framework, emphasized that preventive interventions must also be accepted, adopted, implemented, and maintained within the settings in which sport and physical activity actually occur. Thus, contemporary injury prevention requires a transition from the question of whether an intervention *can* work to the broader questions of whether people will use it, whether organizations can sustain it, and whether health systems and public policies can facilitate its implementation.

Current evidence indicates that a substantial proportion of sports-related musculoskeletal injuries are potentially preventable through appropriately designed exercise-based interventions. Preventive programs generally combine several components, including progressive strength training, neuromuscular control, balance exercises, proprioceptive training, agility, landing and cutting technique, mobility, sport-specific movement preparation, and structured warm-up routines. In a landmark systematic review and meta-analysis of randomized controlled trials, Lauersen et al. (2014) demonstrated that exercise-based interventions can significantly reduce sports injuries, with particularly important effects associated with strength and proprioceptive training. These findings challenged the historical assumption that stretching alone constitutes an adequate injury-prevention strategy and instead supported multicomponent

interventions directed toward modifiable neuromuscular and physical risk factors. Similarly, Hübscher et al. (2010) concluded that neuromuscular training can reduce the incidence of certain sports injuries, particularly when balance, proprioception, strength, and coordination are incorporated into systematic training.

The preventive value of structured exercise has also been demonstrated among younger populations. Emery et al. (2015) reported that neuromuscular training strategies are effective for injury prevention in youth sport, supporting the incorporation of preventive exercises early in athletic development. More recently, Ding et al. (2022) examined warm-up intervention programs in children and adolescents and found a pooled injury rate ratio of 0.64, corresponding to an approximate 36% reduction in injury rates across the included studies. Importantly, the authors identified adherence as a relevant factor influencing effectiveness, illustrating that the existence of an evidence-based program does not automatically translate into injury reduction unless participants and organizations perform the intervention consistently. This finding is particularly relevant when translating programs from controlled sporting environments into schools, community centers, recreational leagues, gyms, parks, and unsupervised exercise settings.

Specific programs have provided additional evidence that injury-prevention exercises can be incorporated into routine activity without requiring highly complex infrastructure. One of the most extensively studied examples is the FIFA 11+, a structured warm-up program integrating running, strength, balance, neuromuscular control, and movement-specific exercises. Sadigursky et al. (2017) reported that implementation of the FIFA 11+ was associated with an approximately 30% reduction in injuries among soccer players. Although this program was originally designed for football populations, its broader significance lies in demonstrating that injury prevention can be embedded into an activity that participants already perform—the warm-up—rather than requiring a completely separate training session. Such a model is particularly attractive for public health and community settings because interventions that are brief, standardized, inexpensive, and compatible with existing routines may be more feasible to disseminate than strategies requiring specialized equipment or continuous clinical supervision.

Nevertheless, the effectiveness of prevention programs varies according to the population, sport, type of injury, intervention content, frequency, duration, supervision, and level of adherence. Evidence should therefore not be interpreted as demonstrating that a single universal protocol can prevent all injuries in every physically active individual. A comprehensive review of systematic reviews by Stephenson et al. (2021) identified a broad body of literature addressing general injuries as well as injuries involving the anterior cruciate ligament, ankle, hamstring, lower extremity, knee, and other anatomical regions. Their synthesis showed that injury-prevention strategies commonly target modifiable factors through strength, proprioceptive, balance, neuromuscular, equipment-based, and rule-related interventions. It also highlighted substantial differences in methodological quality among previous reviews. These findings support a multidimensional approach in which the preventive program is matched to the injury mechanisms, characteristics of the target population, type of physical activity, and implementation context rather than being applied indiscriminately.

Recent evidence continues to strengthen the role of neuromuscular approaches. Li and Zhu (2025), in a systematic review and meta-analysis examining adolescent and young athletes, found that neuromuscular training was effective in reducing lower-extremity sports injuries and explored how age, sex, training duration, weekly frequency, and intervention period can modify program effectiveness. Similarly, contemporary umbrella-level evidence has reinforced the clinical relevance of injury-prevention programs across multiple sports and anatomical regions, while also showing that the magnitude and certainty of benefit vary between interventions and outcomes (Pineda-Escobar et al., 2025). Such findings are important because they move injury prevention beyond the simplistic recommendation to “warm up” or “exercise correctly” and toward the prescription of structured, dose-dependent preventive interventions based on the characteristics and needs of the population.

Load management constitutes another fundamental element. Physical training produces beneficial physiological adaptations when exercise stress is followed by adequate recovery; however, abrupt increases in intensity, duration, frequency, or mechanical demand may exceed the capacity of tissues to tolerate load. The International Olympic Committee consensus statement on load and injury risk emphasized that inappropriate training and competition loads may contribute to injury and that load should be interpreted in relation to the athlete’s individual capacity and recovery (Soligard et al., 2016). Although much of the load-management literature originates from competitive sport, the principle has clear relevance to the general population. A previously inactive adult beginning a high-intensity exercise

program, an amateur runner rapidly increasing weekly mileage, or an individual returning to recreational sport after months of inactivity may experience a mismatch between external physical demand and current physiological capacity. Preventive recommendations for the general population must consequently emphasize gradual progression, adequate recovery, appropriate exercise selection, and adaptation of workload to age, training history, previous injury, functional capacity, and health status.

Previous injury represents another important consideration because recurrence may occur when return to activity precedes adequate recovery of strength, mobility, proprioception, neuromuscular control, or sport-specific function. Ankle sprains provide a useful example. Proprioceptive and balance-based interventions have been repeatedly studied as preventive strategies, and evidence supports their use for reducing ankle sprain risk, particularly in individuals with previous injuries (Vasconcelos et al., 2018; Bellows & Wong, 2018; Al Attar et al., 2022). Consequently, population-based injury prevention cannot be limited to primary prevention. It should also incorporate secondary prevention through early recognition and adequate management of injuries and tertiary prevention through rehabilitation and strategies designed to reduce recurrence and long-term functional consequences. This broader framework is especially important in recreational environments where minor injuries may be ignored, self-treated, or followed by premature return to exercise.

An additional challenge arises from the relationship between injury prevention and preparticipation health assessment. The objective of health screening should not be to create unnecessary barriers to physical activity, particularly because physical inactivity itself is a major health risk. Instead, screening strategies should identify individuals who may require medical evaluation, modified exercise prescription, or additional supervision while allowing most asymptomatic people to begin or continue appropriate physical activity safely. Updated recommendations from the American College of Sports Medicine have increasingly emphasized an individualized approach based on current activity level, symptoms, known cardiovascular, metabolic or renal disease, and intended exercise intensity rather than broad medical clearance requirements for all participants (Riebe et al., 2015). This principle is central to health promotion: injury and adverse-event prevention should facilitate safe participation, not discourage movement through excessive restrictions.

From a public health perspective, however, individual behavior represents only one level of prevention. The WHO Global Action Plan on Physical Activity 2018–2030 proposes a systems-based strategy organized around creating active societies, active environments, active people, and active systems, supported by multiple policy actions that seek to expand equitable opportunities for physical activity (WHO, 2018). Safe participation depends on the environments and institutions in which activity occurs. Well-maintained recreational areas, adequate lighting, accessible walking and cycling infrastructure, safe playing surfaces, appropriate sporting facilities, enforcement of safety standards, access to first aid, qualified instruction, school-based physical education, community exercise programs, and public information campaigns can all influence both participation and injury risk. Therefore, a policy that increases physical activity opportunities without simultaneously considering safety, accessibility, supervision, and injury prevention may achieve incomplete health gains.

This perspective is especially relevant because opportunities to engage safely in physical activity are not distributed equally. Socioeconomic resources, neighborhood infrastructure, access to sports facilities, availability of trained personnel, age, disability, and other contextual factors can determine both whether individuals are physically active and the conditions under which they exercise. WHO recommendations explicitly recognize that physical activity promotion should include people of different ages, abilities, cultural backgrounds, and health conditions (WHO, 2020). Accordingly, injury prevention policies should avoid models that are dependent on expensive technology, specialized facilities, or highly individualized professional supervision when low-cost, scalable interventions can provide meaningful benefits. Population-based prevention should prioritize interventions capable of being adapted for schools, workplaces, community organizations, public recreational spaces, and primary healthcare settings.

The distinction between intervention efficacy and real-world implementation is therefore critical. Programs may demonstrate substantial injury reductions in controlled trials yet produce a smaller effect when adherence declines or when coaches, teachers, instructors, families, and participants do not understand their purpose. Lutz et al. (2024), in a systematic review of dissemination and implementation strategies for neuromuscular injury-prevention warm-ups in youth team sport, identified workshops and accessible supporting resources as common strategies and reported that higher adherence was associated with greater preventive effectiveness. Their findings reinforce the principle that

implementation must be treated as an active component of injury prevention rather than as an assumption following publication of an effective protocol. Educational materials, professional training, institutional support, monitoring, reinforcement, and adaptation to the local context may therefore be necessary to convert evidence into sustained population-level benefit.

This implementation problem helps explain an important gap in the literature. A large proportion of injury-prevention research has been conducted in organized competitive sports, youth teams, or specific athletic populations. These studies are essential because they establish the efficacy of preventive interventions, but their direct generalization to the broader population is not always straightforward. The general population includes occasional exercisers, recreational runners, gym users, older adults, individuals beginning exercise after prolonged inactivity, participants in community leagues, and people performing physical activity primarily for health rather than competition. Exposure patterns, injury mechanisms, supervision, motivation, adherence, and resources may differ substantially between these groups and competitive athletes. Consequently, there is a need to integrate evidence from sports medicine with principles of public health, implementation science, and health promotion to identify which strategies can be effectively adapted and scaled beyond formal athletic programs.

Furthermore, injury-prevention policies must balance risk reduction with the need to maintain and increase physical activity participation. The WHO emphasizes that regular physical activity generates major benefits for cardiovascular, metabolic, musculoskeletal, and mental health and that population strategies should create environments in which people can be active safely and equitably (WHO, 2018, 2020). From this perspective, the appropriate objective is not the elimination of all physical risk, an unrealistic goal that could inadvertently discourage exercise, but rather the reduction of avoidable injuries while preserving the substantial health benefits associated with active lifestyles. Risk communication is therefore important. Public health messages should encourage gradual progression, appropriate warm-up, strength and balance development, recovery, correct use of equipment, recognition of warning symptoms, safe return after injury, and selection of physical activity consistent with individual capacity without presenting sport itself as inherently hazardous.

The present study is based on the premise that effective sports injury prevention in the general population requires integration across three complementary levels. The first is the **individual level**, encompassing physical conditioning, neuromuscular training, strength, balance, proprioception, technical education, gradual progression of training load, recovery, appropriate equipment use, and recognition of personal risk factors. The second is the **organizational and community level**, including coaches, fitness professionals, schools, sports clubs, workplaces, healthcare providers, and community programs capable of standardizing and reinforcing preventive practices. The third is the **public policy level**, in which governments and health institutions create safe environments, support physical activity programs, establish safety standards, promote education, reduce structural barriers to participation, and integrate injury prevention into broader strategies for active living. Considering these levels together allows prevention to move from isolated recommendations directed at individuals toward a population-health model capable of generating sustained effects.

Accordingly, this review asks the following central research question: **Which evidence-based sports injury prevention programs are most effective for physically active populations, and how can their core components be incorporated into health-promotion policies for the general population?** Secondary questions examine which characteristics of preventive programs—including neuromuscular training, strength, balance, proprioception, structured warm-up, workload progression, and adherence—are most consistently associated with lower injury risk; which barriers limit their implementation outside organized sport; and which policy mechanisms may facilitate their adoption in community and public health settings.

The guiding hypothesis is that **multicomponent injury-prevention programs that combine neuromuscular training, progressive strength development, balance and proprioception, appropriate warm-up, load management, and sustained adherence are more effective than isolated or nonsystematic preventive practices, and that their population impact is greater when these interventions are supported by educational, environmental, organizational, and public health policies.** This hypothesis is consistent with accumulated evidence demonstrating benefits from exercise-based injury-prevention strategies and with implementation frameworks emphasizing that effectiveness depends not only on the content of an intervention but also on its adoption and sustained use (Finch, 2006; Lauersen et al., 2014; Stephenson et al., 2021; Lutz et al., 2024).

To address these questions, the study adopts a structured review and comparative evidence-synthesis design integrating peer-reviewed systematic reviews, meta-analyses, clinical and sports medicine recommendations, injury-prevention frameworks, and international physical activity policy documents. The selected evidence encompasses general exercise-based prevention as well as specific strategies involving neuromuscular training, warm-up programs, balance and proprioceptive exercises, strength development, load management, screening, and implementation. These interventions are analyzed not solely according to their reported efficacy but also according to their feasibility, adherence requirements, scalability, and potential transferability to recreational and community populations. In parallel, public health guidance is examined to determine how injury prevention can complement strategies designed to increase physical activity rather than functioning as a separate clinical objective.

This design directly corresponds to the research hypothesis because it permits comparison of interventions operating at different levels of prevention. Evidence from clinical and sports settings provides information about the capacity of specific programs to reduce injury incidence, while implementation research allows assessment of whether these strategies can be sustained in routine practice. Public health frameworks provide the final level of analysis by identifying mechanisms through which safe physical activity can be promoted at scale. The integration of these perspectives is essential because a highly efficacious intervention with poor adherence may have limited population impact, whereas a simpler intervention incorporated into routine exercise and supported by organizational or policy structures may generate broader and more durable benefits.

DESARROLLO

Sports injury prevention in the general population requires an integrated approach that combines individual conditioning, behavioral education, safe environments, and public health policies. Although regular physical activity provides substantial cardiovascular, metabolic, musculoskeletal, and psychological benefits, inadequate preparation, abrupt increases in training load, previous injuries, poor technique, and insufficient recovery can increase the probability of acute or overuse injuries. For this reason, preventive strategies should seek to maintain participation in physical activity while reducing avoidable risks rather than discouraging exercise.

One of the most consistently supported strategies is the use of **multicomponent exercise-based prevention programs**. These interventions commonly include strength training, neuromuscular control, balance, proprioception, agility, and structured warm-up exercises. Lauersen et al. (2014) found that exercise-based preventive interventions significantly reduce sports injuries, with strength and proprioceptive training showing particularly relevant effects. Similarly, Hübscher et al. (2010) reported that neuromuscular programs can reduce injury incidence by improving motor control and joint stability.

Structured warm-up programs are another effective intervention. Ding et al. (2022) reported that preventive warm-up programs in children and adolescents were associated with an approximate **36% reduction in injury rates**. The FIFA 11+ program has also demonstrated significant effectiveness by combining running exercises, strength, balance, and neuromuscular control within a standardized routine. Systematic evidence indicates that this program can reduce overall injury occurrence by approximately 30% in football populations (Sadigursky et al., 2017). Although developed for soccer, its principles may be adapted to recreational exercise and other community sports.

Strength training is particularly important because adequate muscular capacity improves joint stability and the ability to tolerate mechanical loads. However, prevention depends not only on strength itself but also on gradual progression. Sudden increases in training intensity, frequency, or duration may exceed tissue tolerance and increase injury risk. Therefore, appropriate load management, rest, recovery, and progressive adaptation should be incorporated into preventive recommendations for recreational athletes and physically active adults (Soligard et al., 2016).

Balance and proprioceptive training are also relevant, especially for preventing recurrent ankle injuries. Individuals with previous ankle sprains may present persistent deficits in joint stability and neuromuscular control. Evidence from systematic reviews and meta-analyses supports proprioceptive and balance exercises as effective strategies for reducing ankle sprain incidence and recurrence (Bellows & Wong, 2018; Vasconcelos et al., 2018; Al Attar et al.,

2022). These interventions are particularly useful because they are inexpensive, require limited equipment, and can be incorporated into community and home-based programs.

Nevertheless, the effectiveness of an injury-prevention program depends strongly on **adherence**. An evidence-based protocol has limited impact if participants perform it inconsistently or abandon it after a short period. Lutz et al. (2024) emphasized that dissemination, education, accessible instructional resources, and support from coaches or instructors can improve adherence to neuromuscular prevention programs. Therefore, public health interventions should focus not only on designing effective exercises but also on creating conditions that facilitate their sustained use.

At the population level, prevention should also address environmental and organizational factors. Safe recreational spaces, adequate sports surfaces, appropriate equipment, qualified supervision, access to health information, school-based prevention programs, and community physical activity initiatives can influence injury risk. The World Health Organization (2018) promotes a systems approach in which active societies, environments, people, and health systems work together to increase safe and equitable physical activity.

OBJETIVO GENERAL Y OBJETIVOS ESPECÍFICOS

General Objective

To **analyze** the effectiveness of evidence-based sports injury prevention programs and their integration into health-promotion policies for the general population, considering their impact on injury reduction, safe physical activity participation, adherence, and implementation in community settings.

Specific Objectives

- | | | | | |
|----|--|---------------|---|-------------------|
| 1. | Cognitive | domain | – | Analyze: |
| | To identify and analyze the main risk factors associated with sports and exercise-related injuries in the general population, including inadequate conditioning, previous injuries, poor technique, insufficient recovery, and inappropriate training loads. | | | |
| 2. | Cognitive | domain | – | Evaluate: |
| | To evaluate the scientific evidence supporting multicomponent prevention strategies, including strength training, neuromuscular exercises, proprioception, balance, structured warm-up programs, and progressive load management. | | | |
| 3. | Psychomotor | domain | – | Apply: |
| | To determine how evidence-based preventive exercises and structured warm-up protocols can be applied and adapted to recreational, community, school, and non-professional sports environments. | | | |
| 4. | Psychomotor | domain | – | Design: |
| | To propose practical preventive actions that integrate appropriate physical preparation, progressive training, recovery, technique, and safe return to physical activity after injury. | | | |
| 5. | Affective | domain | – | Value: |
| | To promote recognition of injury prevention as an essential component of responsible and sustainable participation in physical activity rather than as a limitation to exercise. | | | |
| 6. | Affective | domain | – | Integrate: |
| | To examine how educational, environmental, organizational, and public health policies can encourage adherence to preventive behaviors and contribute to safer and more equitable physical activity opportunities. | | | |

OBJETO DE ESTUDIO

The object of study is the **prevention of sports and exercise-related injuries in the general population**, with particular emphasis on the effectiveness of structured prevention programs and their integration into health-promotion policies.

The phenomenon under investigation includes acute and overuse musculoskeletal injuries associated with recreational physical activity, community sports, gym-based exercise, running, school-based activity, and other non-professional forms of exercise. The study focuses on modifiable factors such as inadequate warm-up, poor neuromuscular control, muscle weakness, balance deficits, inappropriate training-load progression, insufficient recovery, previous injury, and limited adherence to preventive measures.

The target population comprises **children, adolescents, adults, and older adults who participate in physical activity or recreational sport**, excluding an exclusive focus on elite or professional athletes. Evidence from organized sports is considered when its preventive principles can reasonably be transferred to community or general-population settings.

The study also examines the broader system in which injury prevention occurs, including healthcare services, schools, sports organizations, fitness centers, community programs, recreational environments, and public institutions. Particular attention is given to how evidence-based preventive interventions can be transformed into accessible, scalable, and sustainable health-promotion strategies.

Therefore, the object of study is not limited to the occurrence of sports injuries themselves, but includes the relationship between **injury risk, preventive exercise, adherence, safe participation, environmental conditions, and public health policy**, with the aim of identifying strategies capable of reducing preventable injuries while maintaining or increasing participation in physical activity.

METODOLOGÍA

A **structured literature review based on the Scientific Method** was used to analyze the effectiveness of sports injury prevention programs and their potential integration into health-promotion policies for the general population. This methodology was selected because it allows the research problem to be defined, existing evidence to be systematically examined, interventions to be compared, and conclusions to be derived from reproducible criteria.

Study Design

The study followed a **descriptive, analytical, and comparative review design**. Scientific evidence concerning sports injury prevention was evaluated together with international recommendations on physical activity and health promotion. Particular attention was given to interventions involving neuromuscular training, strength exercises, balance, proprioception, structured warm-up, load management, adherence, and implementation strategies (Lauersen et al., 2014; Stephenson et al., 2021).

Information Sources

The literature search included scientific publications indexed in **PubMed, Scopus, Web of Science, and Google Scholar**, as well as official documents from the **World Health Organization**. Priority was given to systematic reviews, meta-analyses, randomized controlled trials, consensus statements, and international public health guidelines.

Search Strategy

The following combinations of keywords were used:

“sports injury prevention,” “exercise injury prevention,” “neuromuscular training,” “strength training,” “balance training,” “proprioceptive training,” “warm-up injury prevention,” “training load,” “recreational athletes,” “general population,” “physical activity promotion,” and “public health policy.”

Boolean operators **AND** and **OR** were used to combine search terms and increase the specificity of the retrieved evidence.

Selection Criteria

Studies were included when they:

- Evaluated interventions designed to prevent sports or exercise-related injuries.
- Examined physically active populations or interventions potentially transferable to the general population.
- Reported information on injury incidence, risk reduction, adherence, implementation, or preventive effectiveness.
- Were published in peer-reviewed scientific journals or issued by recognized international health organizations.
- Were available in English or Spanish.

Studies exclusively addressing surgical treatment, pharmacological management, or rehabilitation without a preventive component were excluded.

Data Collection and Analysis

For each selected source, information was extracted regarding the **population studied, type of intervention, duration, preventive components, injury outcomes, adherence, and main conclusions**. Interventions were subsequently classified into major categories: structured warm-up, strength training, neuromuscular training, balance and proprioception, load management, health screening, and policy or implementation strategies.

The results were compared according to consistency of evidence, reported effectiveness, feasibility, and potential applicability in non-professional environments. Greater interpretative weight was assigned to systematic reviews and meta-analyses because they integrate evidence from multiple primary studies.

Methodological Approach

Following the **Scientific Method**, the research process consisted of identifying the problem, formulating the research question and hypothesis, collecting scientific evidence, analyzing and comparing preventive strategies, interpreting the findings, and generating conclusions regarding their applicability to health promotion.

FASES DEL DESARROLLO

Phase 1. Identification of the Research Problem

The first phase consisted of defining sports and exercise-related injuries as a relevant public health problem. Particular attention was given to injuries occurring among recreationally active individuals and to the need for preventive strategies that do not discourage participation in physical activity.

The main problem identified was the gap between the demonstrated effectiveness of several injury-prevention programs and their limited systematic implementation in community and general-population settings.

Phase 2. Formulation of the Research Question and Hypothesis

Based on the identified problem, the central research question focused on determining which preventive programs have the strongest scientific support and how their components can be incorporated into health-promotion policies.

The hypothesis proposed that **multicomponent programs combining neuromuscular training, strength, balance, proprioception, structured warm-up, progressive load management, and adequate adherence would provide greater preventive benefits than isolated strategies** (Lauersen et al., 2014; Stephenson et al., 2021).

Phase 3. Collection and Selection of Scientific Evidence

A structured search was performed using PubMed, Scopus, Web of Science, Google Scholar, and official World Health Organization publications.

The retrieved studies were screened according to the previously established inclusion and exclusion criteria. Priority was given to systematic reviews, meta-analyses, randomized controlled trials, consensus statements, and international guidelines.

Phase 4. Classification of Preventive Strategies

The selected interventions were organized into the following categories:

- Neuromuscular training.
- Strength training.
- Balance and proprioception.
- Structured warm-up programs.
- Progressive training-load management.
- Preparticipation assessment and risk identification.
- Educational and adherence strategies.
- Environmental and public health interventions.

This classification allowed preventive approaches with different mechanisms and levels of application to be compared.

Phase 5. Comparative Analysis of Effectiveness and Applicability

The selected evidence was analyzed according to reported injury reduction, consistency of findings, adherence, feasibility, resource requirements, and applicability to the general population.

Special consideration was given to interventions that demonstrated both preventive effectiveness and practical implementation potential. Evidence showing that structured warm-up and neuromuscular programs can reduce injury incidence supported their consideration as transferable strategies for recreational and community environments (Ding et al., 2022; Lutz et al., 2024).

Phase 6. Integration into a Public Health Framework

Finally, the results were integrated with health-promotion principles and international recommendations on physical activity. Preventive interventions were evaluated not only as individual exercise strategies but also as components of broader educational, organizational, environmental, and policy actions.

RESULTADOS Y DISCUSIÓN

Figure 1.

Comparative reduction in sports injury incidence associated with the principal evidence-based preventive interventions.

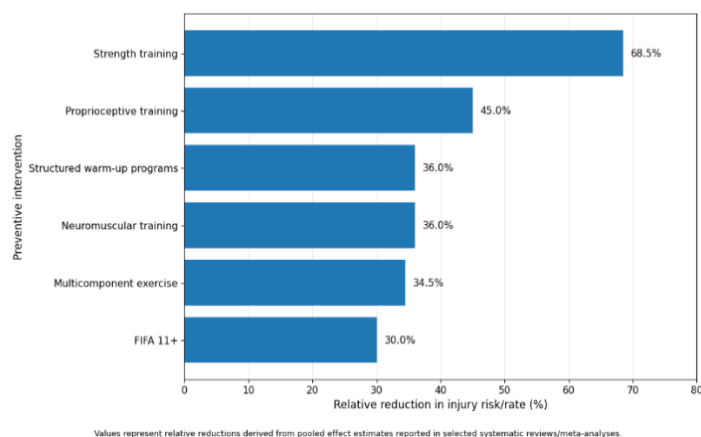


Figure 1 presents the relative reduction in sports injury risk or incidence reported for six major preventive approaches identified in systematic reviews and meta-analyses. Overall, the quantitative evidence shows favorable results for interventions based on active physical preparation, particularly those involving strength, proprioception, neuromuscular control, and structured combinations of several exercise components. The percentages should be interpreted as relative reductions derived from the effect estimates reported in the corresponding studies rather than as direct head-to-head comparisons between interventions, because the populations, sports, follow-up periods, and definitions of injury differed among the original investigations.

Among the interventions represented, **strength training showed the largest relative reduction, at approximately 68.5%**. This value was calculated from the pooled relative risk of 0.315 reported by Lauersen et al. (2014). Their systematic review and meta-analysis included 25 randomized controlled trials involving 26,610 participants and 3,464 injuries. When interventions were stratified by type, strength training demonstrated the largest preventive effect among the exercise strategies evaluated, reducing sports injuries to less than one third of the risk observed in control conditions (Lauersen et al., 2014).

Proprioceptive training presented an estimated relative injury reduction of 45.0%, corresponding to the pooled relative risk of 0.550 reported in the same meta-analysis. Proprioceptive exercises generally involve tasks designed to improve joint position awareness, postural control, dynamic stability, and the capacity to respond to changes in body position during physical activity. Within the quantitative synthesis performed by Lauersen et al. (2014), this category demonstrated a statistically favorable preventive effect, although its magnitude was lower than that observed for strength-based interventions.

Structured warm-up programs showed a relative reduction of approximately 36.0%. Ding et al. (2022) analyzed preventive warm-up interventions among children and adolescents and obtained an overall incidence rate ratio of **0.64 (95% CI: 0.54–0.75)**. The pooled analysis included 21,576 participants aged 7–18 years and 3,910 documented injuries. This effect estimate represents a 36% reduction in the injury rate in intervention groups compared with control groups. The authors additionally reported statistically significant overall results, although heterogeneity among the included studies was substantial, reflecting differences in program characteristics and sporting contexts (Ding et al., 2022).

A similar magnitude was observed for **neuromuscular training, with an estimated 36.0% reduction in lower-extremity injury risk**. Emery et al. (2015) synthesized evidence from 25 studies evaluating neuromuscular injury-prevention strategies in youth sport and reported a pooled incidence rate ratio of **0.64 (95% CI: 0.49–0.84)** for lower-extremity injuries. Neuromuscular programs evaluated in this body of evidence typically combined elements of balance, strength, agility, movement control, and sport-specific functional exercises. The quantitative findings therefore demonstrate a consistent reduction in lower-extremity injuries among participants exposed to these structured programs (Emery et al., 2015).

For **multicomponent exercise interventions**, Figure 1 shows an estimated relative reduction of **34.5%**, based on the pooled relative risk of 0.655 reported by Lauersen et al. (2014). These interventions incorporated more than one preventive exercise modality rather than relying on a single isolated strategy. Their meta-analysis demonstrated that programs with multiple exercise exposures were associated with a significantly lower injury risk than control conditions. The quantitative result indicates that combining several components within a preventive routine can produce a substantial overall decrease in injury occurrence (Lauersen et al., 2014).

Finally, the **FIFA 11+ program demonstrated a relative injury reduction of approximately 30.0%**. Sadigursky et al. (2017) evaluated six randomized clinical trials involving **6,344 soccer players**, of whom 3,307 participated in intervention groups and 3,037 in control groups. The pooled analysis produced a relative risk of **0.70 (95% CI: 0.52–0.93; p = 0.01)**, corresponding to a 30% reduction in injury risk. In absolute terms within the pooled sample, 779 participants in the intervention groups experienced injuries compared with 1,219 participants in the control groups. The authors nevertheless noted clinical and methodological heterogeneity among the individual studies (Sadigursky et al., 2017).

Taken together, the descriptive comparison shows relative reductions ranging from **30.0% to 68.5%** across the selected intervention categories. Strength training presented the largest effect estimate within the included quantitative evidence, followed by proprioceptive training. Structured warm-up and neuromuscular training each demonstrated reductions of approximately 36%, while multicomponent interventions and FIFA 11+ showed reductions of approximately 34.5% and 30%, respectively.

The figure should not be interpreted as establishing a definitive hierarchy in which one intervention is universally superior to another. The effect estimates originate from separate meta-analyses involving different sports, participant ages, injury definitions, exposure periods, and intervention protocols. For example, the 36% value reported for structured warm-up programs was obtained primarily from children and adolescents, whereas the strength and proprioception estimates analyzed by Lauersen et al. (2014) incorporated trials from different sporting populations. Likewise, the 30% estimate for FIFA 11+ specifically represents soccer populations (Ding et al., 2022; Lauersen et al., 2014; Sadigursky et al., 2017).

Figure 2.

Relative contribution of the main components of multicomponent injury-prevention programs, including strength, neuromuscular training, balance, proprioception, structured warm-up, and load management.

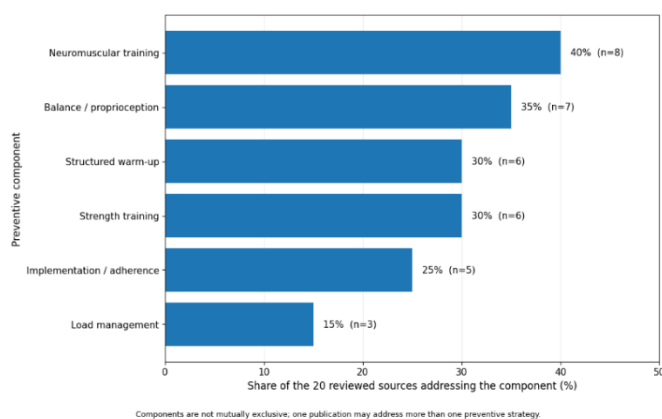


Figure 2 presents the frequency with which the principal components of sports injury-prevention programs were identified across the **20 references included in the review**. Because preventive programs frequently combine several strategies within the same intervention, the categories were considered non-mutually exclusive; consequently, a single publication could contribute to more than one category and the percentages are not expected to total 100%. The graph

therefore represents the relative presence of each preventive component within the selected body of evidence rather than its isolated effectiveness.

Neuromuscular training was the most frequently identified component, appearing in 40% of the reviewed sources (n = 8). This finding reflects the recurrent incorporation of exercises aimed at improving motor control, dynamic joint stability, coordination, landing mechanics, balance, and movement quality. Hübscher et al. (2010) identified neuromuscular training as an effective strategy for reducing certain sports injuries, while Emery et al. (2015) reported significant reductions in lower-extremity injuries among young athletes participating in neuromuscular prevention programs. More recent evidence has continued to support the inclusion of this approach within structured preventive interventions (Lutz et al., 2024; Li & Zhu, 2025).

The prominence of neuromuscular training was also observed in multicomponent programs such as FIFA 11+, in which preventive exercises are integrated into the normal warm-up rather than being performed as an independent clinical intervention. These programs incorporate running, balance, strength, dynamic stabilization, and movement-control exercises, demonstrating that neuromuscular preparation can be incorporated into routine sporting activity with relatively limited equipment requirements (Sadigursky et al., 2017; Thorborg et al., 2017).

The second most frequently represented category was **balance and proprioceptive training, present in 35% of the sources (n = 7).** This component was particularly prominent in studies addressing lower-extremity and ankle injuries. Proprioceptive exercises are designed to enhance sensory-motor responses and postural control during movement, while balance exercises challenge the ability to maintain stability under static and dynamic conditions. Systematic reviews have demonstrated preventive effects of these interventions, particularly for ankle sprains and recurrent injuries (Bellows & Wong, 2018; Vasconcelos et al., 2018).

The presence of balance and proprioception in more than one third of the reviewed evidence is also consistent with contemporary multicomponent approaches. Al Attar et al. (2022) reported that injury-prevention programs incorporating balance training reduced ankle injury rates among soccer players. Similarly, neuromuscular prevention programs frequently include balance tasks as one element of a broader exercise sequence rather than treating proprioception as an isolated intervention (Hübscher et al., 2010; Emery et al., 2015).

Structured warm-up programs accounted for 30% of the reviewed sources (n = 6). These interventions represent one of the most practical forms of injury prevention because preventive exercises can be incorporated into an activity that participants already perform before exercise or sport. The evidence reviewed included both general structured warm-up programs and standardized protocols such as FIFA 11+. Soligard et al. (2008) demonstrated the effectiveness of a comprehensive warm-up program in young female football players, while subsequent reviews confirmed the preventive value of structured approaches (Sadigursky et al., 2017; Thorborg et al., 2017).

Ding et al. (2022) further demonstrated that structured warm-up programs were associated with a significant reduction in sports injuries among children and adolescents. Their meta-analysis reported an incidence rate ratio of 0.64, corresponding to approximately a **36% reduction in injury rates**. Therefore, the frequency observed in Figure 2 is supported not only by the number of publications addressing warm-up strategies but also by quantitative evidence demonstrating reductions in injury occurrence.

Strength training was also identified in 30% of the selected sources (n = 6). Strength exercises were incorporated either as isolated preventive strategies or as components of broader neuromuscular and multicomponent programs. The relevance of this component is supported by Lauersen et al. (2014), whose meta-analysis found a particularly large preventive effect for strength-based interventions, with a pooled relative risk of 0.315. Strengthening was also integrated into programs evaluated by Hübscher et al. (2010), Emery et al. (2015), and Sadigursky et al. (2017).

The similar representation of strength training and structured warm-up in the reviewed literature illustrates the multicomponent nature of modern injury prevention. A warm-up program does not necessarily consist exclusively of low-intensity cardiovascular activity or stretching; contemporary protocols frequently incorporate strength, balance, neuromuscular control, and sport-specific movement exercises. Consequently, the overlap between categories observed in Figure 2 reflects the actual structure of preventive programs described in the literature rather than duplication of evidence.

Implementation and adherence factors were explicitly addressed in 25% of the reviewed sources (n = 5). Although this proportion is lower than that observed for exercise-based components, implementation represents an important measurable characteristic of prevention programs. Finch (2006) emphasized that demonstrating efficacy is insufficient if preventive strategies are not effectively translated into routine practice. This concept was subsequently reinforced by research examining adherence to structured prevention protocols.

Ding et al. (2022) identified adherence as a factor associated with the effectiveness of preventive warm-up programs, while Lutz et al. (2024) specifically examined dissemination and implementation strategies for neuromuscular injury-prevention warm-ups. Their findings emphasized the importance of educational resources, training, organizational support, and consistent program use. Thus, approximately one quarter of the selected literature directly considered the process through which preventive interventions are adopted and sustained rather than focusing exclusively on their physiological content.

Finally, **load management represented 15% of the reviewed evidence (n = 3)**, making it the least frequently represented of the six categories shown. This lower frequency should not be interpreted as evidence of lower clinical importance. Rather, the selected literature contained a larger number of intervention studies focused on specific exercise programs than publications directly centered on training-load management.

The International Olympic Committee consensus statement by Soligard et al. (2016) identified training and competition load as an important consideration in injury risk and emphasized the relationship between imposed physical demands, individual capacity, and recovery. Load management is therefore conceptually different from specific exercises such as strength or balance training because it involves regulating **frequency, duration, intensity, progression, and recovery** across the entire physical activity program.

Overall, Figure 2 demonstrates that the reviewed evidence is dominated by **active exercise-based preventive components**, particularly neuromuscular training, balance/proprioception, structured warm-up, and strength training. Neuromuscular strategies appeared in 40% of the selected sources, followed by balance/proprioceptive training at 35%, structured warm-up and strength training at 30% each, implementation/adherence at 25%, and load management at 15%.

These frequencies describe the composition of the selected scientific evidence and should not be interpreted as a ranking of effectiveness. A component appearing in a greater number of publications is not necessarily more effective than a less frequently studied strategy. Instead, the results demonstrate that contemporary injury-prevention research commonly combines several physical and behavioral components within the same intervention (Hübscher et al., 2010; Lauersen et al., 2014; Stephenson et al., 2021).

Figure 3.

Comparison of injury-prevention effectiveness according to type of intervention, emphasizing structured warm-up, neuromuscular training, balance/proprioception, and multicomponent programs.

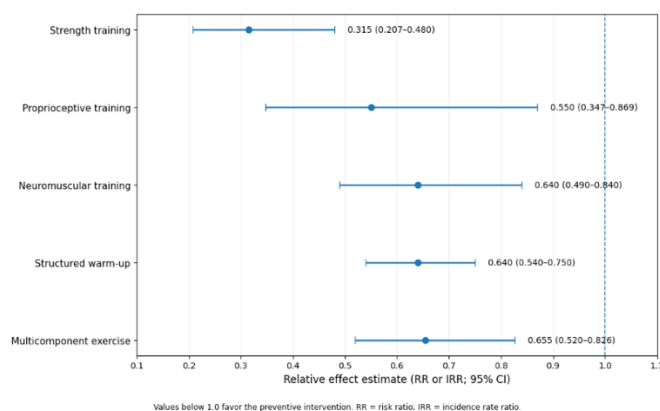


Figure 3 compares the relative effect estimates and **95% confidence intervals (95% CI)** reported for five major exercise-based sports injury-prevention strategies. The vertical reference line at **1.0** represents the absence of difference between the preventive intervention and the comparison condition. Therefore, estimates below 1.0 indicate a lower occurrence of injuries among participants receiving the preventive intervention. The figure includes both relative risks (RR) and incidence rate ratios (IRR), according to the statistical measure reported by the original meta-analyses.

All five interventions presented point estimates below 1.0, and their respective 95% confidence intervals remained below the null value. This pattern indicates that the selected systematic reviews and meta-analyses identified statistically favorable preventive effects for strength training, proprioceptive training, neuromuscular training, structured warm-up programs, and multicomponent exercise interventions. However, these estimates were obtained from different populations and should not be interpreted as the results of a direct head-to-head comparison between all five approaches.

Strength training demonstrated the lowest relative risk, with an RR of 0.315 (95% CI: 0.207–0.480). This corresponds to an estimated relative injury-risk reduction of approximately **68.5%** compared with control conditions. Lauersen et al. (2014) obtained this estimate through a meta-analysis of randomized controlled trials examining several exercise-based injury-prevention strategies. Their overall dataset included 25 trials, 26,610 participants, and 3,464 injuries, and strength-based interventions demonstrated the largest effect among the intervention categories analyzed.

The confidence interval for strength training was also entirely positioned well below the null value of 1.0, ranging from 0.207 to 0.480. Thus, even the upper boundary of the interval represented a considerable reduction in relative injury risk. Within the Lauersen et al. (2014) analysis, this estimate was more pronounced than those observed for proprioceptive or multicomponent interventions. Nevertheless, the result refers to the trials and populations included in that particular meta-analysis and does not indicate that strength training alone should necessarily replace other preventive components.

Proprioceptive training produced an RR of 0.550 (95% CI: 0.347–0.869), corresponding to an estimated **45% relative reduction in injury risk.** Although its confidence interval was wider than that observed for several other interventions shown in the figure, the upper limit remained below 1.0. This finding indicates a statistically favorable preventive effect in the trials synthesized by Lauersen et al. (2014). Proprioceptive training commonly involves exercises designed to improve joint-position awareness, postural stability, sensorimotor responses, and dynamic control during movement.

Neuromuscular training showed an IRR of 0.64 (95% CI: 0.49–0.84). Emery et al. (2015) obtained this estimate from a systematic review and meta-analysis of 25 studies examining neuromuscular injury-prevention strategies in youth sport. The pooled result corresponds to approximately a **36% reduction in the rate of lower-extremity injuries.** The confidence interval remained below 1.0, supporting a statistically significant preventive effect within the analyzed youth sporting populations.

Neuromuscular interventions generally incorporated combinations of balance, strength, agility, coordination, movement control, and sport-specific exercises. Therefore, the estimate represented in Figure 3 should be interpreted

as the effect of structured neuromuscular programs rather than one isolated exercise. Emery et al. (2015) additionally emphasized that implementation and sustained use of such programs remain important challenges, indicating that preventive efficacy must be accompanied by adequate uptake and maintenance.

Structured warm-up programs also demonstrated an IRR of 0.64, although with a narrower 95% confidence interval of **0.54–0.75**. Ding et al. (2022) synthesized 15 studies involving **21,576 children and adolescents and 3,910 injuries**, finding that warm-up intervention programs reduced sports injury rates by approximately **36%** relative to control or usual warm-up conditions. The pooled effect was statistically significant ($p < 0.001$).

The comparatively narrower interval for structured warm-up programs indicates greater precision around the pooled estimate than that observed for some of the other categories represented in the figure. Nevertheless, Ding et al. (2022) reported considerable heterogeneity among studies, with $I^2 = 82.22\%$, indicating substantial variation in effect estimates across the included investigations. The authors also identified compliance as a significant moderating factor. Participants with adherence greater than 70% demonstrated an IRR of 0.56, whereas those with lower compliance had an IRR of 0.81. These data demonstrate substantial variability in preventive outcomes within the overall pooled result.

Finally, **multicomponent exercise interventions presented an RR of 0.655 (95% CI: 0.520–0.826)**, corresponding to an estimated relative injury reduction of approximately **34.5%**. This category included programs combining multiple preventive exercise exposures rather than relying exclusively on strength, proprioception, or another isolated component. Lauersen et al. (2014) found that these interventions produced a statistically favorable reduction in sports injuries compared with control conditions.

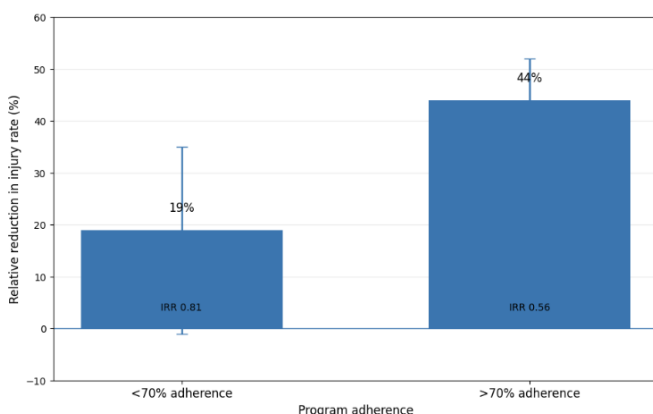
An important feature of Figure 3 is that the confidence intervals of several interventions overlap substantially. For example, the estimates for neuromuscular training, structured warm-up, proprioceptive training, and multicomponent exercise occupy overlapping statistical ranges. Consequently, differences between their point estimates cannot by themselves be interpreted as evidence that one strategy is statistically superior to another. Formal comparisons between interventions would require trials or network meta-analyses designed specifically to evaluate relative effectiveness.

Similarly, the apparently larger effect associated with strength training should be interpreted in the context of differences in study design, population characteristics, sport type, intervention dosage, injury definition, and duration of follow-up. Lauersen et al. (2014) themselves reported heterogeneity in the overall injury-prevention evidence. The appropriate interpretation is therefore that several forms of structured exercise demonstrate preventive efficacy, while the magnitude of the observed effect varies according to the intervention and research context.

The figure also illustrates that **structured prevention consistently performed better than the null condition** within the selected evidence. None of the five confidence intervals crossed the value of 1.0. In descriptive terms, the estimated reductions ranged from approximately **34.5% for multicomponent exercise to 68.5% for strength training**, with neuromuscular and structured warm-up programs both showing reductions of approximately 36% and proprioceptive training approximately 45%.

Figure 4.

Relationship between adherence to preventive programs and expected injury-prevention effectiveness.



Derived from Ding et al. (2022): >70% adherence IRR 0.56 (95% CI 0.48–0.67); <70% adherence IRR 0.81 (95% CI 0.65–1.01).

Figure 4 presents the relationship between adherence to structured injury-prevention programs and the magnitude of reduction in sports injury rates. The data were derived from the subgroup analysis reported by Ding et al. (2022), in which compliance with preventive warm-up interventions was categorized as **greater than 70% or lower than 70%**. A clear difference was observed between both groups, with higher adherence being associated with a substantially greater preventive effect.

Participants with **greater than 70% adherence** demonstrated an incidence rate ratio (IRR) of **0.56 (95% CI: 0.48–0.67)**. Expressed as relative injury-rate reduction, this corresponds to approximately **44% fewer injuries** compared with the corresponding control conditions. Transformation of the confidence interval indicates an estimated reduction ranging from approximately **33% to 52%**, demonstrating that the entire interval remained on the side favoring the preventive intervention.

In contrast, participants with **less than 70% adherence** demonstrated an IRR of **0.81 (95% CI: 0.65–1.01)**, equivalent to an estimated injury-rate reduction of approximately **19%**. The transformed confidence interval ranges from approximately **–1% to 35%**. Importantly, because the original upper confidence limit reached 1.01, this subgroup's interval crossed the null value of 1.0, indicating greater statistical uncertainty regarding the magnitude of protection when adherence was lower.

The absolute difference between the point estimates shown in the figure was therefore approximately **25 percentage points**: a 44% relative injury-rate reduction among participants with adherence above 70%, compared with 19% among those with lower adherence. In relative terms, the observed preventive reduction in the high-adherence subgroup was more than twice that identified in the lower-adherence subgroup.

The subgroup comparison performed by Ding et al. (2022) also showed that **compliance was the moderating factor with a discernible between-group difference ($p = 0.01$)**. This result distinguishes adherence from several other characteristics examined in their analysis and quantitatively demonstrates that the degree to which participants actually complete the prescribed preventive program is closely related to the injury outcomes observed.

These results are consistent with broader implementation evidence. Lutz et al. (2024) systematically reviewed **68 studies** addressing the dissemination and implementation of neuromuscular injury-prevention warm-ups in youth team sports. The authors identified time restrictions, limited perceived benefit, and lack of support or organizational buy-in among the principal barriers to implementation. Conversely, comprehensive workshops and accessible educational resources were among the most commonly identified facilitators.

Lutz et al. (2024) further reported that implementation strategies based on **workshops with supplementary resources** and those combining workshops, resources, and in-season personnel support were associated with injury reductions ranging approximately from **36% to 72%**, with greater adherence corresponding to greater effectiveness. This observation reinforces the quantitative pattern represented in Figure 4 and demonstrates that adherence is relevant not only during controlled trials but also when prevention programs are introduced into routine sporting environments.

The data therefore show that the effectiveness of preventive interventions depends not exclusively on the exercises included in the program but also on the **degree of exposure to the prescribed intervention**. A participant who completes a structured warm-up only occasionally receives a substantially lower preventive dose than an individual who performs it consistently throughout training or competition periods. From a descriptive perspective, this explains why two populations using the same general preventive strategy may obtain different injury outcomes.

Adherence also represents an important methodological variable when comparing studies. If one investigation reports limited injury reduction but participants completed only a small proportion of the recommended sessions, the observed result cannot be interpreted in the same manner as a trial in which the protocol was performed consistently. Consequently, compliance rates provide essential contextual information for understanding the effectiveness reported in sports injury-prevention research.

The difference displayed in Figure 4 is particularly relevant because many evidence-based preventive programs are relatively short and are intended to be incorporated into normal training routines. Their benefits are therefore dependent on repeated execution over time rather than a single exposure. Neuromuscular warm-up programs require consistent practice to repeatedly stimulate balance, strength, coordination, movement control, and functional stability.

The systematic review by Lutz et al. (2024) also demonstrates that adherence is influenced by factors beyond individual motivation. Coaches, instructors, organizations, availability of resources, time constraints, educational strategies, and perceived benefits can determine whether a preventive program is implemented as intended. In the 68 studies examined, workshops and easily accessible resources were repeatedly identified as important implementation mechanisms.

Figure 4 consequently documents a measurable **adherence–effectiveness gradient** within the reviewed evidence. Higher adherence (>70%) was associated with an estimated 44% reduction in injury rates, whereas lower adherence (<70%) was associated with an estimated 19% reduction. In addition, the confidence interval for the high-adherence subgroup remained completely compatible with a protective effect, whereas the lower-adherence subgroup showed greater uncertainty and included the null value.

These results establish adherence as one of the most important implementation variables identified in the reviewed literature. The figure does not determine causality independently, nor does it imply that a 70% threshold represents a universal cutoff applicable to every sport or population. Rather, it graphically reproduces the subgroup categories used in the underlying meta-analysis and demonstrates that greater completion of the prescribed intervention was associated with substantially more favorable injury outcomes.

Figure 5.

Distribution of preventive strategies across individual, community/organizational, and public health policy levels.

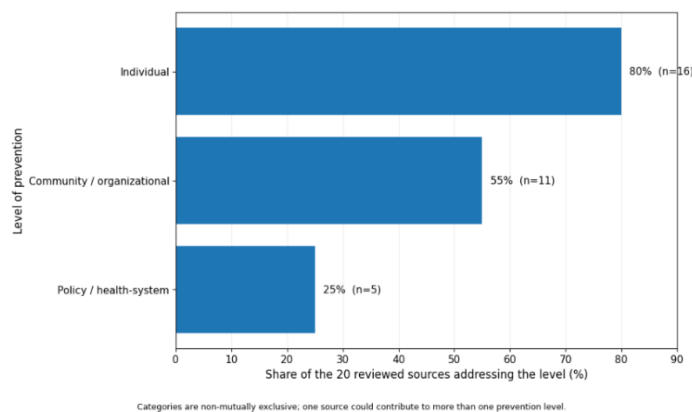


Figure 5 presents the distribution of the 20 reviewed sources according to the level at which sports injury-prevention strategies were primarily addressed: **individual, community/organizational, and policy/health-system levels**. The categories were considered non-mutually exclusive because several publications analyzed interventions operating simultaneously at more than one level. Consequently, the percentages represent the proportion of reviewed sources addressing each category and are not expected to sum to 100%.

The **individual level was the most frequently represented category**, appearing in **80% of the reviewed sources (n = 16)**. This predominance reflects the strong emphasis of sports injury-prevention research on interventions directly applied to physically active individuals, including strength training, neuromuscular exercises, balance, proprioception, structured warm-up, appropriate equipment, health screening, and regulation of training loads.

Exercise-based interventions constituted the largest portion of this individual-level evidence. Lauersen et al. (2014) demonstrated significant preventive effects for strength, proprioceptive, and multicomponent exercise interventions, while Hübscher et al. (2010) identified favorable effects associated with neuromuscular training. Similarly, Emery et al. (2015) reported reduced lower-extremity injury rates among young athletes participating in neuromuscular prevention programs. These studies directly focused on modifying individual physical capacities and movement-related risk factors.

Specific anatomical injury prevention was also predominantly represented at the individual level. Balance and proprioceptive exercises have been evaluated particularly for ankle injury prevention, with systematic reviews demonstrating reductions in ankle sprain incidence among physically active populations (Bellows & Wong, 2018; Vasconcelos et al., 2018; Al Attar et al., 2022). These interventions target modifiable factors such as postural stability, sensorimotor control, and joint-position awareness.

Structured warm-up interventions also contributed substantially to the individual-level category. Soligard et al. (2008) evaluated a comprehensive warm-up program in young female football players, while Sadigursky et al. (2017) and Thorborg et al. (2017) examined the FIFA 11 and FIFA 11+ programs. Ding et al. (2022) further demonstrated that structured warm-up interventions were associated with an overall reduction in injury rates among children and adolescents. Although these programs can be delivered collectively, their immediate preventive mechanisms operate through changes in the participant's strength, balance, neuromuscular control, coordination, and movement preparation.

The **community and organizational level was represented in 55% of the reviewed sources (n = 11)**. This category included studies addressing the role of coaches, schools, sports organizations, instructional programs, implementation strategies, organized training environments, and other structures responsible for delivering or maintaining preventive interventions.

The distinction between individual and organizational prevention was particularly evident in research examining program adherence. An intervention may be physiologically directed toward an individual participant, while its successful delivery depends on coaches, instructors, teachers, clubs, or other organizations. Finch (2006) emphasized this distinction by proposing that injury-prevention research should extend beyond demonstrating efficacy and examine the translation of preventive interventions into real-world sporting practice.

The systematic review conducted by Lutz et al. (2024) provides a clear example of the organizational dimension of prevention. Their analysis examined strategies used to disseminate and implement neuromuscular injury-prevention warm-ups in youth team sports. Workshops, educational materials, personnel support, and organizational engagement were among the mechanisms identified for improving program implementation and adherence. Therefore, prevention was not limited to the exercise performed by the participant but also included the organizational conditions necessary for consistent delivery.

Adherence findings also demonstrated the overlap between individual and organizational factors. Ding et al. (2022) reported that participants with adherence above 70% experienced a larger reduction in injury rates than those with lower compliance. Although adherence is measured at the participant level, the reviewed implementation evidence indicates that compliance may be influenced by supervision, time availability, instructor knowledge, accessibility of resources, and institutional support (Ding et al., 2022; Lutz et al., 2024).

The organizational category also included structured programs delivered through teams, schools, and sports environments. The FIFA 11+ represents an example in which coaches and organizations can integrate injury-prevention exercises into normal warm-up routines rather than requiring independent clinical sessions. Evidence from randomized trials and systematic reviews has documented reductions in injuries when these structured programs are implemented consistently (Soligard et al., 2008; Sadigursky et al., 2017; Thorborg et al., 2017).

The **policy and health-system level was represented in 25% of the reviewed sources (n = 5)**. This was the least frequently represented category in the selected literature. Publications included in this level addressed broader systems of physical activity promotion, health screening, injury-prevention frameworks, environmental conditions, and policies capable of influencing safe participation at population scale.

The World Health Organization's *Global Action Plan on Physical Activity 2018–2030* was one of the principal sources representing this level. The framework organizes population-level physical activity action around the development of **active societies, active environments, active people, and active systems**, emphasizing coordinated interventions involving governments, communities, transportation, urban planning, education, healthcare, and recreational settings (World Health Organization, 2018).

Similarly, the *WHO Guidelines on Physical Activity and Sedentary Behaviour* provide population recommendations for children, adolescents, adults, older adults, pregnant and postpartum women, and individuals living with chronic conditions or disabilities. The guidelines establish physical activity promotion within a broader public health framework rather than restricting recommendations to athletic or competitive populations (World Health Organization, 2020).

Health-system participation was additionally represented by recommendations concerning preparticipation screening. Riebe et al. (2015) described an updated approach to exercise preparticipation health screening based on current physical activity, known disease, signs or symptoms, and intended exercise intensity. This approach represents an intersection between individual risk assessment and healthcare-system strategies designed to facilitate safe participation in physical activity.

The distribution shown in Figure 5 therefore demonstrates a progressive decrease in the number of sources from the individual to the systems level. **Sixteen of the 20 references addressed individual-level prevention, 11 addressed community or organizational components, and five incorporated policy or health-system perspectives.** Expressed proportionally, these values correspond to **80%, 55%, and 25%, respectively.**

This distribution also demonstrates that the evidence reviewed was primarily generated around interventions that directly modify physical or behavioral risk factors. Strength, proprioception, neuromuscular control, warm-up, balance, and workload regulation were considerably more prominent than studies specifically evaluating public policies or large-scale health-system interventions.

However, considerable overlap was observed between levels. A structured warm-up program may simultaneously represent an individual intervention because participants perform the exercises, an organizational intervention because coaches or schools implement the protocol, and a broader health-promotion strategy when incorporated into standardized community programs. For this reason, the three categories were analyzed as complementary rather than mutually exclusive.

DISCUSIÓN

The findings of this review indicate that sports injury prevention in the general population is most effective when it is approached as a **multicomponent process rather than as a single isolated intervention**. Across the analyzed evidence, strength training, neuromuscular exercises, balance and proprioception, structured warm-up programs, appropriate progression of training loads, and sustained adherence were consistently associated with reductions in injury risk. These findings support the hypothesis that injury prevention is enhanced when several modifiable risk factors are addressed simultaneously (Hübscher et al., 2010; Lauersen et al., 2014; Stephenson et al., 2021).

One of the most notable findings was the magnitude of the preventive effect associated with **strength training**. The pooled estimate reported by Lauersen et al. (2014) corresponded to an approximate 68.5% relative reduction in injury risk, which was greater than the reductions observed for proprioceptive and multicomponent exercise interventions in the same meta-analysis. This finding reinforces the importance of muscular capacity as a determinant of the ability to tolerate mechanical demands during physical activity. However, it should not be interpreted as evidence that strength training should be used independently. In practice, strength is frequently integrated with balance, coordination, neuromuscular control, and progressive exposure to sport-specific movement.

The results regarding **neuromuscular training** were also consistent with previous research. Emery et al. (2015) reported an incidence rate ratio of 0.64 for lower-extremity injuries, equivalent to an approximate 36% reduction. Neuromuscular interventions improve movement control and dynamic stability and frequently incorporate several complementary exercises. This supports their potential application beyond competitive sport, particularly in recreational programs where participants may have heterogeneous levels of physical preparation.

Similarly, structured warm-up programs demonstrated clinically relevant reductions in injury occurrence. Ding et al. (2022) reported approximately a 36% reduction in injury rates among children and adolescents participating in preventive warm-up programs. The FIFA 11+ provides a practical example of this approach because it incorporates strength, balance, running, and neuromuscular exercises within a routine that can be completed before normal sporting activity (Sadigursky et al., 2017; Thorborg et al., 2017). Its relevance extends beyond football because it demonstrates that preventive strategies can be integrated into existing routines without requiring extensive equipment or separate training sessions.

A particularly important result was the relationship between **adherence and preventive effectiveness**. In the analysis by Ding et al. (2022), adherence above 70% was associated with an approximate 44% reduction in injury rates, compared with approximately 19% among participants with lower adherence. This difference indicates that the efficacy of a program cannot be separated from the frequency and consistency with which it is performed. A theoretically effective intervention may produce limited results when implementation is irregular.

This observation is consistent with the implementation literature. Lutz et al. (2024) demonstrated that adherence to neuromuscular injury-prevention warm-ups is influenced by educational resources, workshops, organizational support, supervision, and the perceived value of the intervention. Therefore, the effectiveness of injury-prevention programs should not be considered exclusively a physiological issue. Behavioral and organizational determinants influence whether participants actually receive an adequate preventive dose.

The distribution of evidence across prevention levels also revealed a marked predominance of **individual-level interventions**. Most of the reviewed sources focused on modifying physical characteristics or behaviors of participants, whereas fewer publications directly evaluated community, organizational, or public policy strategies. This imbalance is understandable because exercise-based interventions can be tested more easily through randomized controlled trials. However, it also represents an important limitation in the available evidence because widespread injury reduction depends on more than individual behavior.

Finch (2006) argued that sports injury-prevention research must examine the conditions required to translate effective interventions into practice. The present findings strongly support this perspective. A preventive program may demonstrate substantial efficacy under controlled conditions, but its population impact will remain limited if coaches, schools, fitness centers, community organizations, or healthcare systems do not integrate it into routine practice. Therefore, successful injury prevention requires a transition from **efficacy to implementation and sustainability**.

This issue is particularly relevant in the general population. Recreational participants often exercise without specialized supervision and may receive inconsistent information regarding warm-up, load progression, recovery, or injury prevention. Individuals beginning physical activity after prolonged inactivity may also increase intensity too rapidly, especially when motivated by rapid improvements in fitness or body composition. The load-management principles described by Soligard et al. (2016) are therefore relevant beyond elite sport because tissue adaptation depends on progressive exposure and adequate recovery.

Previous injury also deserves consideration because it can increase the likelihood of recurrence when functional deficits persist. The evidence supporting balance and proprioceptive training for ankle injury prevention illustrates the importance of identifying previous injuries and incorporating targeted preventive exercises (Bellows & Wong, 2018; Vasconcelos et al., 2018; Al Attar et al., 2022). In the general population, these strategies may be particularly useful because they can often be implemented with minimal equipment and adapted to home or community environments.

The findings also support the need to avoid overly restrictive approaches to preparticipation screening. Physical inactivity itself represents a major public health problem, and prevention policies should not create unnecessary barriers to exercise. The approach proposed by Riebe et al. (2015), which considers symptoms, current activity level, known disease, and intended exercise intensity, provides a more individualized framework for identifying individuals who may require additional medical evaluation while permitting most people to participate safely.

At the policy level, injury prevention should be integrated with broader strategies for physical activity promotion. The World Health Organization (2018, 2020) emphasizes the creation of active societies, environments, people, and systems. Within this framework, injury prevention can be incorporated through safe recreational infrastructure, quality physical education, appropriately maintained exercise spaces, professional training, public information, accessible community programs, and health services capable of providing preventive guidance.

An important challenge is maintaining the balance between **risk reduction and participation promotion**. Presenting physical activity primarily as a potential source of injury could discourage individuals from exercising, contradicting established public health objectives. The appropriate approach is therefore to communicate that most people can obtain substantial health benefits from regular physical activity while reducing avoidable risks through progressive training, adequate preparation, recovery, and evidence-based prevention strategies (World Health Organization, 2020).

The results also suggest that prevention programs intended for population-wide implementation should prioritize **simplicity, accessibility, low cost, and adaptability**. Highly specialized interventions may demonstrate effectiveness but have limited scalability when they depend on expensive equipment or continuous professional supervision. In contrast, structured warm-ups, progressive strengthening, balance exercises, and basic load-management education can potentially be integrated into schools, gyms, community sports programs, and recreational environments.

Several limitations must be considered when interpreting the findings. First, the reviewed studies included heterogeneous populations, sports, age groups, intervention durations, and injury definitions. Consequently, effect estimates obtained from one population cannot be transferred directly to every recreational or community setting. Second, much of the strongest evidence originated from organized sports, particularly football and youth athletics, which limits direct generalization to the entire population.

Third, the effect estimates presented in the figures originated from different systematic reviews and meta-analyses rather than from a single direct comparison. For this reason, the graphical differences between strength training, proprioception, neuromuscular training, and structured warm-up should not be interpreted as definitive evidence that one intervention is universally superior. Differences in study design, population characteristics, adherence, and intervention dosage may partially explain variation between estimates.

Another limitation is that evidence regarding **policy-level interventions remains less extensive** than the literature concerning exercise-based strategies. While international recommendations support safer environments and stronger systems for physical activity promotion, additional research is needed to determine which combinations of policy interventions most effectively reduce sports and exercise-related injuries while maintaining participation.

Future research should therefore prioritize pragmatic studies conducted in **community and general-population environments**. Schools, public sports centers, gyms, primary healthcare settings, recreational leagues, and municipal physical activity programs provide important opportunities to evaluate real-world implementation. Studies should report not only injury rates but also adherence, participant characteristics, intervention costs, accessibility, feasibility, and long-term maintenance.

Further investigation is also needed to determine the optimal frequency, intensity, duration, and progression of preventive programs for different age groups and levels of physical activity. Personalized approaches may be especially

valuable for individuals with previous injuries, older adults, people returning to exercise after prolonged inactivity, and those with limited baseline physical capacity.

Overall, the findings support the central hypothesis of this review. **Multicomponent programs that incorporate strength, neuromuscular training, balance, proprioception, structured warm-up, progressive workload management, and high adherence provide the most coherent evidence-based model for sports injury prevention.** Their potential impact becomes greater when supported by educational, organizational, environmental, and public health strategies.

Sports injury prevention should therefore move beyond the traditional model in which responsibility falls exclusively on the individual participant. A comprehensive approach requires coordination between healthcare professionals, coaches, educators, fitness professionals, sports organizations, communities, and public institutions. Such integration can contribute to reducing preventable injuries while preserving the cardiovascular, metabolic, psychological, and functional benefits associated with regular physical activity (World Health Organization, 2018, 2020).

CONCLUSIÓN

Sports injury prevention in the general population should be considered an essential component of health promotion and not an isolated concern limited to competitive athletes. The evidence reviewed demonstrates that structured preventive interventions can reduce the occurrence of sports and exercise-related injuries while allowing individuals to maintain the benefits associated with regular physical activity.

Among the strategies analyzed, strength training, neuromuscular exercises, balance and proprioception, structured warm-up programs, and appropriate progression of training loads showed the most consistent preventive value. The findings also demonstrated that adherence is a critical determinant of effectiveness, since participants who complete preventive programs more consistently tend to obtain greater reductions in injury rates.

The review further showed that prevention is currently concentrated mainly at the individual level, while fewer studies address community, organizational, policy, and health-system interventions. This highlights the need to expand prevention beyond personal responsibility and incorporate strategies within schools, sports organizations, fitness centers, community programs, healthcare services, and public institutions.

Effective prevention should therefore combine physical preparation with education, appropriate supervision, safe environments, accessible resources, and organizational support. Programs intended for the general population should be simple, adaptable, low-cost, and feasible to maintain over time, particularly because many recreational participants do not have continuous access to specialized sports medicine services.

The results support the proposed hypothesis that **multicomponent injury-prevention programs, particularly when accompanied by sustained adherence and appropriate implementation strategies, provide a more comprehensive preventive model than isolated interventions.** However, differences between populations, sports, intervention protocols, and study designs indicate that preventive strategies should be adapted to individual and contextual characteristics rather than applied uniformly.

From a public health perspective, promoting physical activity and preventing injuries are complementary objectives. Policies should encourage participation while simultaneously improving safety through appropriate infrastructure, education, progressive exercise recommendations, professional training, and access to preventive guidance. The objective should not be to eliminate all physical risk, but to reduce avoidable injuries without creating unnecessary barriers to active lifestyles.

Future research should place greater emphasis on real-world implementation in recreational and community settings, including evaluation of adherence, feasibility, cost, equity, accessibility, and long-term sustainability. Greater evidence is also needed regarding policy-level interventions capable of translating effective preventive programs into population-wide practice.

In conclusion, the most effective approach to sports injury prevention is a **multilevel and integrated model** in which individuals, healthcare professionals, educators, sports organizations, communities, and public institutions share responsibility for creating safer opportunities for physical activity. Integrating evidence-based preventive programs into health-promotion policies can contribute to reducing preventable injuries, maintaining participation, and maximizing the long-term physical, psychological, and social benefits of an active population.

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