Research Article

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A Retrospective Study To Determine Injury Incidences In Indian Male Youth Football Sport Athletes Aged Between 13-18 Years Over Two Years.

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ABSTRACT

Justification: There is a shortage of evidence concerning the incidence of injuries among male youth football athletes in India, and the risk of reinjury remains uncertain. Hence, this study aimed to (1) ascertain injury patterns and incidence rates in an elite youth football academy in India, (2) monitor overuse and trauma-related injuries over two seasons, and (3) evaluate injury risk across different age groups.
Methods: A retrospective cohort study was conducted over the 2022-23 and 2023-24 seasons involving approximately 90 male athletes from an elite youth football academy in India. Injuries were documented following the consensus statement on injury definitions, with classifications aligned accordingly. Injury incidence was reported as injuries per 1000 hours of exposure and injuries per squad season.
Results: Across the two seasons, there were 153 injuries during 19,257 hours of total exposure in 2022-23 and 138 injuries during 19,452 hours in 2023-24. U-19 players had the highest injury incidence in 2022-23, while U-14 players had the highest in 2023-24. Match-related injuries were 2 to 6 times more frequent than training-related injuries, with U-14 players exhibiting the highest match-related injury rates in both seasons. Muscle strains, ruptures, tears, joint sprains, and ligament tears were the most common injury types. U-16 and U-15 players had the highest rates of recurring injuries per 1000 hours of exposure, with U-16 leading in 2022-23 and U-15 in 2023-24. Approximately 35% to 40% of injuries were overuse injuries, with U-15 and U-16 experiencing the highest rates and U-17 the lowest. Most injuries were mild (lasting 4 to 7 days) in 2022-23 and minimal (1 to 3 days) in 2023-24, although severe injuries (>28 days) were most prevalent among U-17 players in 2023-24, followed by U-19 players. The most commonly injured locations were the knee, ankle, groin, and thigh.
Conclusion: This study revealed an average of 27-30 injuries per season per squad, resulting in 339 days lost per squad per season at the elite youth football academy. The findings underscore the need for continued emphasis on injury prevention strategies tailored to different age groups and injury types prevalent among youth football players in India.

INTRODUCTION

Football, also known as soccer, enjoys widespread popularity worldwide. Played with teams of 11 on each side, the aim is scoring goals by hitting the ball into the opposing team's home net. The football game takes place on a rectangular field, usually 100 meters by 65 meters, featuring goalposts at each end, as depicted in **Figure 1**.
Footballers must have physical attributes like high- intensity running, explosive acceleration and deceleration, and the ability to sprint repeatedly (Harper, 2019). Additionally, endurance plays a pivotal role, with players covering up to approximately 11 kilometres per game, although this metric fluctuates depending on the player's position (Bradley et al., 2009), (Mallo et al., 2015), (Di Salvo et al., 2007). Beyond this, football demands agility, tackling, dribbling, jumping, shooting proficiency, muscular strength, joint stability, and expression of power (Bangsbo, 2005), (Stølen et al., 2005),(Hulton, A.,2008). Moreover, over the past few years, there has been a notable evolution in the demands placed on footballers. We observe a substantial increase of almost 30% in the volume covered during high-intensity running, alongside a slight reduction of 2% in the total volume covered. Additionally, there is a remarkable 85% surge in the number of sprints made, with sprint distance rising by 35%. This trend is further underscored by a rise in short and medium passes, indicating a shift towards a possession-based style of play. Consequently, athletes must maintain a higher level of physical activity, enabling them to effectively occupy spaces and respond with more intense and explosive movements (Barnes, C. et al., 2014).

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Figure 1. Structure of the football field.



Epidemiology

Football injuries significantly impact the performance of professional teams, affecting metrics such as goals scored, points accrued, and championship titles won. The availability of players is closely linked to team success, with a strong correlation coefficient ($r > 0.85$), as documented by Eirale et al. (2013) and Ekstrand et al. (2011). A 25-player squad experiences approximately 50 injuries per season, averaging two per player annually (Ekstrand et al., 2011). Beyond competitive success, injuries also impose a substantial financial burden on clubs. The cost of an injury sidelining a top professional player for a month is estimated to be around 0.5 million euros (Ekstrand, 2013). Over the 2012 to 2017 seasons, English Premier League teams incurred an estimated loss of 45 million euros due to injuries (Eliakim et al., 2020). However, this figure could be significantly higher when accounting for inflation and assuming a consistent injury rate. Hence, given the factors above, it is crucial to measure the occurrence of injuries in professional football accurately. Since 2006, there has been enhanced consensus regarding injury descriptions and data-gathering procedures (Fuller et al., 2006), improving the field's consistency and research quality. Numerous epidemiological papers have been printed, detailing injury patterns across single seasons or multiple seasons and outlining the frequency and seriousness of football-related injuries (López-Valenciano et al., 2019) (Pfirrmann et al., 2016) (Robles-Palazón et al., 2022). Below, we delve into a detailed analysis of some critical studies in this area.

The studies were obtained by conducting an extensive search on PubMed using the keywords "Injury Incidence", "Soccer", and "Football," explicitly targeting meta-analyses and systematic reviews published within the last ten years. This approach aimed to provide a broader overview of the literature. Subsequently, we identified the following meta-analyses and systematic reviews, offering valuable insights from a macro perspective.

In 2019, López-Valenciano et al. conducted a systematic review and meta-analysis focused on the epidemiological aspects of injuries among male football professional players. They aimed to identify prevalent and severe injuries, their occurrence during matches or training sessions, and the associated factors. They meticulously searched various bibliographic databases. They applied a Boolean search strategy and limited the search to publications until February 28, 2018.

Additionally, they explored specialised electronic journals. Eligible studies' variables were categorised into three groups: general descriptors, population description, and epidemiological data detailing injury features like type, location, severity, mechanism, recurrence, competitive level, and distinctions between national leagues and international tournaments.

The quality assessment of these studies utilised a modified version of the 'Strengthening the Reporting of Observational Studies in Epidemiology' (STROBE) statement (Von Elm et al., 2007) and a modified version of the Newcastle Ottawa Scale (NOS) for cohort studies, explicitly tailored for football player populations and injury incidence. Modifications to the original scales included adding two new items and removing two, resulting in eight criteria for bias risk assessment. Two reviewers conducted data extraction and quality assessment, demonstrating high intercoder reliability through intraclass correlation coefficients and Cohen's κ coefficients. Any disagreements were resolved through consensus or by referring to a third reviewer.

Injury rates, calculated per 1000 hours of player exposure, were pulled out from the selected studies. Out of the 2013 references identified, the study included 44 articles, resulting in 56 cohorts meeting the inclusion criteria for quantitative synthesis. The combined injury incidence data comprised 29,991 overall injuries, 12,089 training-related injuries, and 14,974 match-related injuries. The reported incidence was

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8.1 injuries per 1000 hours of exposure, with a training rate of 3.7 injuries per 1000 hours of training exposure and a match rate of 36.0 injuries per 1000 hours. Among the 26 cohorts reporting injury location, lower extremity injuries were most common at 6.8 injuries per 1000 hours, followed by trunk at 0.4 per 1000 hours, upper extremity at 0.3 per 1000 hours, and head and neck injuries with the lowest incidence rates at 0.2 per 1000 hours. Within the lower extremity, thigh at 1.8 per 1000 hours, knee at 1.2 per 1000 hours, ankle at 1.1 per 1000 hours, hip/groin at 0.9 per 1000 hours, lower leg/Achilles tendon at 0.8 per 1000 hours, and foot/toe at 0.4 per 1000 hours were the most common sites of injury. The types of injuries across the 26 cohorts included muscle/tendon injuries at 4.6 per 1000 hours, contusions at 1.4 per 1000 hours, undefined/other injuries at 0.6 per 1000 hours, joint (non-bone) and ligament injuries at 0.4 per 1000 hours, fracture and bone stress injuries at 0.2 per 1000 hours), lacerations and skin lesions at 0.05 per 1000 hours, and central nervous system/peripheral nervous system injuries at 0.04 per 1000 hours.

The pooled analysis from 28 cohorts indicated minimal injuries at 3.1 per 1000 hours, moderate severity at 2 per 1000 hours, minor injuries at 1.7 per 1000 hours, and severe injuries at 0.8 per 1000 hours of exposure. Traumatic injuries were more prevalent than overuse injuries, which were 5.9 per 1000 hours and 2.4 per 1000 hours, respectively.

Recurring injuries were reported at

1.3 per 1000 hours from 21 cohorts. The level of play did not significantly impact injury incidence, with training-related injuries at 3.6 per 1000 hours in the top 5 UEFA leagues compared to 3.9 per 1000 hours in other professional leagues and match-related injuries at 35.5 per 1000 hours for the former and 31.9 per 1000 hours for the latter. International matches reported higher incidences than national matches, with 41.1 per 1000 hours for the former and 32.3 per 1000 hours for the latter.

The research represents a commendable effort to shed light on the detailed occurrence of injuries in football, diligently adhering to the criteria established by Fuller et al. in 2006. However, there is a notable disparity in the number of cohorts reported for specific parameters such as injury location, type, and severity compared to the overall injury incidence. This disproportion may skew the interpretation of the study's findings, hindering the derivation of practical and actionable outcomes. The significance of non- contact muscle sprains over contact injuries is worth noting, a discerning observation given the nature of football play.

Pfirrmann et al. (2016) systematically compared injury incidence and characteristics between elite youth and professional adult soccer players. The study, conducted using MEDLINE and Web of Science databases, aimed to analyse injury rates and types in male players. Search terms included various descriptors related to soccer, injury, and player demographics. Studies meeting specific criteria, including prospective design and reporting injury data, were selected. Elite youth was defined as aged 8 to 19, with exclusion criteria applied to amateur studies and those focused on specific injuries or age groups.

Reviewers assessed study quality independently, resulting in 18 selected articles: 6 on youth and 12 on professionals.

Injuries ranged from 2.0 to 19.4 per 1000 hours of exposure for elite youth players, with match- related injuries ranging from 9.5 to 48.7 per 1000 hours and training-related injuries from 3.7 to 11.14. Common injuries included strains, sprains, and contusions, with matches posing higher risks than training. Severity varied, with reinjuries, particularly overuse types during training, notable. Professional players reported rates of 2.48 to 9.4 injuries per 1000 hours, with match-related injuries ranging from 8.7 to 65.9 and training- related from 1.37 to 5.8. Hamstring strains were prominent, with fractures less common but categorised as significant injuries. Reinjuries, predominantly overuse, demanded extended rest periods.

In conclusion, elite youth players face heightened injury risks during training, possibly due to differing standards. The study covered the suitable age bracket for the youth cohorts ranging from 9 years to 18 years of age. The physical immaturity of youth heightens their vulnerability to injuries, particularly with extended training exposure. This is particularly evident among athletes around 16 years old, a trend corresponding to the onset of peak height velocity (Tsutsui T. et al., 2022).

Monitoring stress and recovery can aid in identifying vulnerable athletes. Ergün et al. (2013) stress a cautious approach to training, highlighting skill development.

Robles-Palazón et al. (2022) conducted a meta- analysis and systematic review of youth football injuries to quantify their incidence and explore factors such as location, type, severity, and mechanism. The study's eligibility criteria included participants aged ≤19 years, clear injury definitions, and publication in peer-reviewed journals in English or Spanish before 1st January 2021. The meta-analysis categorised injuries based on football-related incidence rates, location, type, severity, mechanism, age groups, and skill levels. Quality assessment utilised adapted versions of the STROBE statement and Newcastle Ottawa Scale, with two reviewers conducting data extraction and reliability assessments. Despite the inclusion of both sexes, the analysis of the study is focused on outcomes of the male populations due to the research focus. Analysis revealed significant injury rates across age groups and levels of play, with lower limb injuries being the utmost shared. Specifically, 33 studies (38 cohorts) reported overall incidence, 25 studies (30 cohorts) reported training incidence, and 29 studies (34 cohorts) reported match incidence. A

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whole of 7,495 injuries were recorded from 25,600 players. The overall injury incidence rate (IIR) was approximately 5.70 per 1000 hours, with training IIR at 2.77 per 1000 hours and match IIR at 14.43 injuries per 1000 hours. Lower limb injuries dominated the upper limb injuries, followed by injuries to the trunk and head/neck region. Muscle/tendon injuries were the most common type, with minimal injuries being the most frequent in severity. Recurring injuries were significantly fewer than new injuries, with an incidence rate of 0.81 per 1000 hours compared to 5.87 per 1000 hours. These findings have significant implications for preventing and managing youth football injuries. According to the study, male youth players faced a 47% probability of injuries. The U17-19 age group exhibited the highest probability across the sexes (56% for males and 58% for females), while the U12 age group had the lowest (7% for males and 18% for females).

In summary, youth athletes face a significant risk of injury, particularly during matches. Therefore, training protocols should mirror match demands to enhance readiness for competitive play.

Additionally, males are prone to muscle injuries in the thigh, emphasising the need for targeted injury prevention measures.

Table 1. Age group injury incidence table of Robles-Palazón et al. (2022).

Age group	Overall IIR (per 1000 hours)	Match IIR (per 1000 hours)	Training IIR (per 1000 hours)
U12	1.61	2.60	1.07
U13-16	5.35	13.67	3.39
U17-19	7.54	20.05	3.51

Table 2. Level of play injury incidence table of Robles-Palazón et al. (2022).

Level of play	Overall IIR (per 1000 hours)	Match IIR (per 1000 hours)	Training IIR (per 1000 hours)
Elite	6.19	17.91	2.68
Sub-elite	4.77	10.63	2.83

METHODS

Study Design and Participants

A retrospective cohort study was conducted on male youth football players from India during the 2022-23 and 2023-24 seasons. Each season typically runs from June to May, encompassing pre-season and competitive periods. Participants were from an elite youth academy based in Mumbai, India, including teams ranging from U-14 to U-19. The study included 90 athletes for the 2022-23 season and 91 for the 2023-24 season (Table 6). Players were registered or omitted from the study based on their entry or exit dates to ensure the collection and analysis of relevant exposure and injury data.

The academy operates a complete scholarship program, selecting athletes through annual trials. Selected players receive residential accommodation and education, nutrition, and wellness support. The academy employs a methodical training approach with progressive adjustments in athletic and football-specific training. Younger age groups receive training that targets specific technical, tactical, and physical qualities, while older groups focus on improving football capabilities and athleticism in preparation for the adult level. Training loads and intensities vary by age group, typically including four days of structured training sessions and small-sided games, one day of personal development planning (PDP), one day of internal games, and one day of friendly matches with peers or adult teams. Once the competitive season starts, the weekly schedule is adjusted to match the tournament fixtures relevant to the particular age group. Strength and conditioning routines include two days of strength and power workouts, one day of linear speed training, and two days focused on agility and reactive speed; for the U-14 and U-15 age groups, strength, agility, and reaction training are integrated through gamified strength drills and multi-sport activities.

Informed consent was obtained from the academy management and legal team, as this retrospective study does not involve any intervention on the athletes, eliminating the need for separate parental consent. Proof of informed consent is provided in Appendix 1. The study methods and definitions adhere to the consensus statement (Fuller et al., 2006) and follow the guidelines for STROBE.

Data collection

The data was collected by the Medical Department, which is accountable for maintaining injury surveillance reports for the academy each season. These reports included information about various aspects of injuries and the time lost due to injuries, and the data was recorded using Microsoft Excel. The documentation of musculoskeletal injuries was primarily aligned with the data-gathering procedures described by Fuller et al. (2006), and the cases where classification of the various aspects was required have been mentioned in Tables 9, 10 and 11 below.

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Table 3. Grouping and Classification of Type of Injury

Grouping as per Fuller et al. (2006)	Detailed classification in Injury surveillance report
Central/Peripheral Nervous System	Concussion/brain injury
	Spinal cord injury
	Peripheral Nerve Injury
Contusion/ bruise (superficial)	Contusion/ Bruise (Superficial)
Fracture and Bone Stress	Bone Fracture
	Bone Stress Injury
	Bone Contusion
	Avascular Necrosis
	Physis Injury
Joint (Non-Bone) and Ligament	Cartilage Injury
	Joint Sprain / Ligament Tear
	Chronic Instability
	Arthritis
	Bursitis
	Synovitis / Capuslitis
Laceration and Skin Lesions	Laceration
	Abrasion
Muscle and Tendon	Tendon Rupture
	Tendinopathy
	Muscle Strain / Rupture/ Tear
	Muscle Contusion
	Muscle
	Vascular Damage
Other	Stump Injury
	Internal Organ Trauma
	Unknown,

The location of injury was another parameter considered for the injury incidence; the groups of the same are mentioned in Table 4.

Table 4. Grouping and Classification of Location of Injury.

Grouping as per Fuller et al. (2006)	Detailed classification in Injury surveillance report
Head and Neck	Head/face
	Neck/ cervical spine
Upper limbs	Shoulder/Clavicle
	Upper arm
	Elbow
	Forearm
	Wrist
	Hand/finger/thumb
Trunk	Chest (including chest organs)
	Thoracic spine / upper back
	Lumbar-sacral spine/buttock
	Abdomen (including abdominal organs)
	Pelvis
Lower limbs	Hip
	Groin
	Thigh
	Knee
	Shin
	Achilles tendon
	Calf
	Ankle
	Foot/toe

The severity of the layoff period due to injury was logged in actual days within the injury surveillance report. This data was subsequently classified: slight (0 days), minimal (1 to 3 days), mild (4 to 7 days), moderate (8 to 28 days), severe (greater than 28 days), and career-ending injuries, following Fuller et al. (2006). Additionally, injury incidence was assessed based on two other criteria: the classification of the reason for injury and its frequency. Detailed information on these classifications is provided in Table 5.

The absenteeism caused by sicknesses like flu infections or regular ailments was excluded from this study.

Training exposures were extracted and calculated using each season's RPE load monitoring database. Unfortunately, the data are predominantly filled by the older age groups (U-17 and U-19), with less sincere reporting by the younger athletes (U-14, U- 15, and U-16). Consequently, we calculated the overall average based on the training exposure reported by the older age group, as no other logical or mathematical method was feasible. Match exposure data were obtained from the web-based software Pro-Soccer Data, where the academy documents the number of matches played. The summary of exposure in hours is mentioned in Appendix 2.

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Table 5. Grouping and Classification of Reason (overuse/trauma) and Frequency (New/Recurring) of Injury.

Grouping as per Fuller et al. (2006)	Detailed classificati on in Injury surveillance report	Grouping as per Fuller et al. (2006)	Detailed classificati on in Injury surveillance report
Overuse	No identifiable single event (repetitive transfer of energy, overuse)	New	New
Traumatic	Acute non- contact trauma	Recurring	Recurrent after full recovery & return to sports
	Direct contact with another player	Recurring	Exacerbati on of a stable (not recovered) condition
	Following contact with another player (fall after a push)	Unknow n, or not specified	Unknown, or not specified
	Direct contact with an object (ball, wall, ground, slipped & fall)		
	Following contact with an object		

Statistical data analysis

Data were recorded and analysed using Microsoft Excel and Google Sheets. Injury incidence for matches, training, and the combination of both was computed per 1000 hours of exposure. The incidence rate was determined by dividing the number of injuries per group by the hours of exposure per group and multiplying by 1000 (Fuller et al., 2006). Incidences were presented as either absolute numbers or relative percentages, and injury incidence rates were reported per 1000 hours of exposure to analyse injury location, type, severity, and related factors.

Risk calculations were included to provide additional insights into the injuries. The age-related risk of injury incidence was compared between age groups for training and matches. To compute this, the number of injured players was divided by the total number of players, adjusted for total exposure (including training and matches), and multiplied by 1000 for each age group. Relative risk between match-related and training-related injuries was also calculated. This involved dividing match-related injuries' risk ratio by training-related injuries' risk ratio for each age group.

RESULTS

Ninety athletes for the 2022-23 season and Ninety- one for the 2023-24 season were monitored. The academy players were categorised into the age groups U-14, U-15, U-16, U-17, and U-19, each experiencing varying levels of exposure and injury incidences. The number of players in each age group for both seasons is detailed in the table below (Table 6).

Table 6. Total number of athletes in each age group.

Season	U-14	U-15	U-16	U-17	U-19	Total
2022-23	17	16	16	16	25	90
2023-24	15	17	17	18	24	91

Player injuries

During the 2022-23 and 2023-24 seasons, 153 and 138 injuries were recorded, respectively. At the academy level, 42% and 32% of these injuries occurred during matches for each season, respectively. The remaining injuries were sustained during training, gym sessions, or other circumstances. Most age groups reported a lower percentage of injuries in matches compared to training, except for the U-14 group in 2022-23 (**Figure 2**) and the U-19 group in 2023-24 (**Figure 3**), who reported a higher or nearly equal percentage of injuries in matches compared to training.

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Figure 2. Overall injury details for the season 2022- 23 (Total no. of injuries).

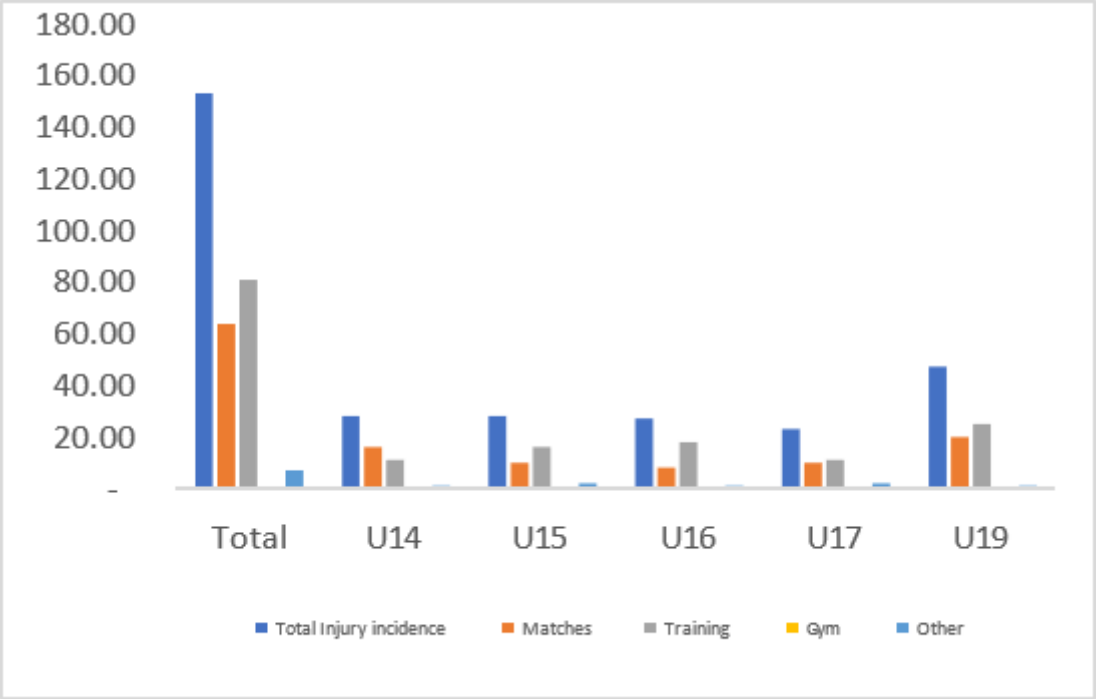
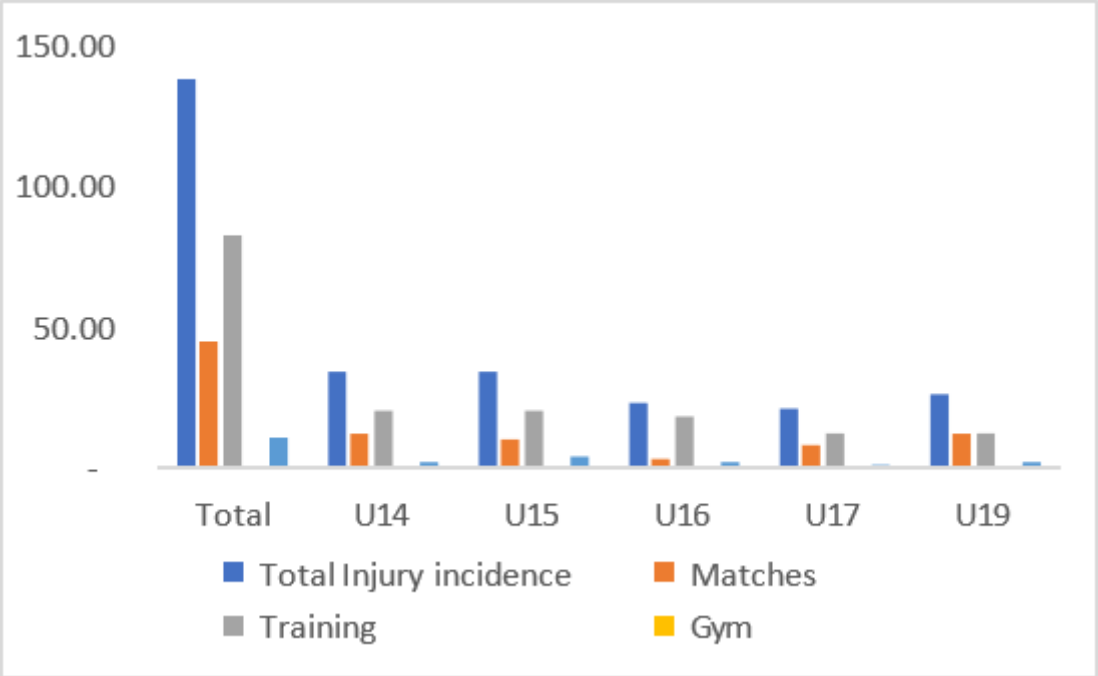


Figure 3. Overall injury details for the season 2023- 24 (Total no. of injuries).



Player injury incidence

The total injury incidence at the academy level was highest for the U-19 age group at 8.33 per 1000 hours in 2022-23 (Figure 4), and U-14 was highest at 11.31 per 1000 hours of exposure in 2023-24 (Figure 5). Conversely, the lowest total injury incidence was reported for the U-17 age group in both seasons, with rates of 6.96 per 1000 hours of training in 2022-23 (Figure 4) and 4.60 per 1000 hours of training in 2023-24 (Figure 5). Although, as mentioned in the above section, in total percentage terms, match-related injuries were lower than training-related injuries, when considering the exposure, the match-related injury incidence rate was almost two to six times more than the training-related injury incidence; it was highest again for U-14, with rates being 25.52 per 1000 hours of exposure in 2022-23 (Figure 4) and 18.65 per 1000 hours of exposure in 2023-24 (Figure 5).

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The lowest injury match-related incidence rate was reported by the U-16 team, with rates of 13.47 per 1000 hours of exposure and 4.33 per 1000 hours of exposure in 2022-23 and 2023-24, respectively (**Figure 4** and **Figure 5**).

Figure 4. Injury incidence (per 1000 hours exposure) for the season 2022-23.

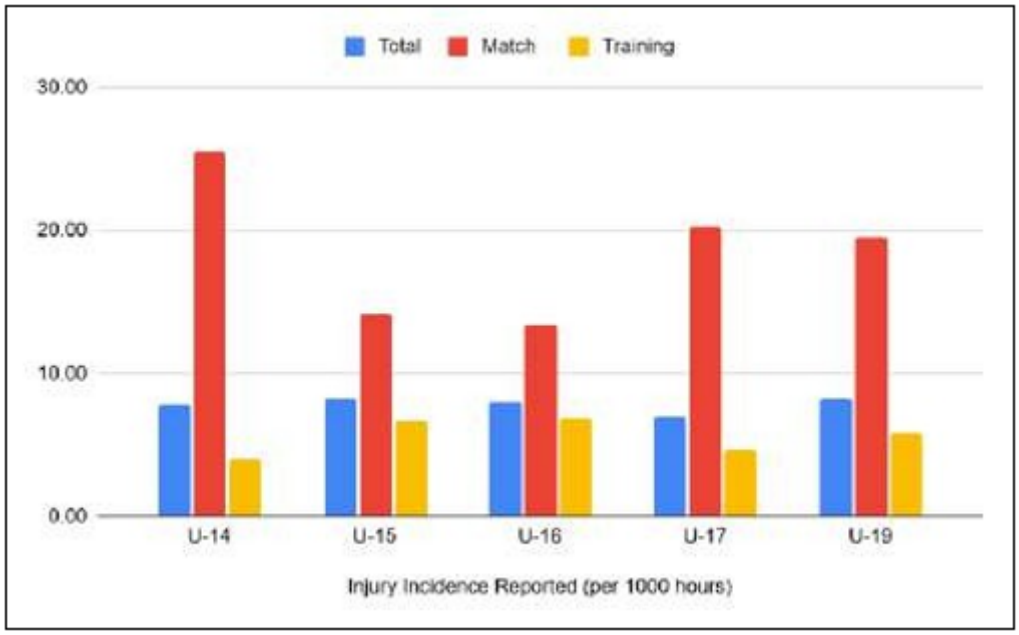
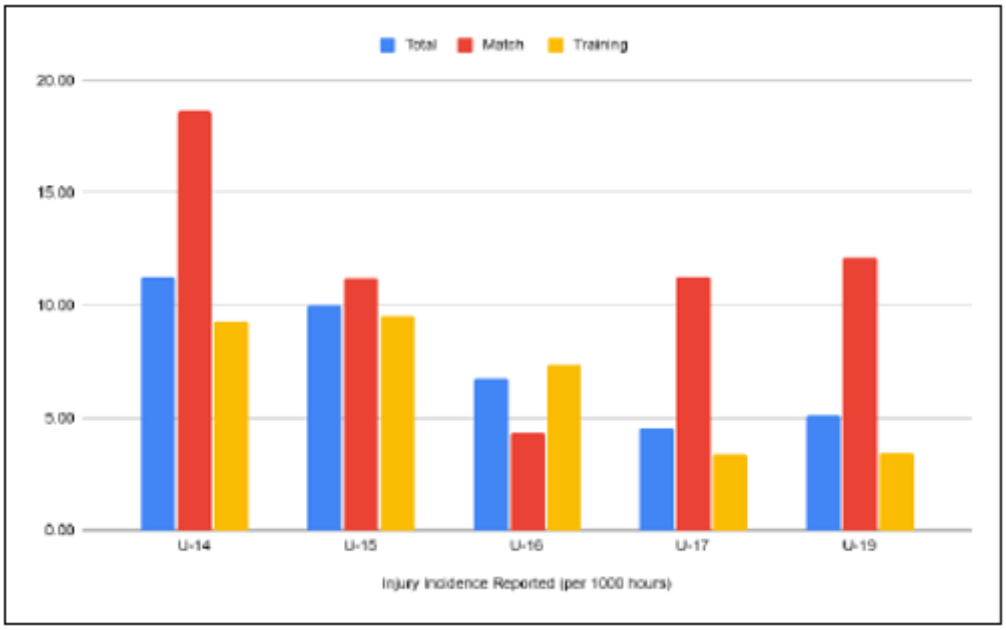


Figure 5. Injury incidence (per 1000 hours exposure) for the season 2023-24.



Type of Injury

The types of injuries most prevalent across both seasons were muscle and tendon injuries, fractures, bone stress injuries, and joint (non-bone) and ligament injuries (**Figures 6 and 7**). A drill down from the above categories revealed that muscle strains, ruptures, or tears and joint sprains or ligament tears were the top categories, accounting for approximately 52% of injuries in 2022-23 and 59% in 2023-24.

When considering exposure, it's crucial to note the age-specific incidence of injuries. The academy- level burden of muscle strains, ruptures, or tears occurred at 2.80 per 1000 hours of exposure in 2022-23 and 2.36 per 1000 hours in 2023-24. The U-14 category had the least incidence at 1.12 per 1000 hours of training in 2022-23, while the U-15 category had the highest at 4.75 per 1000 hours.

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Similarly, for joint sprains or ligament tears, at an academy level, the overall incidence was 1.40 per 1000 hours of training in 2022-23 and 1.85 per 1000 hours in 2023-24. For specific age groups, the highest incidence in 2022-23 was in the U-14 category at 1.68 per 1000 hours, and the lowest was in the U-15 category at 0.59 per 1000 hours. In 2023-24, the U-19 category had the maximum incidence at 1.77 per 1000 hours, while the U-15 category had the least at 0.59 per 1000 hours of exposure. These insights into injury incidence guide us to the robust need for training and injury prevention strategies for different age groups.

Figure 6. Type of Injury for the season 2022-23 (% of total contribution).

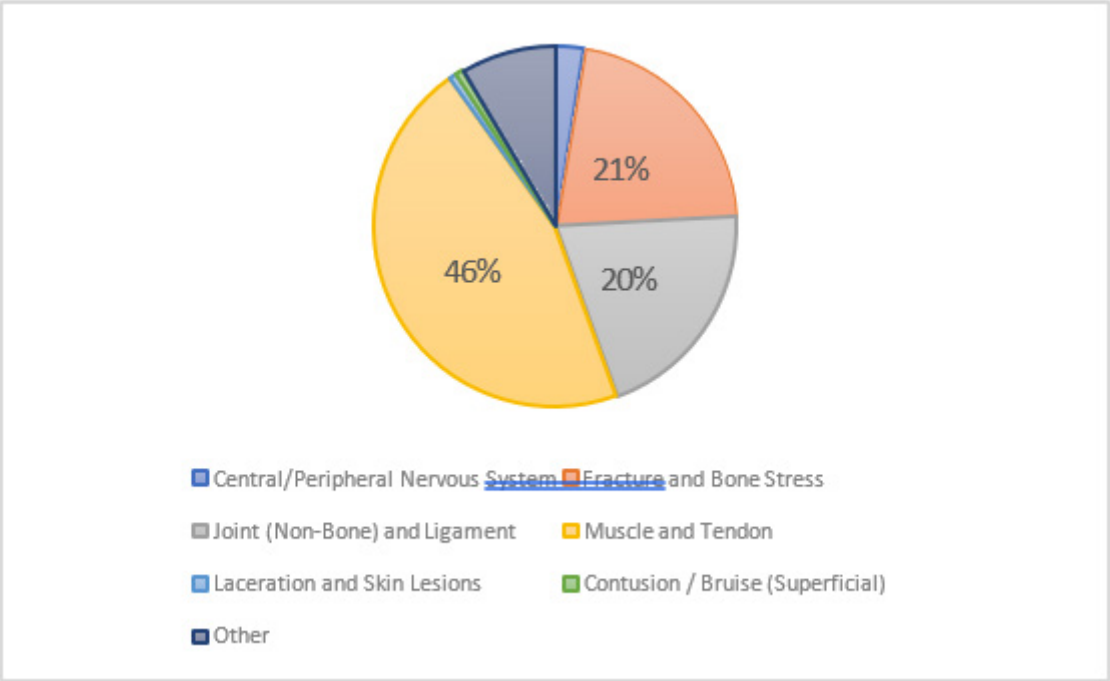
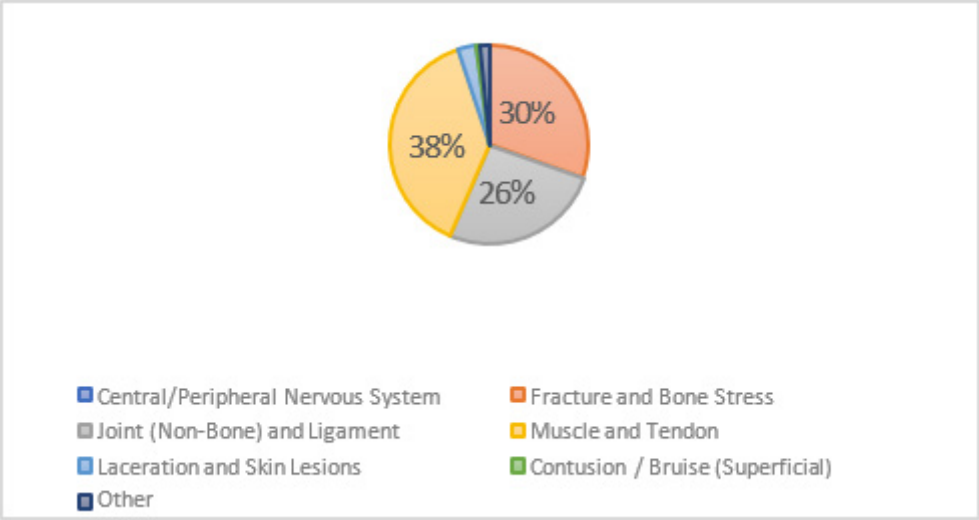


Figure 7. Type of Injury for the season 2023-24 (% of total contribution).



Injury Location

In alignment with the findings presented in the literature review, our sample also demonstrates a high prevalence of lower limb injuries (López- Valenciano et al., 2019; Pfirrmann et al., 2016; Robles-Palazón et al., 2022). Specifically, during the 2022-23 season, 124 out of 153 injuries involved the lower limbs. During the 2023-24 season, 109 out of 138 injuries involved the lower limbs. In the 2022-23 season, injuries were distributed relatively evenly among the knee, ankle, groin, and thigh, significantly contributing to the total injuries (**Figure 8**). However, there was a notable shift in the 2023-24 season, with ankle injuries comprising most of the total and thigh and hip injuries falling significantly (**Figure 9**).

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When adjusted for exposure, the rate of injuries in 2022-23 was 1.66 per 1000 hours for the thigh, 1.45 per 1000 hours for the knee, and 1.35 per 1000 hours for the ankle. The U-15 age group had the maximum thigh injury rate at 2.08 per 1000 hours, while the U-14 group had the lowest at 0.84 per 1000 hours. For knee injuries, the U-16 group had the maximum incidence at 2.08 per 1000 hours, and the U-17 group had the lowest at 0.61 per 1000 hours. Ankle injuries were most frequent in the U- 19 group at 1.59 per 1000 hours and least frequent in the U-16 group at 0.89 per 1000 hours. In the 2023-24 season, ankle injuries were the most prevalent, with an overall incidence rate of 2.21 per 1000 hours. The highest rate was observed in the U-14 age group, at 4.32 per 1000 hours, while the U-19 group had the lowest incidence rate, at 1.19 per 1000 hours.

Figure 8. Location of Injury for the season 2022-23 (Total no. of injuries).

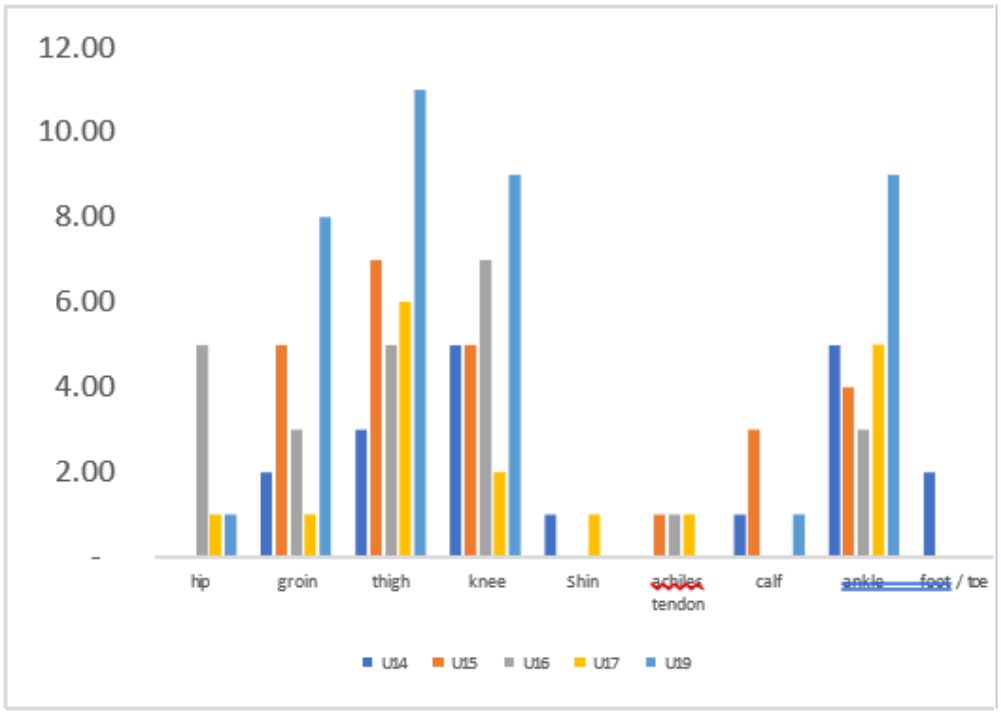
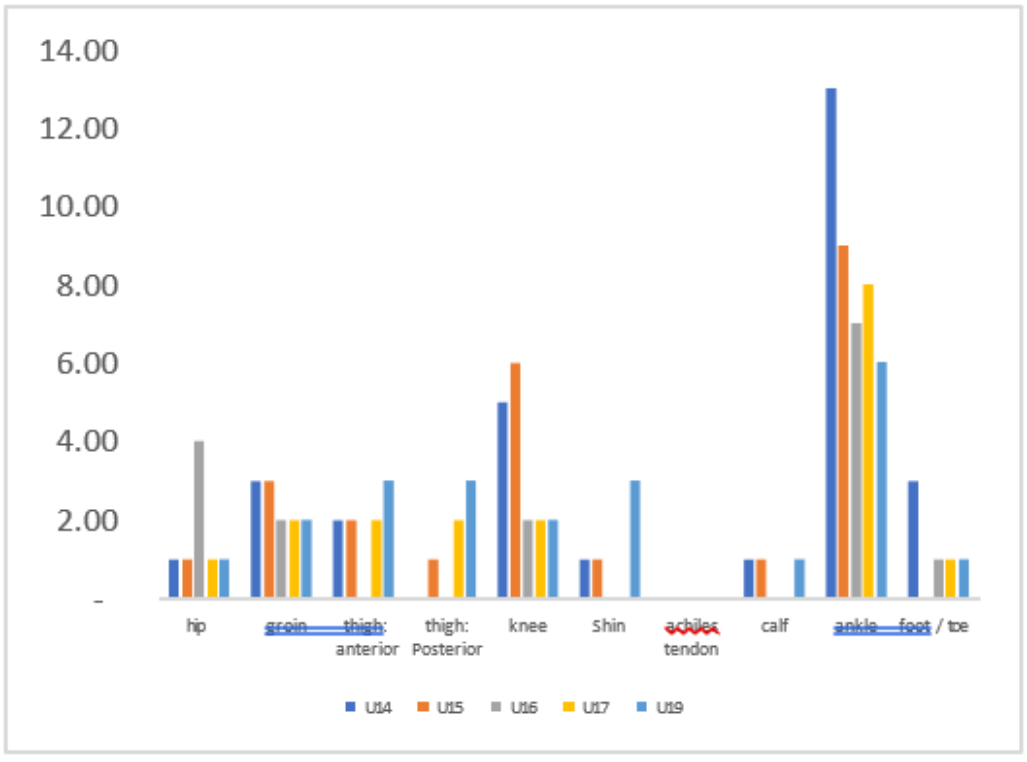


Figure 9. Location of Injury for the season 2023-24 (Total no. of injuries).



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Injury recurrence

In the 2022-23 season, recurring injuries constituted 18% (n = 27) of all injuries, whereas in the 2023-24 season, this figure decreased to 8% (n = 12). Notably, no recurring injuries were reported in the U17 team during either season, and the U14 team experienced no recurring injuries in the 2022- 23 season. The primary site for recurring injuries was the knee in the 2022-23 season, while in the 2023-24 season, the lumbar-sacral spine and buttock were the predominant locations (Table 7, Table 8).

Table 7. Injury recurrence in the season 2022-23.

Injury Location	Exacerbation of a stable (not recovered) condition	Recurrent after fullrecovery & return to sports	Grand Total
Achilles tendon		2	2
Ankle		2	2
Groin	1	4	5
Hip		3	3
Knee	4	5	9
Lumbar-sacral spine/buttock		1	1
Thigh		3	3
Thoracic spine / upper back		1	1
Wrist		1	1
Grand Total	5	22	27

Table 8. Injury recurrence in the season 2023-24.

Injury Location	Exacerbation of a stable (not recovered) condition	Recurrent after full recovery & return to sports	unknown, or not specified	Grand Total
Ankle		2	1	3
Foot/toe		1		1
knee		2		2
Lumbar-sacral spine/buttock	1	3		4
Pelvis		1		1
Shin		1		1
Grand Total	1	10	1	12

The overall recurrence rate of injuries, adjusted for exposure, was 1.40 per 1000 hours in 2022-23 and 0.62 per 1000 hours in 2023-24. The U-16 team contributed the most to recurring injuries in 2022- 23, with a rate of 2.67 per 1000 hours, while in 2023-24, the U-15 team had the highest recurrence rate at 1.17 per 1000 hours.

Mechanism of injury

Approximately 65% (n=100) of the injuries in 2022-23 and 60% (n=82) in 2023-24 were no- contact-related. Overuse injuries accounted for 40% (n=62) in 2022-23 and 36% (n=49) in 2023-24. Most overuse injuries occurred in the U-15 and U-16 categories in both seasons. The U-17 group experienced the fewest overuse injuries in 2022-23 (**Figure 10**), while the U-14 group had the fewest in 2023-24 (**Figure 11**).

The overuse injury incident to overall exposure stood at 3.22 per 1000 hours in 2022-23 and 2.52 per 1000 hours in 2023-24.

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The major contributors were U-15 and U-16, as also mentioned above; their rates were 4.75 in 2022-23 and 3.52 in 2023- 24, and the lowest injury incidence rate was for U- 17, which was 1.21 per 1000 hours in 2022-23 and 1.53 per 1000 hours in 2023-24.

Figure 10. Mechanism of the injury for the season 2022-23 (Total no. of injuries).

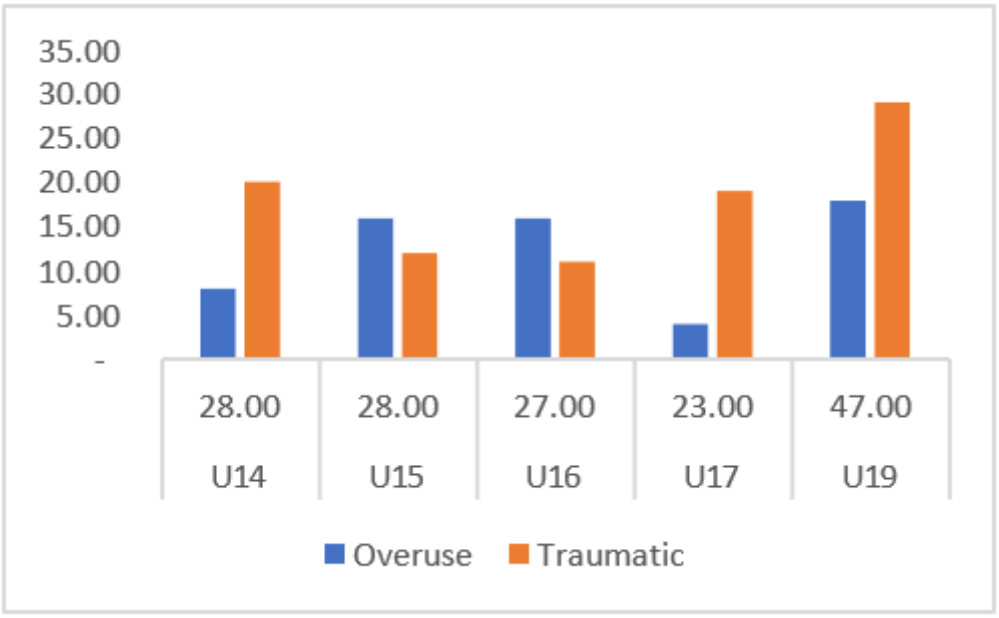
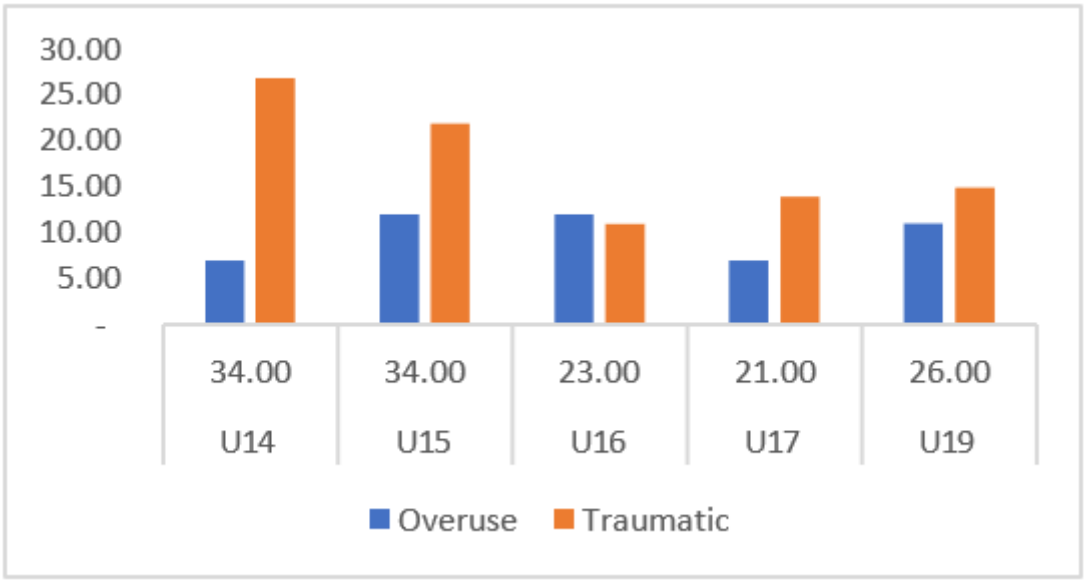


Figure 11. Mechanism of the injury for the season 2023-24 (Total no. of injuries).



Severity

At the academy level, most injuries in the 2022-23 season were of mild severity (4 to 7 days) (n=52, 34%). This trend was consistent across all age groups except for the U-14s and U-16s, where the common injuries were of minimal severity (1 to 3 days) (U-14: n=10, 36%, U-16: n=11, 41%) (**Figure 12**). In the 2023-24 season, the majority of injuries were of minimal severity (1 to 3 days) (n=67, 48.6%), a trend seen across all age groups except for the U-17s, where moderate severity injuries (8 to 28 days) were the most common (n=13, 61.9%) (**Figure 13**).

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Figure 12. Severity of the injury for the season 2022-23 (Total no. of injuries).

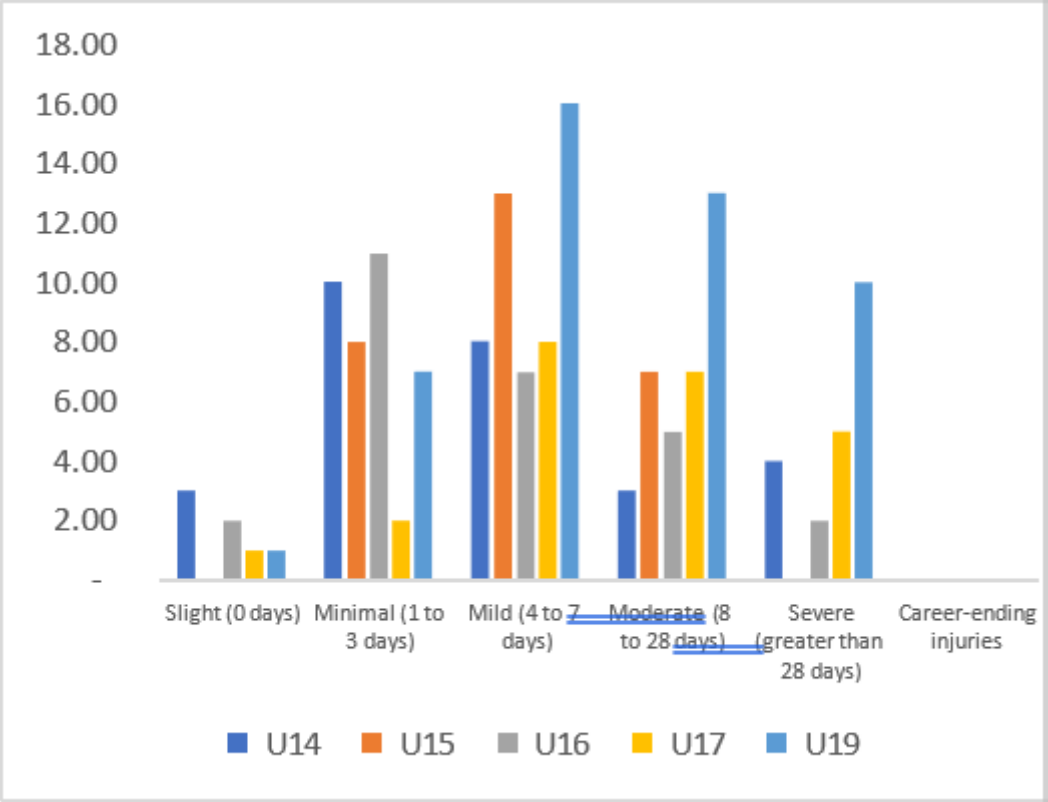
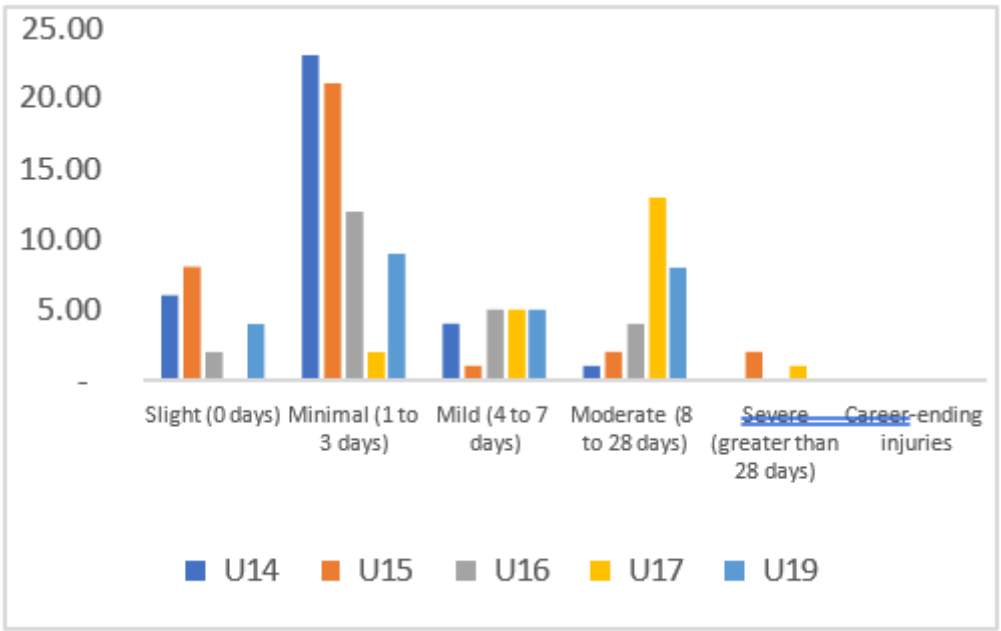


Figure 13. Severity of the injury for the season 2023-24 (Total no. of injuries).



aspect of injury incidence reporting. In the 2022-23 season, mild injuries (4 to 7 days) had the maximum incidence rate at 2.70 per 1000 hours. In the 2023-24 season, minimal injuries (1 to 3 days) were most common, with an incidence rate of 3.44 per 1000 hours at an overall level. Most age groups reflected these overall trends, except for the U-16 and U-14 groups in 2022-23, which had the highest incidence rate from minimal injuries (1 to 3 days) at 3.27 per 1000 hours and 2.80 per 1000 hours, respectively (**Figure 14**) and U-17 in 2023-24, which reported highest incidence rate in the Moderate (8 to 28 days) category with the rate of 2.85 per 1000 hours (**Figure 15**).

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Figure 14. Severity of the injury incident rate for the season 2022-23 (Total no. of injuries per 1000 hours of exposure).

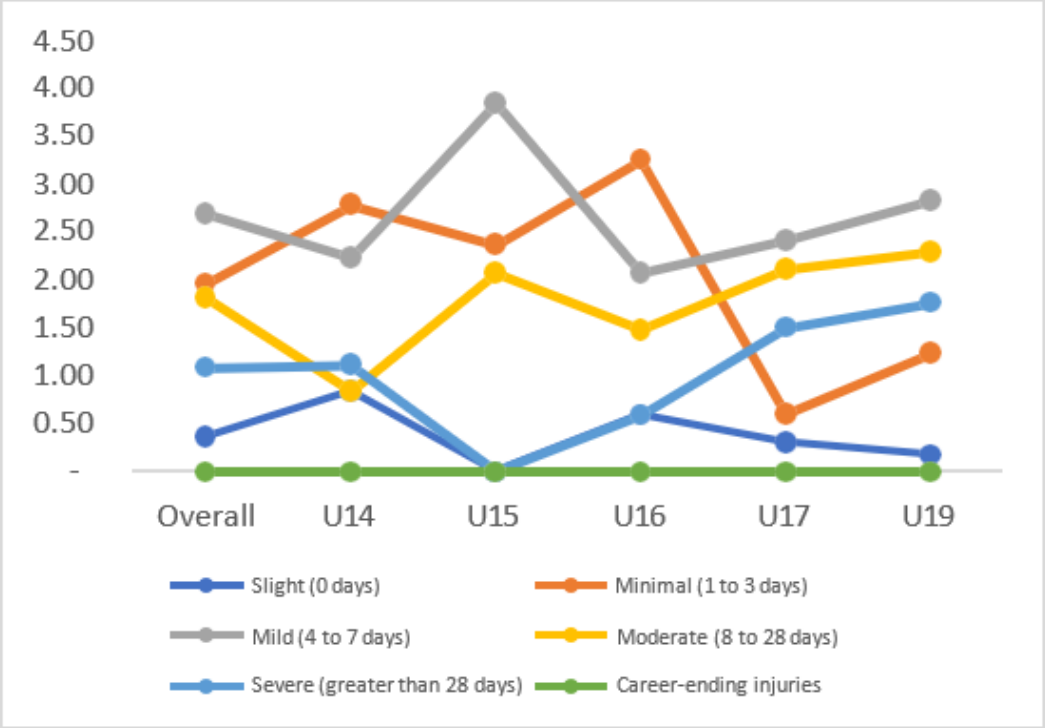
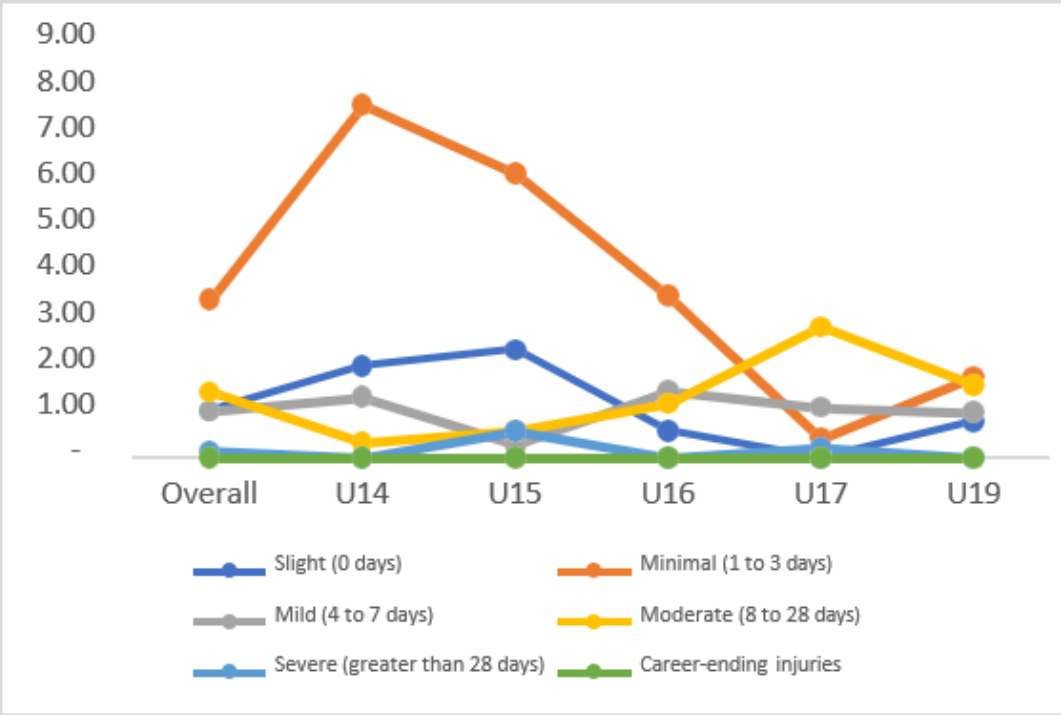


Figure 15. Severity of the injury incident rate for the season 2023-24 (Total no. of injuries per 1000 hours of exposure).



Risk Analysis

Risk analysis was conducted by calculating the risk factor, as described in the data analysis section of this study. A higher factor indicates a more significant risk of injury. In the 2022-23 season, the U-16 age group had the highest overall training-related risk at 0.25 (Figure 16), while the U-14 and U-19 teams had the lowest training-related risk factors at 0.16 (**Figure 16**). The match-related risk factor was highest for the U-14 group at 1.03 and lowest for the U-19 group at 0.55 (Figure 16). When comparing the relative risk of match injuries to training-related injuries, the U-14 group had the highest ratio at 6.47, while the

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U-16 group had the lowest at 2.55 (**Figure 16**).

For the 2023-24 season, the training-related risk factor was highest for the U-14 group at 0.31 and lowest for the U-19 group at 0.10 (Figure 17). Similarly, the match-related risk factor was also highest for the U-14 group at 0.72 and lowest for the U-16 group at 0.25 (Figure 17). Regarding the relative risk of match injuries compared to training- related injuries, the U-19 group ranked highest at 4.11, and the U-16 group had the least relative risk at 0.98 (**Figure 17**).

Figure 16. Risk factors for training, match, and relative risk for match to training for the season 2022-23.

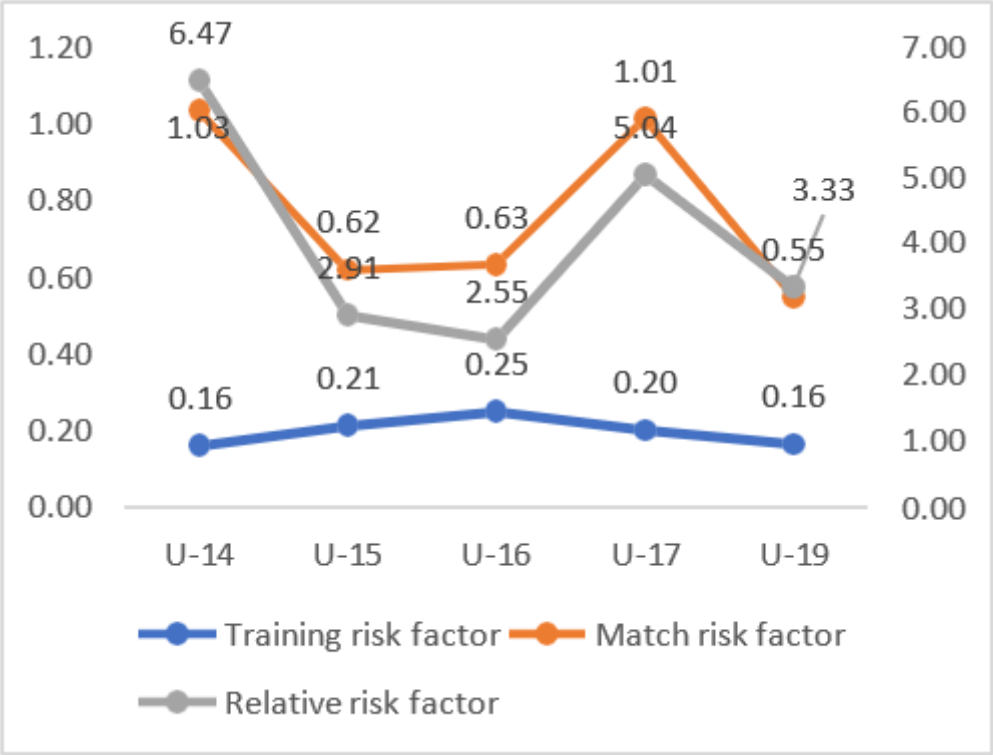
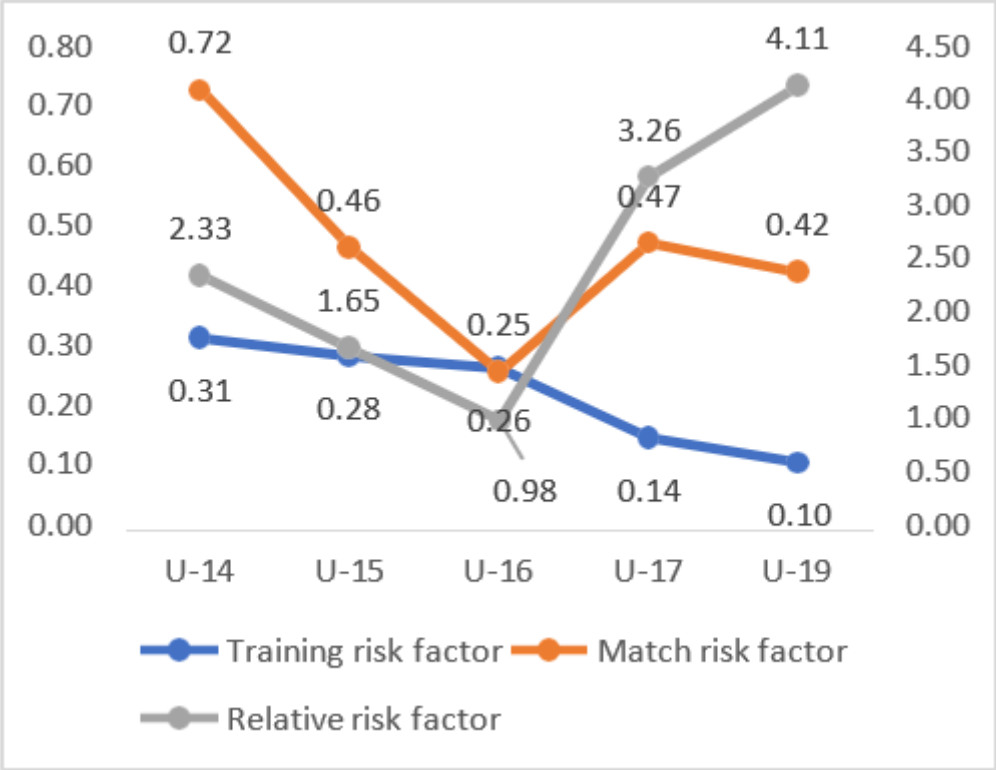


Figure 17. Risk factors for training, match, and relative risk for match to training for the season 2023-24.



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DISCUSSION

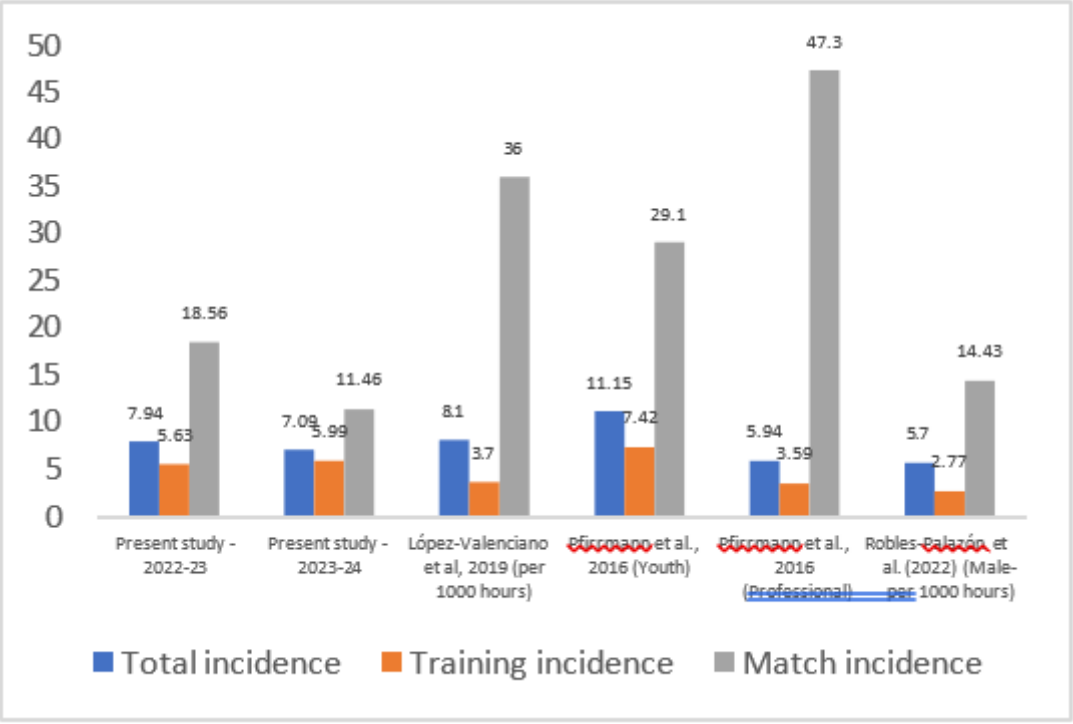
Injury incidence

The study aimed to utilise a consensus statement (Fuller et al., 2006) to define the injury incidence, patterns, and risks among youth football athletes at an academy in Mumbai, India, focusing on a target population aged 13 to 18. While numerous studies have examined injury incidence in football, research is scarce specifically on youth athletes, and almost none have focused on athletes in India.

Our findings on the injury incidence rate revealed a range from approximately 4 to 11 injuries per 1000 hours (Figure 4) (Figure 5), which aligns with the literature we reviewed (López-Valenciano et al., 2019),(Pfirrmann et al., 2016), (Robles- Palazón et al., 2022). Additionally, injuries during matches are significantly higher than during training (**Figure 18**).

Robles-Palazón et al. (2022) reported higher incidences among youth aged U17-19 than those aged U13-16. In contrast, our data showed either an improvement or no change in injury incidence as we progressed from the lower to the higher age group over both seasons (Figures 4 and 5). This difference may be due to match-related injuries. In the Indian academy, younger age groups are often compelled to compete with adults due to a lack of competitive opportunities within their age group of 14s and 15s, leading to more injuries caused by the disparity in physicality, the relatively higher incidences of match-related injuries which can also be observed in Figure 4 and 5. By the time athletes reach U-17 and U-19, they have developed the necessary physicality, resulting in a more level playing field and a lower rate of injury incidences. Navigating this complexity alongside the crucial professional development needed may pose challenges. However, emphasising thorough physical preparation throughout the week and adopting a systematic approach to selecting appropriate opponents, including overage and similar-age teams in friendly matches throughout the season, could mitigate injury risks.

Figure 18. Comparison of injury incidence for the present study with the literature review.



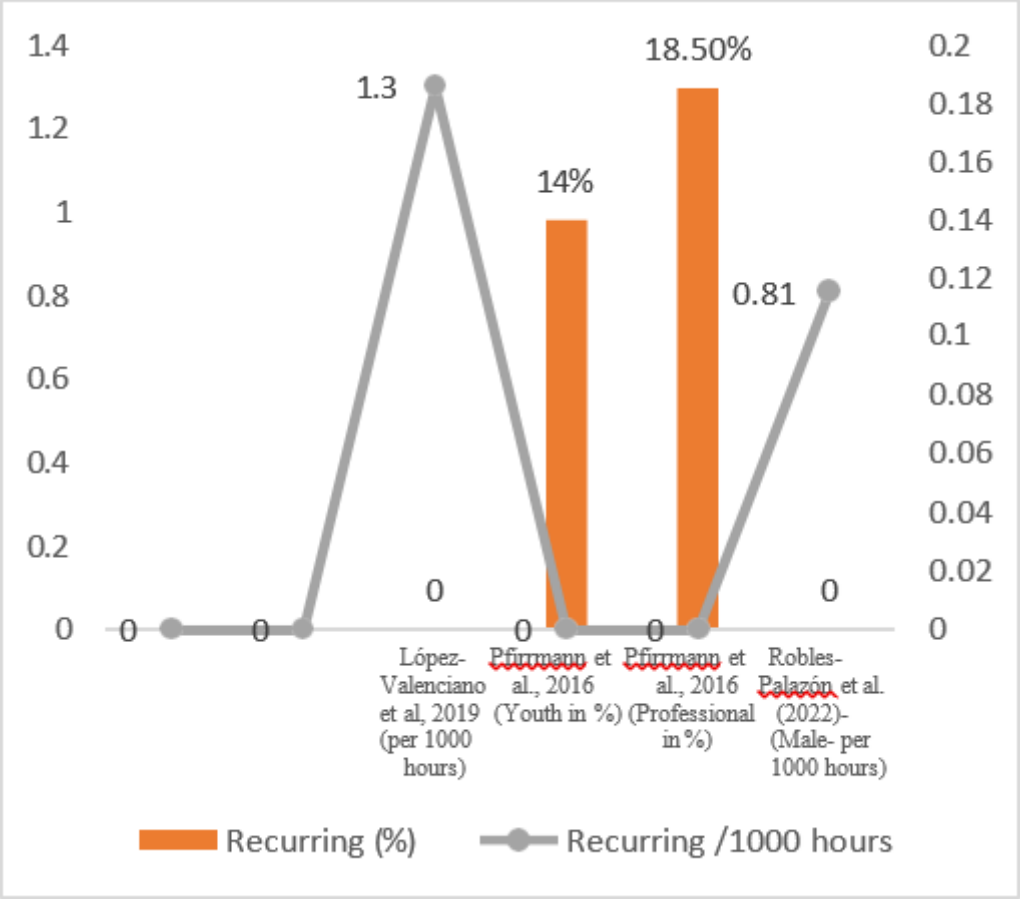
Recurrence

In our study, training-related injuries were most prevalent in the U-15 and U-16 age groups (Figures 4 and 5). These age groups also exhibited a more significant incidence of recurring injuries compared to others, indicating potential growth- related problems such as Morbus Sever and Osgood-Schlatter disease, which are commonly observed within this age group (Hendrix, 2005), (Ladenhauf, 2020), (Circi, 2017). This hypothesis is bolstered by the observation that the knee and ankle were prominent sites of these recurring injuries, alongside contributions from the groin and Lumbar-sacral spine/buttock (Tables 13 and 14). While the general pattern of recurring injury incidences is consistent with findings in the literature (**Figure 19**), the notable frequency prompts consideration of a premature return to training or play. These findings underscore the urgency and the

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importance of evidence-backed criteria to ensure a safe return to exercise and play, highlighting an area in football that may require immediate improvement. Further, it also compels the sports medicine team to have good injury prevention and load management strategies around the specific joints and muscles like the knee, ankle, lower back and groin, which have a very high likelihood of recurrence and are also connected to growth spurt.

Figure 19. Comparison of recurring injury incidence for the present study with the literature review.



Location of injury

The studies above identified the thigh, particularly the posterior upper leg muscles, as the most frequent location of injuries, followed by the knee (Table 6). However, injury locations in our study encompassing both seasons collectively show a more balanced distribution (Figures 8 and 9). This discrepancy may stem from including both professional and youth populations in the literature review, potentially diluting the effect of growth- related issues on knee and ankle injuries. Nevertheless, definitive conclusions are challenging due to other variables such as playing level, sample size, or specific training methods that could also contribute to these variations.

Unsurprisingly, lower extremity injuries predominate in our study and the literature, given the nature of football. Addressing these challenges requires a comprehensive approach to lower limb development (Croisier, J. L., 2008), encompassing eccentric strength training (Petersen, J. et al., 2011), neuromuscular development (Emery, 2010) (Silvers-Granelli et al., 2015), flexibility (Henderson, G., 2010), and meticulous management of player workload, wellness, and adherence (McCall, A., 2016). This meticulous management is a crucial aspect of injury prevention, ensuring the safety and performance of football players and instilling a sense of responsibility and dedication in the sports medicine team.

Mechanism of injury

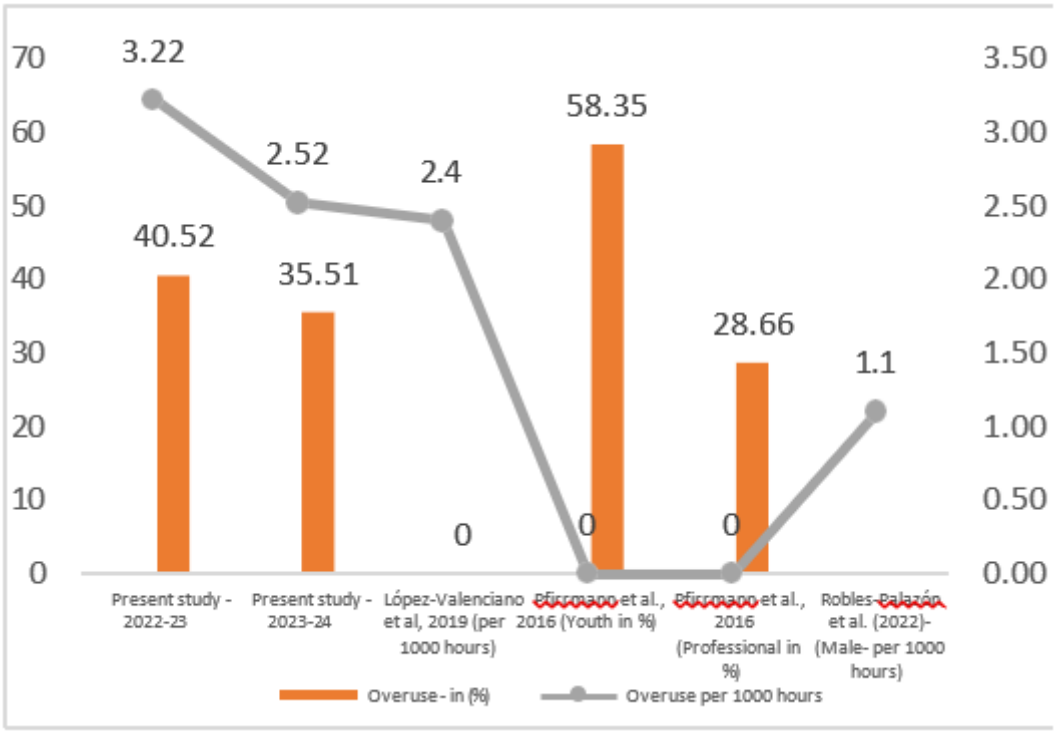
Pfirrmann et al. (2016) observed that overuse injuries are significantly more common in youth than in professional adult players (Table 6). The present study corroborates this finding, showing a more significant percentage of overuse injuries amongst youth athletes than professional adults in percentage terms and when measured per 1000 hours of exposure in the overall literature review (**Figure 20**). This highlights the importance of greater attention to rest, recovery, and load monitoring

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for youth athletes, as they are more susceptible to overuse injuries than their professional adult counterparts. For non-contact traumatic injuries, such as those occurring during running, sprinting, or jumping, employing neuromuscular training programs to improve a player's motor abilities, joint-related stability, and better fatigue management may reduce the likelihood of injury due to sudden strain on soft tissues (Emery, 2010) (Silvers-Granelli et al., 2015). Players should also engage in both unstructured and structured strength training. Younger age groups, such as U-14 and U-15, may incorporate foundational and free-play strength training elements to enhance their physical literacy, considering they will most likely be before their Peak height velocity (PHV) (Lloyd, R. S., 2012). Modalities like animal flow and gamified strength exercises can effectively develop strength and foster force absorption, force production, contact readiness, rolling techniques, jumping abilities, and understanding of momentum.

personnel must be adequately equipped to prevent these numbers from escalating as workloads increase for youth athletes. As athletes advance to higher age groups such as U-16, U-17, and U-19, it becomes crucial to introduce and transition them to a more structured training regimen. This should include targeted sessions that commence with foundational movements like squatting, hinging, pulling, and pressing with weights and gradually introduce athletes to more intricate exercises such as ballistic movements like push press, swings, and Olympic lifts. Furthermore, there should be a strong emphasis on progressive overload regarding training variables such as volume and intensity. This structured approach not only aids in motor skill development but also fosters muscular strength and power improvement to aid performance improvements and plays a significant role in injury prevention (Moran, J.et al., 2017).

Figure 20. Comparison of the mechanism of injury incidence for the present study with the literature review.

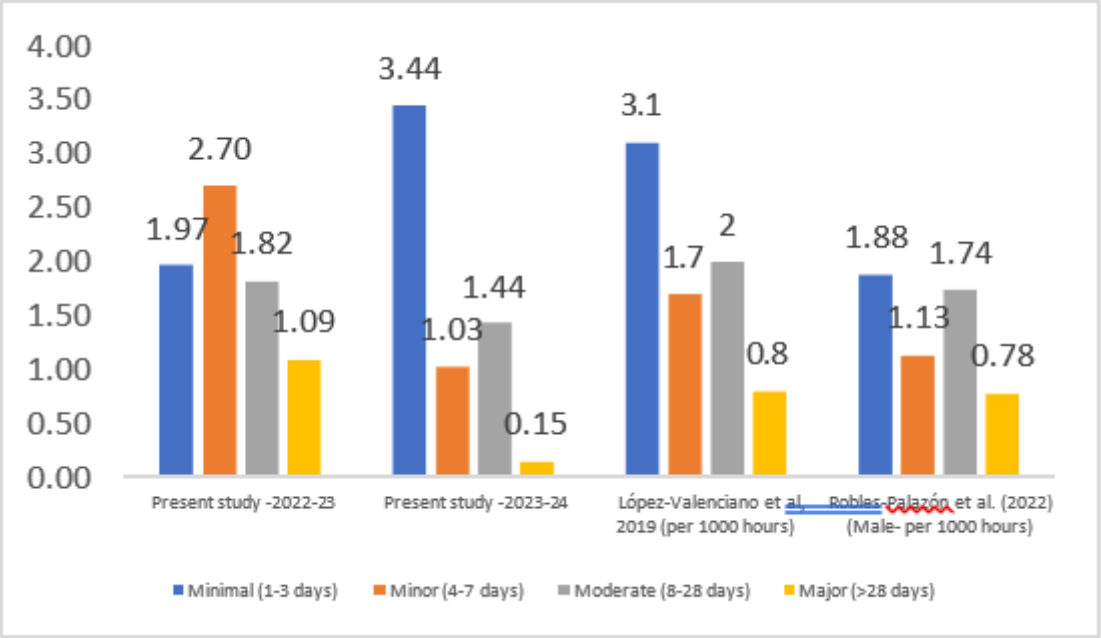


Severity of injury

. Thankfully, most football injuries are minimal (1- 3 days) or minor (4-7 days). However, severe injuries (>28 days) also make up a reasonable portion, although they are less common among youth athletes (Table 8). Our study's injury incidence ratios align with the literature review (**Figure 21**). However, it is crucial to acknowledge that the workload for athletes in India may be lower than that of athletes abroad. Therefore, our sports science and sports medicine infrastructure.

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Figure 21. Comparison of injury incidence basis the severity of incidence for the present study with the literature review.



CONCLUSION

This study employed the consensus statement methodology (Fuller et al., 2006) to examine injury rates among youth academy soccer players in India. Across age groups, there were an average of 27-30 injuries per season per squad, involving 90 athletes in the 2022-23 season and 91 in the 2023-24 season (Table 6). The results highlight that match-related injuries were significantly more frequent (2 to 6 times) than training-related injuries, with common types including muscle strains, ruptures, tears, joint sprains, and ligament tears affecting the knee, ankle, groin, and thigh. Overuse injuries accounted for approximately 35% to 40% of all injuries. In the 2022-23 season, injuries were mild primarily (lasting 4 to 7 days), whereas in 2023-24, they were generally minimal (resolving within 1 to 3 days). These findings underscore the relevance of injury prevention strategies, load monitoring, and optimising rehabilitation and return-to-sport protocols, as stated in the study's discussion section. Future research should consider larger participant cohorts and more rigorous tracking of athlete exposure.

Future Recommendation

A significant limitation was the irregularity among younger athletes (U-14, U-15, and U-16) in updating their session durations, which impacted the exposure numbers of those age groups. Consequently, session durations of older athletes (U-17 and U-19) from the load monitoring system were used as a representation to estimate exposure for the younger athletes. Additionally, injury incidences were reported by athletes who benefit from high-quality coaching and sports medicine practices in India. However, access to such facilities is limited for aspiring youth football athletes across India, suggesting that these findings may not fully represent the experiences of all Indian athletes. In future studies, involving more academies and a broader population would be beneficial to achieve a more comprehensive representation.

REFERENCES

1. Bangsbo, J., Mohr, M., & Krustrup, P. (2006). Physical and metabolic demands of training and match-play in the elite football player. Journal of Sports Sciences, 24(7), 665–674.https://doi.org/10.1080/02640410500482529

2. Barnes, C., Archer, D. T., Hogg, B., Bush, M., & Bradley, P. S. (2014). The evolution of physical and technical performance parameters in the English Premier League. International Journal of Sports Medicine, 35(13), 1095–1100. https://doi.org/10.1055/S-0034-1375695

3. Bradley, P. S., Sheldon, W., Wooster, B., Olsen, P., Boanas, P., & Krustrup, P. (2009). High-intensity running in English FA Premier League soccer matches. Journal of Sports Sciences, 27(2), 159–168. https://doi.org/10.1080/02640410802512775

4. Circi, E., Atalay, Y., & Beyzadeoglu, T. (2017). Treatment of Osgood-Schlatter disease: review of the literature. Musculoskeletal Surgery,101(3),195–200. https://doi.org/10.1007/S12306-017-0479-7.

The British Journal of Sports Medicine (ISSN 3064-8130)

5. Croisier, J. L., Ganteaume, S., Binet, J., Genty, M., & Ferret, J. M. (2008). Strength imbalances and prevention of hamstring injury in professional soccer players: a prospective study. The American Journal of Sports Medicine, 36(8), 1469–1475. https://doi.org/10.1177/0363546508316764.

6. di Salvo, V., Baron, R., Tschan, H., Calderon Montero, F. J., Bachl, N., & Pigozzi, F. (2007). Performance characteristics according to playing position in elite soccer. International Journal of Sports Medicine, 28(3), 222–227. https://doi.org/10.1055/S-2006-924294

7. Eirale, C., Tol, J. L., Farooq, A., Smiley, F., & Chalabi, H. (2013). A low injury rate strongly correlates with team success in Qatari professional football. British Journal of Sports Medicine,47(12), 807–808. https://doi.org/10.1136/BJSPORTS-2012- 091040

8. Ekstrand, J. (2013). Keeping your top players on the pitch: the key to football medicine at a professional level. British Journal of Sports Medicine, 47(12), 723–724. https://doi.org/10.1136/BJSPORTS-2013- 092771

9. Ekstrand, J., Hägglund, M., & Waldén, M. (2011). Injury incidence and injury patterns in professional football: the UEFA injury study. British Journal of Sports Medicine, 45(7), 553–558. https://doi.org/10.1136/BJSM.2009.060582

10. Eliakim, E., Morgulev, E., Lidor, R., & Meckel,Y. (2020). Estimation of injury costs: Financial damage of English Premier League teams' underachievement due to injuries. BMJ Open Sport andExercise Medicine,6(1). https://doi.org/10.1136/BMJSEM-2019- 000675

11. Elm, E. von, Altman, D. G., Egger, M., Pocock, S. J., Gøtzsche, P. C., & Vandenbroucke, J. P. (2007). Strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. BMJ: British Medical Journal, 335(7624), 806. https://doi.org/10.1136/BMJ.39335.541782.A D

12. Emery, C. A., & Meeuwisse, W. H. (2010). The effectiveness of a neuromuscular prevention strategy to reduce injuries in youth soccer: a cluster-randomised controlled trial. British Journal of Sports Medicine, 44(8), 555–562. https://doi.org/10.1136/BJSM.2010.074377

13. Ergün, M., Denerel, H. N., Binnet, M. S., & Ertat, K. A. (2013). Injuries in elite youth football players: a prospective three-year study. Acta Orthopaedica et Traumatologica Turcica, 47(5), 339–346. https://doi.org/10.3944/AOTT.2013.3177

14. FIFA publishes Professional Football Report 2023. (n.d.). Retrieved May 18, 2024, from https://inside.fifa.com/legal/news/fifa-ublishes-professional-football-report-2023

15. Fuller, C. W., Ekstrand, J., Junge, A., Andersen, T. E., Bahr, R., Dvorak, J., Hägglund, M., McCrory, P., & Meeuwisse, W.H. (2006). Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. Clinical Journal of Sport Medicine, 16(2), 97–106. https://doi.org/10.1097/00042752-200603000-00003

16. Harper, D. J., Carling, C., & Kiely, J. (2019). High-Intensity Acceleration and Deceleration Demands in Elite Team Sports Competitive Match Play: A Systematic Review and Meta- Analysis of Observational Studies. Sports Medicine (Auckland, N.Z.), 49(12), 1923–1947. https://doi.org/10.1007/S40279-019-01170-1 .

17. Hendrix, C. L. (2005). Calcaneal apophysitis (Severe disease). Clinics in Podiatric Medicine and Surgery, 22(1), 55–62. https://doi.org/10.1016/j.cpm.2004.08.011

18. Henderson, G., Barnes, C. A., & Portas, M. D. (2010). Factors associated with increased propensity for hamstring injury in English Premier League soccer players. Journal of Science and Medicine in Sport, 13(4), 397–402. https://doi.org/10.1016/J.JSAMS.2009.08.003

19. Hulton, A., Ford, T., & Reilly, T. (2008). Match analyses of australian international female soccer players using an athlete tracking device. Science and Football VI, 250–254. https://doi.org/10.4324/9780203893685-51

20. Ladenhauf, H. N., Seitlinger, G., & Green, D.W. (2020). Osgood-Schlatter disease: a 2020 update of a common knee condition in children. Current Opinion in Pediatrics, 32(1), 107–112. https://doi.org/10.1097/MOP.0000000000000 842

21. Lloyd, R. S., & Oliver, J. L. (2012). The youth physical development model: A new approach to long-term athletic development. Strength and Conditioning Journal, 34(3), 61–72. https://doi.org/10.1519/SSC.0B013E31825760 EA

22. López-Valenciano, A., Ruiz-Pérez, I., Garcia- Gómez, A., Vera-Garcia, F. J., de Ste Croix, M., Myer, G. D., &

The British Journal of Sports Medicine (ISSN 3064-8130)

Ayala, F. (2020).Epidemiology of injuries in professional football: a systematic review and meta- analysis. British Journal of Sports Medicine, 54(12), 711–718. https://doi.org/10.1136/BJSPORTS-2018- 099577

23. Mallo, J., Mena, E., Nevado, F., & Paredes, V. (2015). Physical Demands of Top-Class Soccer Friendly Matches in Relation to a Playing Position Using Global Positioning System Technology. Journal of Human Kinetics, 47(1), 179–188. https://doi.org/10.1515/HUKIN-2015-0073

24. McCall, A., Dupont, G., & Ekstrand, J. (2016). Injury prevention strategies, coach compliance and player adherence of 33 of the UEFA Elite Club Injury Study teams: a survey of teams' head medical officers. British Journal of Sports Medicine,50(12),725–730.https://doi.org/10.1136/BJSPORTS-2015- 095259

25. Moran, J., Sandercock, G. R. H., Ramírez- Campillo, R., Meylan, C., Collison, J., & Parry, D. A. (2017). A meta-analysis of maturation- related variation in adolescent boy athletes' adaptations to short-term resistance training. Journal of Sports Sciences, 35(11), 1041–1051. https://doi.org/10.1080/02640414.2016.12093 06

26. Pfirrmann, D., Herbst, M., Ingelfinger, P., Simon, P., & Tug, S. (2016). Analysis of Injury Incidences in Male Professional Adult and Elite Youth Soccer Players: A Systematic Review. Journal of Athletic Training, 51(5), 410–424. https://doi.org/10.4085/1062-6050-51.6.03

27. Robles-Palazón, F. J., López-Valenciano, A., de Ste Croix, M., Oliver, J. L., García-Gómez, A., Sainz de Baranda, P., & Ayala, F. (2022). Epidemiology of injuries in male and female youth football players: A systematic review and meta-analysis. Journal of Sport and Health Science, 11(6), 681–695.https://doi.org/10.1016/J.JSHS.2021.10.002

28. Silvers-Granelli, H., Mandelbaum, B., Adeniji, O., Insler, S., Bizzini, M., Pohlig, R., Junge, A.,Snyder-Mackler, L., & Dvorak, J. (2015). Efficacy of the FIFA 11+ Injury Prevention Program in the Collegiate Male Soccer Player. The American Journal of Sports Medicine, 43(11), 2628–2637.https://doi.org/10.1177/0363546515602009

29. Stølen, T., Chamari, K., Castagna, C., & Wisløff, U. (2005). Physiology of soccer: an update. Sports Medicine (Auckland, N.Z.), 35(6), 501–536.https://doi.org/10.2165/00007256-200535060- 00004

30. Tsutsui, T., Iizuka, S., Sakamaki, W., Maemichi, T., & Torii, S. (2022). Growth until Peak Height Velocity Occurs Rapidly in Early Maturing Adolescent Boys. Children, 9(10). https://doi.org/10.3390/CHILDREN9101570