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 Poli clinico 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 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.

Yeong et al. suggest the use of a four-stage method in the prevention of sports-related injuries. To provide adequate prevention measures [8] 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 rou-
tines 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 ef-
fective in preventing injuries to the anterior cruciate ligament
(ACL) and the hamstring (HAM). These programs include dif-
ferent 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, ex-
ercises 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 un-
fortunately reported no evidence that stretching the lower limb
muscles effectively reduces lower limb injuries [12]. Further-
more, Herman et al. underline the insufficiency of stretching
alone for injury prevention, even though stretching has tradi-
tionally 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 [4]. In another review, conditioning exer-
cises 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 leader-
ship 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 exer-
cises 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 in-
jury 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 clin-
ical characteristics of the injuries) or to absence of a protocol or
a lack 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 inju-
ries 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
that decreased strength, coordination, and delayed neuromus-
cular activation. Studies have reported that decreased strength,
motor coordination, and neuromuscular activation due to fa-
tigue negatively affect the risk of lower extremity injury [14].
Suggested programs seem to improve joint position sense, en-
hance joint stability and develop protective joint reflexes, all
reducing the risk of injury [14].

Herman et al. reviewed nine articles that combined includ-
ed 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 In-
jury 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 im-
plementation appears somewhat realistic. Such a review should
also discuss and create the basis for further guidelines for spe-
cific 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 mul-
tiple risk factors in these pathologies [15,16]. It has been demon-
strated that women have a higher risk of knee and ankle inju-
ries than men, while the latter more often suffer hamstring and
groin injuries [5].

Crossely et al. [5] evaluated exercise-based injury preven-
tion programs in women’s football. They performed a me-
ta-analysis and evaluated programs focusing on improving
strength and whole-body biomechanics during activities or
sports entails 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=1773). Single-component and multi-
component exercise-based strategies reduced hamstring inju-
ries by 60%.

In addition, no significant statistical association was found
between the number of exercise-based training components in-
cluded 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 fur-
ther studies be carried out in this regard.

Longo UG et al.
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 [8]. 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 [8].

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 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.

References


Acknowledgments: Nothing to declare
Conflict of Interest: Nothing to declare