

Review

Understanding Injuries in Young Female Soccer Players: A Narrative Review on Incidence, Mechanism, Location Risk Factors, and Preventive Strategies

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Abstract: There has been growing interest in understanding the injury profiles of young female soccer players due to their increasing participation in the sport and the unique risk factors they face. This narrative review examines the incidence, mechanisms, and location of injuries in this population, alongside the primary risk factors and effective preventive strategies. Injury incidence is higher during matches than in training sessions, with contact injuries dominating in games and non-contact injuries prevailing in practice. Knee and ankle injuries are the most prevalent, with anterior cruciate ligament (ACL) injuries being particularly concerning due to their frequency and long-term impact. The interplay of intrinsic factors, such as hormonal fluctuations, anatomical characteristics, and biomechanics, with extrinsic factors like training load, surface type, and footwear significantly influences injury risk. Prevention programs, particularly those combining neuromuscular, balance, and strength training, demonstrate high efficacy, provided that adherence is maintained. Moreover, fostering awareness among players, coaches, and stakeholders about psychosocial factors and menstrual health further enhances injury prevention. Tailored strategies addressing the specific needs of young female soccer players are crucial to ensuring their safety, optimizing performance, and supporting their long-term athletic development.



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1. Introduction

Soccer stands as the most popular sport worldwide, boasting approximately 265 million players, and the number of female soccer players is experiencing unprecedented growth [1]. The rapid expansion of female participation spans all levels, from grassroots to elite competitions, solidifying its place as one of the fastest-growing sectors in sports [2]. This remarkable growth reflects not only a societal shift towards greater inclusivity in athletics but also an increasing recognition of the multifaceted benefits that soccer offers. These benefits include enhanced physical conditioning, improved psychological resilience, and the cultivation of social connections. However, with increased participation comes an inevitable rise in the risk of injuries [3]. This could be due to the fact that in soccer, high-intensity actions such as jumping, landing, sprinting, and changes of direction have

a higher prevalence [4], often compounded by physical contact, especially to the lower extremities. These demands are inherent to this sport, significantly contributing to the prevalence of injuries [5]. Moreover, the unique physiological and biomechanical characteristics of female players may predispose them to certain injury types, further amplifying the risk [6]. The risk is particularly pronounced in youth players, where the challenges of individual growth and maturation compound their vulnerability [5,7]. During adolescence, rapid physical development associated with the stage of peak height velocity—a period marked by growth spurts and neuromuscular imbalances—places additional stress on the musculoskeletal system [8]. Epidemiological studies highlight an increase in both injury frequency and severity during this critical phase, underlining the need for specialized attention.

In youth female soccer players, injuries related to the knee and ankle ligaments, as well as thigh muscle strains, are among the most common and concerning [9]. For instance, anterior cruciate ligament (ACL) injuries represent a particularly significant issue due to their long-term implications [10]. Beyond the immediate challenges of pain, rehabilitation, and absence from sport, such injuries drastically increase the risk of early-onset osteoarthritis [11]. This can lead to chronic limitations, negatively affecting not only the player's athletic potential but also their overall quality of life. While injuries in adult soccer players are often assessed in terms of their impact on team performance and success, the developmental consequences of injuries in youth players remain less explored [9]. Nevertheless, it can be reasonably assumed that being sidelined for an extended period, such as over 28 days, during formative years can adversely affect the short-term tactical, technical, and physical development of young players [12]. More critically, these disruptions may also impede long-term health outcomes, career prospects, and progression within the sport [13]. Addressing these risks underscores the importance of injury prevention programs for high-risk injuries to safeguard the immediate well-being and future potential of youth female soccer players [9].

Addressing these challenges necessitates proactive, evidence-based prevention strategies tailored to the unique characteristics of youth female soccer players, whose injury rates often remain underexplored despite the growing participation in the sport. Effective programs should aim to reduce vulnerability by fostering proper movement patterns, neuromuscular control, and dynamic stability [6]. Early interventions, incorporating components such as strength training, balance exercises, and awareness of biomechanics, are particularly crucial during the early stages of organized participation [1,10]. In addition, a comprehensive understanding of key factors—competition demands, training loads, injury epidemiology, and underlying risk mechanisms—is essential for designing targeted strategies [14,15]. By bridging gaps in research and practical implementation, it is possible to promote safer participation, optimize performance, and support the long-term athletic development of youth female soccer players. As women's soccer continues to grow, prioritizing injury prevention is critical to ensuring its sustainable and inclusive future.

This narrative review aims to synthesize the current knowledge on the incidence, burden, mechanisms, location, risk factors, and effective prevention strategies for injuries in youth female soccer players. It seeks to explore and highlight gaps in the literature by emphasizing the unique injury patterns and risks associated with this population, particularly during critical developmental stages. By consolidating findings from epidemiological studies, biomechanical analyses, and evidence-based prevention programs, this review aims to provide a comprehensive understanding of how these factors interconnect. Ultimately, the goal is to guide future research and inform the development of tailored interventions that safeguard young female athletes, promoting their long-term health, performance, and continued engagement in the sport.

2. Materials and Methods

This narrative review was conducted to explore the incidence, burden, mechanisms, and prevention strategies for injuries in youth female soccer players. Articles were identified by searching three electronic databases: PubMed, Scopus, and Web of Science. The search was conducted by four authors without blinding to journal names or manuscript authors and covered articles published before 15 December 2024. The search terms employed included combinations of keywords related to injury epidemiology, mechanisms, and prevention in youth female soccer players: (youth OR young) AND (female OR women) AND (soccer OR football) AND (“injury epidemiology” OR “injury prevention” OR “injury mechanisms” OR “injury incidence”). Additionally, we reviewed reference lists from key studies to identify relevant papers not found in the initial search. While the search primarily targeted studies focused on soccer, we also considered literature from related fields when it provided evidence-based findings, methodological approaches, or theoretical perspectives directly applicable to understanding injury prevention, workload management, or neuromuscular performance in soccer. These criteria ensured that only studies with clear and direct relevance to the research questions were included. After the completion of the database search, articles were imported into Mendeley 2.129.0 for organization. The inclusion criteria were as follows: (i) studies involving youth soccer players aged 10–19 years; (ii) published in peer-reviewed journals; (iii) available in full-text format; and (iv) written in English or Spanish. Studies were excluded if they met any of the following criteria: (i) did not focus on soccer or injuries in youth female players; (ii) addressed non-sports-related topics, such as public health or unrelated injury types; or (iii) contained duplicate records or ambiguous information. The final dataset included studies that explored injury characteristics, epidemiological data, injury mechanisms, and prevention strategies specific to youth female soccer players. This process was similar to that of previous narrative reviews [16–18].

3. Injury Incidence

The incidence of injuries in sports is typically reported as rates per 1000 h of player exposure during matches or training sessions ($(\Sigma \text{injuries} / \Sigma \text{hours}) \times 1000$) [9,19]. Most prior reviews have focused on injury incidence in senior female soccer players (older than 18 years) [20–22]. For example, a systematic review with meta-analysis by Lopez Valenciano et al. [19] reported an overall injury incidence of 6.1 (95% CI 4.6–7.7) injuries per 1000 h of exposure, with rates of 19.2 (95% CI 16–22.4) and 3.5 (95% CI 2.4–4.6) injuries per 1000 h of exposure for matches and training sessions, respectively. Similarly, Hallén et al. [21] observed an injury incidence of 6.7 injuries per 1000 h (95% CI 6.4–7.0) across four consecutive seasons (2018–2021) in 596 players from 15 elite women’s teams in Europe, with rates of 18.4 (95% CI 16.9–19.9) and 4.8 (95% CI 4.5–5.1) injuries per 1000 h for matches and training sessions, respectively.

While physical demands in soccer vary depending on the level of play (e.g., youth, amateur, elite club, international), high injury incidence rates have been consistently reported across all levels [22]. Specifically, elite youth female soccer players exhibit a significantly higher injury incidence during matches (22.4 per 1000 h) compared to training (4.6 per 1000 h) [23]. A study examining 375 players across six soccer academies in age groups (U10–U16) reported an overall incidence of 2.1 injuries per 1000 h (95% CI 1.7–2.5), with match and training rates of 11.5 (95% CI 9.1–14.4) and 1.5 (95% CI 1.2–1.9) injuries per 1000 h, respectively. Similarly, Sprouse et al. [3] analyzed time-loss injuries over eight seasons (2012–2020) in English youth international female players (U15–U19) and found that match injury incidence reached 27.6 ± 11.3 injuries per 1000 h, compared to 5.1 ± 1.8 injuries per 1000 h during training. The burden of injuries during matches (506.7 ± 350.2 days

absent/1000 h) was notably higher than during training (87.6 ± 32.8 days absent/1000 h), reinforcing the increased risk and impact of match play. Furthermore, a group \times season interaction was observed, with higher training injury rates recorded in senior players compared to youth players during certain periods. Complementing these findings, a meta-analysis by López-Valenciano et al. [9] reported an overall injury incidence of 6.77 per 1000 h in youth female players, with match-related injury rates being significantly higher than those in training.

Injury rates systematically increased with age, peaking in the U16 age group at 3.2 injuries per 1000 h (95% CI 2.4–4.2), with a match-specific rate of 13.7 injuries per 1000 h (95% CI 9.6–19.6) [24]. These findings align with previous studies suggesting a relatively low injury risk for players under 12 years [25] and trends observed in male players [26]. Several factors contribute to higher injury rates in more experienced youth players, often referred to as older players in this context, including increased training exposure (4–6 h per week plus 1–2 matches) [27], heightened match demands [28,29], and physiological changes related to growth and maturation [30]. Girls typically attain peak height and body mass around age 15, often without corresponding increases in relative strength [31]. This imbalance can predispose this subgroup to injuries due to soft tissue strain exceeding mechanical tolerance [32]. Therefore, future studies must address the interaction between growth, maturation, and injury risk in female athletes.

In recreational youth female soccer players, higher injury rates have been reported, including 4.6 injuries per 1000 h during matches in 6–16-year-olds [25] and 7.6–9.1 injuries per 1000 h in 13–17-year-olds [6,33]. A recent review by Mandorino et al. [34] highlighted a wide range of injury incidences in female players (1.1–7.2 injuries per 1000 h), with match-specific rates ranging from 2.88 to 30.59 injuries per 1000 h and training sessions rates ranging from 0.74 to 3.47 injuries per 1000 h of exposure. Variability in these findings may be attributed to differences in match formats, training loads, skill levels, and age-related maturity. Similarly, in 12 female soccer teams with players ages 11–14 years, the injury incidence rate was 2.2 per 1000 soccer exposure hours (95% CI 1.5–3.1), with an injury incidence rate of 6.1 (95% CI 3.5–9.9) during games and 1.0 (95% CI 0.5–1.8) during training sessions [35].

The higher variability in injury incidence may be due to several factors. It has been indicated that young players (children aged 6–12 years) participating in five- or seven-a-side soccer show a lower incidence of injuries compared to adolescents aged 13–16 years playing regular 11-a-side soccer [25]. Furthermore, the physical fitness level of the players can influence injury risk, as higher levels of physical fitness have been associated with a greater rate of all injuries (1.3 times higher injury rate) compared to players with lower fitness levels [36]. Several potential reasons, such as increased exposure, higher training loads, more frequent competition, playing with older junior teams, and greater involvement in the game, might explain why more fit players sustain a higher injury rate than their less fit counterparts. Lastly, players with higher soccer skills are at a greater risk of sustaining injuries—particularly contact injuries—than their less skilled teammates [37]. It is possible that skilled players, with more ball possession and active involvement in the game, are more susceptible to tackles and foul play, leading to a heightened risk of injury. These players are consequently more exposed to collisions and other physical duels [37,38].

Adolescence is marked by significant psychological and physiological transformations, resulting in players of the same chronological age being at varying stages of puberty. Consequently, some research has explored the relationship between biological age and injury risk. Materne et al. [39] reported the highest overall injury risk among early maturers. Conversely, Le Gall et al. [12] observed no significant differences in overall injury incidence but noted that early and late maturers might be predisposed to different types of injuries.

Similarly, Johnson et al. [40] found a greater number of injuries in early maturers compared to normal or late maturers, but these differences disappeared after accounting for variables such as training volume, playing time, height, and playing position.

Stronger consensus exists in studies that used the maturity offset method to assess timing of maturation [41]. There is a heightened injury incidence during the circa-PHV phase—a period of rapid growth spurt often referred to as “adolescent awkwardness”. During this stage, motor control strategies are disrupted [42], and the accelerated growth of anatomical structures like bones, tendons, and ligaments increases injury risk in soccer players.

While it is well-recognized that female athletes are more prone to ACL injuries [43] due to hormonal, anthropometric, and biomechanical factors, it remains unclear whether sex differences affect susceptibility to other types of injuries compared to male soccer players. Some studies have found no significant differences between males and females in overall injury rates [25,44,45], although others have reported higher injury rates in females [5,9,46].

A greater injury incidence rate during matches compared to training is a consistent finding in research on female soccer players [6,9,23]. This difference can be attributed to the higher physical demands of matches [4,47], the greater variability and unpredictability of game scenarios when competing against opponents (compared to the familiarity of training with teammates) [9], the number of collisions during matches [48], and the fatigue generated throughout a game [49].

Recently, a systematic review reported an overall meta-analyzed injury incidence rate of 4.4 per 1000 h (95% CI 3.3–5.9) in female athletes across various sports, with a significant moderating effect of sport type. Track and field demonstrated the highest injury incidence rate at 14.8 injuries per 1000 h (95% CI 11.9–18.3) [50]. This higher injury incidence may be attributed to the high, consistent, and monotonous training intensities, durations, and frequencies required in disciplines like track and field [51] and endurance sports [52]. The repetitive nature of such activities increases injury risk. In contrast, team sports typically involve diverse training modalities, including technical, tactical, and physical development training, which might reduce the monotony-related injury risks seen in individual sports [53]. Moreover, team sports often receive greater attention in injury epidemiological research and the development of preventive strategies. Female tennis players, by comparison, exhibited the lowest pooled injury incidence rate, with two injuries per 1000 h (95% CI 0.7–5.1) [50].

4. Injury Severity

Injury severity is defined as the number of days that elapse from the date of injury to the player’s return to full participation in team training and availability for match selection [54]. Classifications typically include slight/minimal (1–3 days), minor/mild (4–7 days), moderate (8–28 days), and major/severe (>28 days) injuries [9]. Beyond severity, injury burden, defined as the number of days lost per 1000 h of exposure, is also a key metric used to quantify time lost due to injuries [23].

Injury severity data are more commonly reported for youth male soccer players, where average time lost ranges from 7 to 22 days per player [34], but few studies have reported injury severity in young female soccer players, highlighting the scarcity of data specific to this population. A recent systematic review by Robles-Palazón et al. [9] revealed that in a typical youth female soccer squad of 20 players, coaches might expect two high-burden injuries (>28 days of time loss) per season. Fortunately, most injuries appear to be of minimal severity, requiring only 1–3 days of recovery. Nevertheless, the injury incidence rates for moderate (1.5 injuries per 1000 h of exposure) and severe injuries (1.3 injuries per 1000 h of exposure) are concerning and warrant attention.

The mean number of days lost due to injuries for youth female soccer players is 11 days (95% CI 6–16), closely aligning with the pooled estimate of 10 days (95% CI 6–15) for youth female athletes across various sports (e.g., inclusion of team sports, court sports, and individual sports) [50]. Tennis, in particular, reported the lowest mean days lost and injury burden, reinforcing its status as a relatively low-risk sport.

In elite English youth female soccer players, the mean burden of time-loss injuries was 37 days lost per 1000 h (95% CIs: 31–44) and was significantly higher during matches than during training (183 days lost/1000 h, 95% CIs: 142–237 vs. 17 days lost/1000 h, 95% CIs: 13–22, respectively) [24]. Similar to higher incidence during matches, this elevated burden aligns with the greater physical demands and the higher number of collisions that occur compared to training [47,55].

Time-loss injury, both in terms of severity and burden, increase with age, peaking in players aged U16 compared to U12 [24]. The factors contributing to this increase parallel those associated with injury incidence. These include heightened training exposure, increased match demands, and physiological changes related to growth and maturation. Moreover, the greater body size of older adolescent athletes can exceed the tolerance of soft tissues, while significant decreases in motor competency and neuromuscular control, especially during the post-peak height velocity period, further elevate injury risk [27,28,30,32,56].

5. Onset of Acute, Overuse, and Recurrent Injuries

Injuries are typically categorized into acute, overuse, or recurrent injuries, each with distinct mechanisms and implications [9]. Acute injuries, caused by sudden traumatic events, are significantly more common than overuse injuries, which develop gradually due to repetitive stress without a specific trauma [57]. Epidemiological data indicate that the incidence rate of acute injuries in female players is 4.55 injuries per 1000 h, substantially higher than the incidence rate for overuse injuries, at 1.56 per 1000 h [58]. However, adolescent female soccer players, who are undergoing rapid physical and neuromuscular development, are particularly vulnerable to both acute and overuse injuries due to factors such as disrupted motor coordination, increased physical demands, and higher training intensities [9]. As these players transition into late adolescence (U17–U19), they face increased workloads and physical demands associated with competitive environments, further contributing to elevated injury rates [59]. During this critical period, overuse injuries often result from repetitive activities, while acute injuries are predominantly linked to high-intensity actions such as accelerations, decelerations, and physical contact during matches [45].

Simultaneously, these young female players—characterized by less developed neuromuscular and metabolic systems, lower muscle mass, and more compliant muscle-tendon structures—may experience a slightly reduced risk of certain injuries due to their lower capacity to generate and tolerate high levels of force [60].

Conversely, the prevalence of recurrent injuries is lower in youth players compared to adults, with an injury incidence of 1.4 per 1000 h versus 5.1 per 1000 h for females, respectively [9,19]. This discrepancy may be attributed to the reduced pressure for early return to play at younger ages, allowing for more effective rehabilitation [61]. Nevertheless, a history of previous injuries remains a strong predictor for future occurrences, particularly in the knee and hamstring [5,62]. This highlights the importance of delaying the onset of the first injury through targeted prevention strategies, as recurrent injuries not only compromise short-term athletic performance but also negatively impact long-term development and overall health.

To reduce the risk of recurrent injuries, particularly in high-risk areas like the knee and hamstring, specific rehabilitation techniques and injury prevention strategies are crucial.

Recent studies have highlighted the importance of proper landing techniques in reducing lower limb injury risks. Optimizing landing strategies, such as improving neuromuscular control and adjusting ankle motion patterns (i.e., increasing ankle initial contact angle and ankle range of motion during single-leg landings) [63], can help to dissipate the impact forces on the knee and ankle joints, thus reducing the risk of injuries like ACL tears and lateral ankle sprains. Additionally, targeted strength training and neuromuscular control exercises can further enhance injury prevention and help mitigate the risk of recurrent injuries.

6. Location and Type of Injuries

Understanding the location of injuries (i.e., in which parts of the body they typically occur) is critical to developing prevention and treatment strategies to ensure the health and performance of young female soccer players [9]. In general, scientific literature categorizes the location of injuries into five zones: head, neck, upper extremity, trunk, and lower extremity. However, when it comes to the lower body more specifically, the most analyzed regions are the hip, groin, thigh, knee, calf, ankle, and foot [54]. Figure 1 displays the percentages of injuries collected from various studies evaluated based on their anatomical location. In female youth soccer players, ankle injuries (18–38.9%) are the most frequent. These results are in line with those found for adult female soccer players [19], with ankle sprains being the most frequent type of injury [6,33,64,65]. When we analyze knee injuries, the chances that young female soccer players may have an injury to this joint are very high (16.1–25.3%). As we can see, injuries related to the joints and ligaments (i.e., the ankle and knee joints) are very common in young female soccer players. The incidence of injuries to these joints can be up to twice as high as that of their male counterparts [9]. Furthermore, studies reveal that females are 2.5 times more susceptible to ACL ruptures and ankle sprains compared to males [20,43]. It appears that sex-related differences, such as anatomy and biomechanics [66], hormonal fluctuations [67], and neuromuscular control of the trunk, hip, knee, and ankle, are responsible for this phenomenon. These differences may predispose female athletes to utilize altered lower extremity movements and motor control strategies during the performance of soccer-specific tasks. For example, they are more likely to have excessive dynamic knee valgus motion and have limited ranges of motion in the lower extremity joints (hip, knee, and ankle flexion), which are common patterns associated with knee and ankle injuries [68,69]. Furthermore, it has been justified that this higher number of joint/ligament injuries in young female soccer players is in line with the nature of youth soccer, where kicking, cutting, sprinting, jumping, and landing are performed on irregular or artificial natural fields, causing stressful situations for both joints [5].

Another of the most injured areas in young female soccer players is the thigh (11.1–20.7%). This region has a high correlation with muscle strains and represents between 8% and 25% of all acute injuries in young female soccer players [23,33]. Furthermore, injuries in the posterior thigh (i.e., hamstrings) and anterior thigh (i.e., quadriceps) have been differentiated. In the first investigations, the percentage of injuries in the anterior thigh was higher than in the posterior thigh [6,57]. Results were similar when analyzing elite female players, where quadriceps strains were diagnosed more than hamstring strains [20]. It is possible that the lower activation of the iliopsoas (muscle responsible for hip flexion) in female soccer players during ball kicking, which has been considered the main injury mechanism of quadriceps strain [76], could expose female to greater injury to this musculature. However, in a recent study [24], posterior thigh injuries were higher than those of the anterior thigh. It is possible that increased physical demands in female soccer matches [77], as well as increased exposure to high-intensity actions (i.e., sprints,

which have been considered the primary mechanism of hamstring injuries), may cause this change in trend. We must interpret these results cautiously because only one study found these differences.

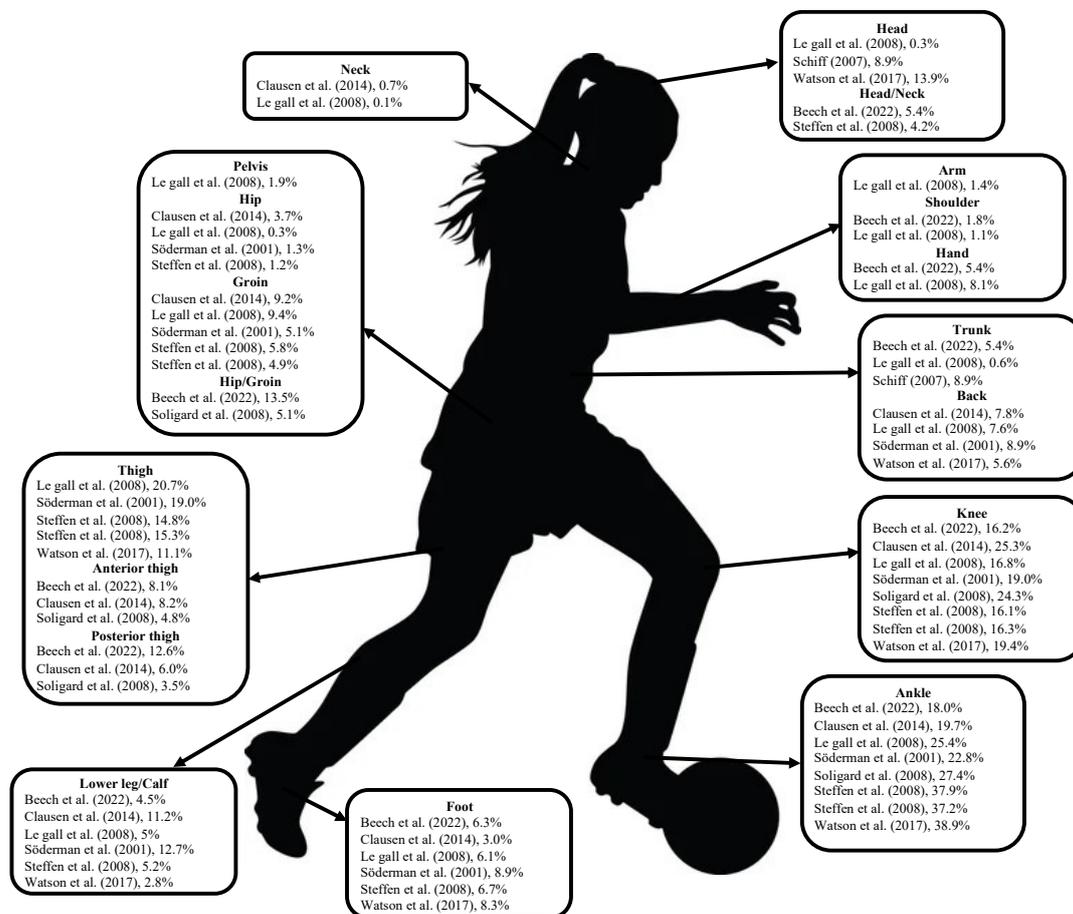


Figure 1. Percentages of injuries based on their anatomical location in youth female soccer players [8,11,28,70–75].

Figure 1 illustrates that groin and hip injuries range from 0.3% to 13.5%. It is true that there are studies that included both parts as one, but if we analyze them separately, we find that groin injuries (4.9–9.4%) are more frequent than hip injuries (0.3–3.7%). During soccer, actions such as kicking, quick changes of direction, accelerations, and decelerations are closely linked to this area of the body. Therefore, we should treat groin injuries due to strain with caution and follow established steps for optimal recovery to prevent them from becoming a chronic problem in young female soccer players [78]. However, the anthropometric characteristics of females, i.e., a wide and light pelvis with a greater subpubic angle and a greater angle between the medial line of the body and the line of action of the hip adductors [79,80], may contribute to a reduction in groin injuries among young female soccer players. These characteristics may influence the force vectors by improving the transmission of force to the lower extremities [80].

Another relevant area of the analysis of injuries in young female soccer is the calf and foot areas. In these areas, the injury percentages ranged from 2.8% to 12.7% in the calf and 3% to 8.9% in the foot. The literature has identified age as a factor that increases the likelihood of calf injuries [81,82]. Therefore, considering the wide age range of young female players in soccer academies, age is a crucial factor to monitor [8]. In addition, it has been noted that the length of the gastrocnemius fascicle is of vital importance in athletes who sprint [83], so reducing the injury rate in this area will be critical. Within this area

of the body, we must highlight the importance of the Achilles tendon; although only one study has recorded this structure in its analysis of injuries [57], the complexity of this injury can cause major problems in the trajectory of young female soccer players [84], so injury prevention programs should emphasize situations that favor the reduction of this type of injury.

In relation to the central area of the body (i.e., core), injuries were recorded in the trunk (i.e., injuries in the anterior and posterior part of this anatomical region, 0.6–8.9%) and in the back (i.e., posterior area of the trunk, 5.6–8.9%). Although the percentage of injuries in these areas of the body is relatively low, we should be aware that females opt for a more upright position during landing, which could expose the central area of the body to overload situations and/or injuries [8]. Thus, conditioning and strength coaches must remember that core muscle activation is crucial during these actions [85]. On the other hand, the percentage of cervical and cranial injuries, which are located in the head and neck, ranged from 0.3% to 13.9% in the head, 0.1% to 0.7% in the neck, and 4.2% to 5.4% in the head/neck region. Note that only a few studies have documented injuries to these particular body parts. Despite this, this percentage of injuries can be considered quite concerning, as head injuries, including concussions, are a major concern in youth female soccer due to their potential long-term effects on cognitive and neurological health [86,87].

7. Non-Contact vs. Contact Injuries

Understanding the mechanisms underlying injuries is critical for implementing effective preventive measures, particularly given the challenges in mitigating contact-related injuries. The literature consistently indicates that non-contact injuries are more prevalent during training sessions, whereas contact injuries dominate during matches, often resulting from physical interactions with opponents. For example, Beech et al. [24] reported that 63% of match-related injuries among English youth female soccer players occurred in contact situations, while 69% of training-related injuries were attributed to non-contact mechanisms, primarily involving soft tissue. Similarly, studies by Horan et al. [88], Lislevand et al. [58], and Soligard et al. [6] observed a higher incidence of contact injuries during matches among young female soccer players in Kenya and Norway. Consistent findings were reported by Kuzuhara et al. [89], who identified body contact as the leading cause of match injuries (43.8%) among Japanese youth female soccer players. This pattern extends to international tournaments. For instance, injury data from the Women's European U19 Championships revealed that between 61% and 100% of injuries in each tournament were classified as contact related [48]. Other studies examining injuries during international competitions corroborate this trend, noting a greater incidence of contact injuries during matches compared to a predominance of non-contact injuries during training session [3,90]. Across these studies, player-to-player contact emerged as the most common mechanism for contact injuries. Moreover, Junge et al. [90] found that only half of the injuries attributed to foul play, as assessed by team doctors and injured players, were sanctioned by referees. These insights provide a valuable foundation for strength and conditioning coaches to develop tailored preventive programs aimed at reducing injury risk in youth female soccer players.

8. Risk Factors for Injuries

Injury risk in young female soccer players stems from a multifactorial interplay of intrinsic and extrinsic factors, requiring targeted prevention strategies.

Intrinsic factors, such as anatomical and biomechanical variables, play a central role. Females typically exhibit a greater Q-angle due to a wider pelvis, increasing lateral forces on the patella and predisposing them to knee valgus collapse during dynamic move-

ments, which contributes to ACL injuries [91]. This alignment also affects hip mechanics, heightening stress on the medial knee compartment and leading to overuse injuries like patellofemoral pain syndrome [92]. Additionally, weaker hamstrings relative to quadricep strength can reduce hamstring activation, elevating anterior tibial translation and the risk of ACL ruptures [93]. The hormonal profile of youth female players also influences injury susceptibility. Cyclic fluctuations in estrogen and relaxin levels affect ligament properties and neuromuscular control. For example, estrogen reduces ligament tensile strength and increases laxity, while relaxin compromises knee stability [94]. Studies indicate a 30–50% higher risk of knee injuries during the late follicular phase of the menstrual cycle [95]. Neuromuscular deficiencies further exacerbate injury risks. Proprioceptive deficits, typical during adolescence, impair joint stability under dynamic loads [96]. Female players perform worse in single-leg stability tests and exhibit higher ground reaction forces with less hip and knee flexion during landing, increasing anterior tibial shear forces [97]. Strength imbalances, such as weaker hamstrings compared to quadriceps, are linked to higher risks of hamstring strains, especially during high-speed running or deceleration [98]. Delayed activation of stabilizing muscles like the hamstrings and gluteus medius also heightens the likelihood of both muscle injuries and joint instability [99].

Extrinsic factors also must be considered due to their implication in the injury risk profile of youth female soccer players. Training load and scheduling are central contributors; excessive volumes combined with insufficient recovery significantly increase the likelihood of overuse injuries. Sudden, unplanned increases in training intensity exacerbate fatigue, impairing neuromuscular control and elevating the risk of acute injuries. Research consistently underscores the adverse effects of chronic overload and inadequate recovery on young athletes [100]. Playing surfaces and equipment further influence injury risks. Artificial turf, due to its higher traction and altered force absorption, has been linked to increased rates of non-contact lower-limb injuries, especially during high-stress movements like cutting and pivoting. Improper footwear, such as cleats with longer studs or poorly fitted shoes, exacerbates biomechanical stresses on the foot, ankle, and knee, potentially increasing ligament and overuse injury risks. These factors are particularly critical in dynamic sports like soccer [101]. Psychosocial and developmental factors also contribute significantly. Competitive pressures and the pursuit of scholarships often drive young athletes to overtrain or play for multiple teams, compounding both physical and psychological stress [102]. During growth spurts, coordination deficits and temporary disruptions in neuromuscular control lead to biomechanical inefficiencies that heighten injury risk. These developmental changes highlight the need for tailored interventions to protect adolescent athletes during critical stages of maturation.

9. Multicomponent Injury Prevention Programs in Youth Female Soccer: A Key Strategy for Athletes

The high incidence of injuries in youth female soccer, particularly the elevated risk of severe knee injuries such as ACL ruptures [1], underscores the urgent need for prevention programs specifically tailored to this population [70,103]. Female youth players experience higher ACL injury rates compared to their male counterparts, and adolescent girls are especially at risk [43,104], which reinforces the necessity of investing resources into effective injury risk reduction strategies within female youth and sub-elite programs. Prioritizing the development of targeted interventions for younger and developing players is essential to ensure that they can progress to senior soccer with optimal health, well-being, and performance [105]. These programs should focus on personalized interventions that address the distinct injury risk profile of female players, shaped by their unique physiological and biomechanical characteristics. This approach eliminates the ineffective practice of merely

adapting prevention strategies originally designed for men, which fail to meet the specific needs of female athletes. To maximize their impact, prevention programs must consider the context-specific factors of the playing group—such as sex, age, level of competition, and injury profile (e.g., as well as staffing, training formats, and facility availability). Such considerations are crucial for informing program content and optimizing adherence and implementation strategies [106]. Furthermore, tailored injury prevention programs can play a pivotal role in overcoming barriers to sports participation, including fear of injury and insufficient physical preparedness, challenges that are particularly prevalent among adolescent female footballers [105]. By addressing these factors, such programs not only reduce injury risk but also support continued participation and long-term athletic development.

Recognizing the importance of preventive strategies in female soccer players, well-structured exercise-based programs are essential for mitigating the complex interplay of risk factors that contribute to injuries [71]. Injury prevention programs can be broadly categorized into two main approaches [105]: multi-component programs and single-component programs. Multi-component programs, commonly referred to as neuromuscular training programs, are often incorporated into the warm-up phase prior to a session, integrating elements such as balance, strength, agility, plyometrics, and running exercises. Through their comprehensive design, these programs effectively address multiple risk factors simultaneously, solidifying their role as a cornerstone of injury prevention strategies in sports [1]. For example, plyometric exercises such as drop jumps or single-leg hops aim to enhance landing mechanics and improve control during deceleration, while balance drills like single-leg stance with torso movements target neuromuscular control. Strengthening exercises, including Nordic hamstring curls and hip abductor work, are essential for improving posterior chain and lateral stability, particularly in female athletes who are at increased risk for ACL injuries. By incorporating these components, these programs target critical biomechanical and neuromuscular factors, enhancing key movement patterns and optimizing neuromuscular control [107], which is particularly crucial in soccer-specific scenarios. Specifically, these interventions help players maintain proper knee alignment, reducing the tendency for the knee to collapse medially during sudden changes in speed, soccer-specific movements, or physical contact with opponents [6]. As a result, multi-component neuromuscular training programs have been shown to significantly reduce injury rates, particularly for ACL, knee, and ankle injuries, with evidence demonstrating a 27% reduction in overall injuries and a 45% decrease in ACL injuries [105]. Notable examples include the FIFA 11+ [108], the Prevent Injury and Enhance Performance (PEP) program [107], Knäkontroll [1], and Footy First [72], which, by targeting key movement patterns and incorporating sport-specific exercises, play a pivotal role in promoting safer, more effective athletic performance.

While some studies report inconsistent outcomes due to small sample sizes and low compliance [109], most demonstrate significant benefits. For instance, Foss et al. [110] observed reduced overall injuries (25 vs. 31) and knee injuries (11 vs. 15), and Emery and Meeuwisse [111] reported decreases in overall (27 vs. 61) and ankle injuries (8 vs. 23). Similarly, ACL-specific reductions were noted in studies by Gilchrist et al. [112] and Heidt et al. [73]. Programs specifically designed for younger players, such as FIFA 11+ and FIFA 11+ Kids, have shown remarkable outcomes, including no ACL injuries and a reduction in overall injuries (5 vs. 7) among U9 to U13 players [74] and fewer overall injuries (161 vs. 215) and knee injuries (35 vs. 58) in under-15 and under-16 teams [6]. For older youth players, Waldén et al. [1] found a 64% reduction in ACL injuries among adolescent female soccer players through a twice-weekly neuromuscular warm-up program targeting core strength, balance, landing technique, and proper knee alignment. Key improvements in

knee valgus, hip abductor strength, and core stability contribute to better movement control, enhanced landing mechanics, and reduced injury risk [113]. These improvements likely contribute to better control during landing, allowing athletes to absorb ground reaction forces more effectively and reduce the risk of injury [114].

Early introduction of neuromuscular training mitigates growth and maturation risks, including knee valgus, and improves leg stiffness and stability through plyometric exercises [115]. Furthermore, the observed improvements in leg stiffness, which are enhanced through plyometric exercises, highlight how neuromuscular training contributes to the stretch-shortening cycle, increasing stability during landing and reinforcing the long-term injury prevention benefits for female youth athletes [116,117]. However, these benefits are strongly tied to maintaining high compliance rates, as consistent adherence is critical to achieving these outcomes [118]. Finally, while neuromuscular programs are highly effective in reducing lower-limb musculoskeletal injuries, further specificity in training, such as progressive hip adductor strengthening, load management strategies, and soccer-specific skill development, may enhance their ability to address particular injury mechanisms, particularly for knee, ankle, and hip/groin injuries [119].

Finally, tailoring neuromuscular programs with increased specificity can significantly improve their efficacy in addressing particular injury mechanisms, particularly for high-risk female youth players. The study by De Ste Croix et al. [113] highlights that multi-component training programs, incorporating strength, plyometrics, stabilization, and balance exercises, lead to significant improvements in key injury risk factors such as knee valgus, leg stiffness, and high knee abduction moment. Importantly, these benefits are more pronounced among high-risk athletes, classified by elevated knee valgus probabilities, compared to their low-risk counterparts. For instance, high-risk players experienced a 30.3% reduction in knee valgus compared to 12.2% in low-risk players, underscoring the greater responsiveness of those at higher risk to targeted interventions. These findings suggest that identifying and prioritizing high-risk individuals for tailored training can maximize the preventive potential of neuromuscular programs. Additionally, these findings emphasize the need to assess individual responses to such programs, even when a team approach to prevention is used, emphasizing the importance of individualization in injury prevention strategies. Furthermore, the inclusion of progressive strength training, particularly targeting the posterior chain and hip abductors, alongside sport-specific skill development, can address unique biomechanical demands, contributing to greater injury mitigation and long-term athletic performance.

10. Targeted Injury Prevention: The Role of Single-Component Programs in Youth Female Soccer

An alternative to multi-component programs, particularly for addressing secondary prevention aimed at minimizing the impact of an existing injury, is single-component programs. These programs target specific objectives, such as eccentric hamstring strengthening or balance training. While their narrower focus limits their scope compared to multi-component programs, they have demonstrated effectiveness in reducing injury rates, achieving a 22% decrease in overall injuries and a 38% reduction in ACL injuries [105]. Despite their more restricted approach, single-component programs play a valuable role in preventing specific types of injuries, making them a strategic option in cases where targeted interventions are necessary.

Espinosa et al. [75] highlighted the benefits of eccentric hamstring exercises performed twice per week for 10–15 min, achieving a notable reduction in hamstring injuries (1 vs. 5) among players in the first and second national divisions. These findings align with previous evidence indicating that eccentric hamstring exercises can reduce injury rates

by 45% to 77%, provided that there is high adherence to the program [120]. Increasing eccentric muscle strength not only reduces the incidence of hamstring strain injuries but also enhances the role of the hamstring muscles as dynamic agonists to the ACL, particularly during high-demand actions such as stopping and jumping [121]. By generating protective forces, especially at knee flexion angles above 30°, stronger hamstring muscles contribute to knee stabilization, potentially reducing the risk of ACL injuries [122]. Although the direct relationship between hamstring strength and ACL injury prevention remains to be conclusively established, the biomechanical benefits provided by improved hamstring function highlight the critical role of eccentric strength training in comprehensive injury prevention programs.

Similarly, Söderman et al. [123] evaluated a home-based balance training program consisting of daily sessions for 30 days, followed by three weekly sessions for the remainder of the season, with each session lasting 10–15 min. This intervention resulted in modest reductions in knee injuries (8 vs. 6) and hamstring injuries (1 vs. 7) but also showed a slight increase in ACL injuries (4 vs. 1), emphasizing the need for more targeted strategies to address ACL-specific injury mechanisms.

Overall, single-component programs demonstrate meaningful injury prevention benefits when designed to target specific biomechanical risks or tailored to the demands of particular sporting contexts. However, combining these programs with multi-component strategies may offer a more comprehensive approach to reducing injury rates and enhancing athlete safety.

11. Limitations and Future Lines of Research

The study of injuries in female youth soccer players faces notable limitations due to methodological inconsistencies and variability in reporting systems. Factors such as differences in injury definitions, data collection methods, and exposure measurements make cross-study comparisons challenging. Additionally, most studies rely on short-term designs, limiting the understanding of the long-term implications of injuries or the effectiveness of preventive strategies over time. These gaps underline the need for standardized injury surveillance protocols that incorporate exposure-adjusted data, uniform injury definitions, and classifications by severity and recovery timelines.

Future research should focus on longitudinal studies that examine the interplay between growth, maturation, and injury risk in youth female soccer players. Investigating the role of biomechanical, hormonal, and psychosocial changes during puberty could provide valuable insights into injury etiology. Moreover, exploring the impact of contextual factors such as playing position, match intensity, and playing surface on injury patterns would help tailor prevention strategies. Collaborative, multidisciplinary approaches that integrate coaches, physiotherapists, and medical staff are essential for developing holistic injury prevention models that can be implemented across diverse competition levels.

12. Conclusions and Practical Applications

The findings highlighted in this review underscore the importance of tailored injury prevention strategies for female youth soccer players, considering their unique physiological and biomechanical characteristics. To address the challenges that coaches face in implementing effective programs, especially with limited resources and varying competition levels, it is crucial to provide practical, scalable recommendations that can be adapted across different contexts: (i) Implementing Multi-Component Programs: Evidence-based programs like FIFA 11+ should be integrated into warm-up routines. Coaches can start with basic components such as strength, balance, and plyometric exercises and gradually introduce more complex elements (e.g., eccentric hamstring strengthening, landing me-

chanics, and core stability) as players progress. These exercises should be designed to be simple yet effective, making them feasible even in resource-constrained environments; (ii) Periodization and Load Management: Coaches should focus on structured periodization and avoid sudden spikes in intensity, especially during growth spurts. By monitoring workload using tools such as GPS tracking or perceived exertion scales, coaches can ensure that players are not overtrained. This proactive approach helps to minimize the risk of overuse injuries and ensures that training is developmentally appropriate for each age group; (iii) Tailoring to Individual Needs: Recognizing the diversity in injury risk among players is key. Identifying players at higher risk (e.g., those with knee valgus or weak hamstrings) allows for targeted interventions. Coaches can personalize aspects of the training program to address these specific deficits, ensuring that every player benefits from a program suited to their unique needs; (iv) Education and Awareness: Coaches, players, and parents should be educated about the role of the menstrual cycle in injury risk and its effects on training and performance. Providing this information will help to make training adaptations that are better aligned with the physiological needs of female athletes; (v) Promoting Mental and Physical Resilience: In addition to physical training, coaches should foster an environment that supports players' mental resilience. Addressing external pressures such as competition stress and promoting a balanced approach to sports and academics will help players manage stress, reducing the likelihood of burnout and fostering long-term participation in soccer.

By implementing these strategies, coaches can create a more effective and supportive environment for female youth players, reducing injury risk and promoting long-term athletic development.

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