

Lower limb risk prevention in athletes: evaluation and strategies

Umile Giuseppe Longo^{1,2}, Rocco Papalia^{1,2}, Sergio De Salvatore^{1,2}, Alessandra Greco^{1,2}, Martina Marino^{1,2}, Marco Bravi^{1,2}, Fabio Santacaterina^{1,2}, Vincenzo Denaro^{1,2}

¹ Research Unit of Orthopaedic and Trauma Surgery, Fondazione Policlinico Universitario Campus Bio-Medico, Rome, Italy; ² Research Unit of Orthopaedic and Trauma Surgery, Department of Medicine and Surgery, Università Campus Bio-Medico, Rome, Italy

ABSTRACT

Risk prevention of sports-related lower limb musculoskeletal injuries in adult and youth athletes is an important topic encompassing health and economic factors. For example, muscle injuries in professional football players could expose these athletes to recurrence, creating a significant economic problem for the football club. Such observations have led to the development of prevention programs, predominantly exercise-based injury prevention strategies, which may be multi-component or single-component. These programs focus on intrinsic risk factors, such as strength deficits, lack of flexibility, poor balance, coordination, endurance, previous injury, body size, anatomical alignment issues, foot shape, age, and sex. The FIFA 11+ program is an important example of an exercise-based program. It was developed under the leadership of the Fédération Internationale de Football Association with the aim of evaluating and, where necessary, implementing preventive training routines for soccer players. Despite the program being designed for soccer players, it has shown efficacy in other sports too. Many studies also emphasize the importance of identifying and avoiding extrinsic risk factors related to type and level of activity, shoe type, bracing equipment, etc. Understanding of the incidence, the severity, and the etiology of a specific injury is required in order to provide adequate prevention measures and to reduce the need for surgery. The present study focuses explicitly on identifying and evaluating possible interventions for lower limb injuries.

KEYWORDS

Lower limb, exercise program, exercise therapy, strategies, FIFA, stretching.

Introduction

Risk prevention of sports-related lower limb musculoskeletal injuries in adult and youth athletes is an important topic encompassing health and economic factors. For example, muscle injuries in professional football players could expose these athletes to recurrence, creating a significant economic problem for the football club^[1]. Furthermore, injuries in childhood and adolescence could negatively impact the individual's quality of life due to incomplete recovery and residual symptoms that can influence mobility in adulthood^[2].

Different types of sport lead to specific musculoskeletal injuries; those seen in basketball, for example, are related to the fact that players need to change direction or action every 2–3 seconds^[3]. In football, muscle and tendon injuries show a high incidence compared with other lesions^{1,4}. In this setting, improper warm-ups, muscle fatigue, and muscle imbalance are considered to be leading causes of non-traumatic injuries^[4].

Such observations have led to the development of prevention programs, predominantly exercise-based injury prevention strategies, which may be multi-component or single-component. Such programs often focus on increasing strength, on improving balance, and ideally on whole-body biomechanics^[5].

They focus on a range of intrinsic risk factors, such as strength deficits, lack of flexibility, poor balance, coordination, endurance, previous injuries, body size, anatomical alignment

Article history

Received 27 Nov 2021 – Accepted 11 Feb 2022

Contact

Umile Giuseppe Longo; g.longo@policlinicocampus.it
Tel: +39 06 225411613; Fax: +39 06 225411638

issues, foot shape, age, and sex^[6]. Many studies also emphasize the importance of identifying and avoiding extrinsic risk factors related to type and level of activity, shoe type, bracing equipment, etc.

Yeoung *et al.* suggest the use of a four-stage method in the prevention of sports-related injuries. To provide adequate prevention measures^[6] and to reduce the need for surgery^[7,8], it is necessary to understand the incidence, severity and etiology of a specific injury. The present study focuses explicitly on identifying and evaluating possible interventions for lower limb injuries.

Exercise-based muscle injury prevention strategies

Exercise-based programs are mainly concerned with improving whole-body biomechanics^[5,9,10]. Most of them include multiple training components, targeting aspects such as mobil-

ity, balance, and strength^[5]. The importance of warm-up routines has been indicated by several studies, which point out that most non-traumatic injuries occur during the first and last 15 minutes of exercise. These data highlight the critical role of warming up and the role of fatigue in injuries.

Multifaceted programs are hypothesized to be the most effective in preventing injuries to the anterior cruciate ligament (ACL) and the hamstring (HAM). These programs include different types of exercises involving several muscle actions^[11]. Although the risk of both ACL and HAM injuries is inversely associated with the hamstring-to-quadriceps strength ratio, exercises focusing on strength alone have not been shown to be of significant help in minimizing injuries^[11].

Stretching

Stretching exercises were tested by Yeung *et al.* who unfortunately reported no evidence that stretching the lower limb muscles effectively reduces lower limb injuries^[12]. Furthermore, Herman *et al.* underline the insufficiency of stretching alone for injury prevention, even though stretching has traditionally been advocated as effective and used as part of warm-up routines^[13]. In a systematic review, studies that stated the usefulness of stretching as a tool for injury prevention were evaluated and found to show a high risk of bias; they were thus considered unreliable^[1]. In another review, conditioning exercises were not found to make a decisive difference in reducing the number of injuries involving the lower limbs^[12].

FIFA 11+

The FIFA 11+ program was developed under the leadership of the Fédération Internationale de Football Association to evaluate and, where necessary, implement preventive training routines for soccer players. This program is structured as 15 exercises which form a complete warm-up procedure^[4].

Sadigursky *et al.* systematically reviewed the literature on this topic to explore in depth this warm-up strategy and take stock of its effectiveness^[4]. The study found that the risk of injury was reduced by 30% in soccer players who took part in the program. However, the authors also highlighted the importance of performing the routine following the existing standards. Heterogeneity in results could be attributed either to clinical factors inherent to the sample (such as sex, age, BMI, and clinical characteristics of the injuries) or to absence of a protocol or a lack of motivation among trainers and players.

Although the program is designed for soccer players, its efficacy in other sports has been proved as well^[4]. Longo *et al.* tested, for the first time, the efficacy of the FIFA 11+ program in the prevention of injuries in basketball players. Their study found no significant improvement in the rates of match injuries, knee injuries, ankle injuries, and overuse injuries; however, the results were auspicious in relation to lower extremity, trunk, leg, hip, and groin injuries^[13]. In addition, no significant injuries were observed among players who followed the FIFA 11+ protocol.

Neuromuscular warm-up strategies

Neuromuscular training programs seem to show promising effects in the field of injury prevention. Studies have postulated decreased strength, coordination, and delayed neuromuscular activation. Studies have reported that decreased strength, motor coordination, and neuromuscular activation due to fatigue negatively affect the risk of lower extremity injury^[14]. Suggested programs seem to improve joint position sense, enhance joint stability and develop protective joint reflexes, all reducing the risk of injury^[14].

Herman *et al.* reviewed nine articles that combined included amateur football, basketball, and volleyball players and army recruits. The authors concluded that several strategies (including FIFA 11+) appear to be effective and might reduce lower limb overuse in female football players. The ‘Knee Injury Prevention Program’ strategy may reduce non-traumatic, overall, and overuse of lower limb injuries. The ‘Prevent Injury and Enhance Performance’ program may reduce ACL injuries, and the ‘Anterior Knee Pain Prevention Training Program’ may reduce the incidence of anterior knee pain.

Despite these findings, Herman highlighted the need for an updated systematic review of the available literature, focusing on neuromuscular warm-up strategies. These methods seem to have the potential to prevent lower limb injuries and their implementation appears somewhat realistic. Such a review should also discuss and create the basis for further guidelines for specific neuromuscular warm-up strategies.

Risk prevention in female athletes

As previously mentioned, sex can be an intrinsic factor in lower limb injuries, thanks to the dynamic interactions of multiple risk factors in these pathologies^[15,16]. It has been demonstrated that women have a higher risk of knee and ankle injuries than men, while the latter more often suffer hamstring and groin injuries^[5].

Crossely *et al.*^[5] evaluated exercise-based injury prevention programs in women’s football. They performed a meta-analysis and evaluated programs focusing on improving strength and whole-body biomechanics during activities or sports entailing changing direction movements. Specifically, nine studies looked at neuromuscular exercise-based training involving multiple components and at exercise-based training components in general.

The application of the exercise-based programme included in the meta-analysis by Crossely^[5], resulted in 22% reduction in overall injuries (n=11773). Single-component and multi-component exercise-based strategies reduced hamstring injuries by 60%.

In addition, no significant statistical association was found between the number of exercise-based training components included in the intervention and reduction in overall injuries^[5]. Some association was found between a high number of training components and knee injury, and even though the relationship was not statistically significant; the authors recommended further studies be carried out in this regard.

Risk prevention in youth athletes

Age can have a significant impact on injury. Injuries in youth athletes differ from those seen in adults due to anatomical and physiological differences^[6]. These injuries could result in progressive, permanent damage as the skeleton grows, influencing bone and soft tissue. For example, epiphyseal growth plate disorders can result in limb length discrepancy, angular deformity, altered joint mechanics, and marked long-term disability^[2,17]. Up to 30–40% of injuries in children and adolescents occur during sports; the percentage is higher in adolescents than in children^[2].

Extrinsic risk factors include training schedules of over 18 hours a week, use of faulty equipment, not enforcing rules, and lack of supervision, while growth spurts constitute a major intrinsic factor^[2,17]. Hanlon *et al.* identified FIFA 11+ as the widely most used training program and found that application of exercise-based injury prevention programs decreased injury rates by up to 46%. In addition to this, the study identified modifiable risk factors for lower extremity injuries; these included force generation, coordination, posture, balance, speed, and endurance. All of these, except endurance, were seen to be improved with the aforementioned program^[6].

In addition to implementing a training program, aspects such as training duration, intensity and frequency, as well as recovery, should be carefully evaluated and modified based on the child. To maximize the benefit and minimize the risk of injury, it is essential also to have ways of identifying high-risk athletes; and it may also be crucial to educate coaches and parents in these matters^[2,17].

Conclusion

Several training programs contribute to the reduction of injuries in athletes involved in various sports. In particular, the FIFA 11+ program and several neuromuscular warm-up strategies, like the KIPP program, have been shown to be effective. It is essential to highlight that any kind of program strongly depends on clinical factors inherent to the sample (as sex and age, which play a significant role), but above all, on the commitment and motivation of trainers and athletes to adhere to its protocol.

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Acknowledgments: Nothing to declare

Conflict of Interest: Nothing to declare