Injury incidence and burden in a youth elite football academy: a four-season prospective study of 551 players aged from under 9 to under 19 years

Olivier Materne,1,2 Karim Chamari,1,2 Abdulaziz Farooq,1,3 Adam Weir,1,3,4 Per Hölmich,1,5 Roald Bahr,1,6 Matt Greig,7 Lars R McNaughton7,8

ABSTRACT

Objective Investigate the incidence and burden of injuries by age group in youth football (soccer) academy players during four consecutive seasons.

Methods All injuries that caused time-loss or required medical attention (as per consensus definitions) were prospectively recorded in 551 youth football players from under 9 years to under 19 years. Injury incidence (II) and burden (IB) were calculated as number of injuries per squad season (s-s), as well as for type, location and age groups.

Results A total of 2204 injuries were recorded. 40% (n=882) required medical attention and 60% (n=1322) caused time-loss. The total time-loss was 25 034 days. A squad of 25 players sustained an average of 30 time-loss injuries (TLI) per s-s with an IB of 574 days lost per s-s. Compared with the other age groups, U-16 players had the highest TLI incidence per s-s (95% CI lower-upper): II= 59 (52 to 67); IB=992 days; (963 to 1022) and U-18 players had the greatest burden per s-s: II= 42.1 (36.1 to 49.1); IB= 1408 days (1373 to 1444). Across the cohort of players, contusions (II=7.7/s-s), sprains (II=4.9/s-s) and growth-related injuries (II=4.3/s-s) were the most common. Meniscus/cartilage injuries had the highest injury severity (95% CI lower-upper): II= 0.4 (0.3 to 0.7), IB= 73 days (22 to 181). The burden (95% CI lower-upper) of physeal fractures (II= 0.8; 0.6 to 1.2; IB= 58 days; 33 to 78) was double than non-physeal fractures.

Summary At this youth football academy, each squad of 25 players averaged 30 injuries per season which resulted in 574 days lost. The highest incidence of TLI occurred in under-16 players, while the highest IB occurred in under-18 players.

INTRODUCTION

Elite youth football (soccer) academies across the world exist to support young players becoming professional players.1 2 Talented children and adolescent athletes are a unique population and require a safe, adapted and developmental coaching programme including appropriate illness and injury surveillance systems.3 There is a lack of prospective epidemiology studies over consecutive seasons among youth elite football academies around the world including large cohorts.4 In an English youth academy, Price et al5 found a rate of 0.8 injuries per player season for a mean time-loss of 9 days per player season, while Le Gall et al6 in elite youth French players observed a rate of 2.2 injuries per player season for a mean time-loss of 32 days per player season. Recently from different academies in Belgium, Brazil, England, Netherlands, Spain and Uruguay, a rate between 0.7 and 1.3 injuries per player season with a mean time-loss ranging from 16 to 29 days per player season have been reported.6–13 The limited depth jeopardises the scientific and clinical understanding of injury prevention, examination, rehabilitation and long-term consequences of severe injuries and much could be learnt from other more experienced paediatric healthcare providers.14–18 More detailed and precise prospective investigations are required using diagnoses that are specific to children and adolescents. This will allow clinicians to more accurately determine the pattern, incidence and burden of the type of injuries in these young players.15 Understanding of injury risk, burden and precise aetiology will help to consistently optimise clinical management, injury prevention and optimise the development in elite youth football.19 The objective of this study was to examine the extent of the different types of injuries and their respective incidence and burden, in all age groups from U-9 to U-19 over four-consecutive seasons, in an elite youth football academy.

METHODS

Study design and subjects

A prospective cohort study of Qatari male youth elite football players was performed during four consecutive seasons (from 2012-13 through 2015-16) in different age groups from under 9 (U-9) to U-19, including a total of 551 players from childhood to late adolescent. Players trained and played at the National training centre ASPIRE Academy in Doha, Qatar. All trained at a similar time of the day (between 10am-12pm and between 4pm-6pm), except when an international tournament or training camp were set overseas. Age groups from U-13 to U-18 trained for approximately 14hour/week including combined football-specific training and competitive play, with a single rest day per week. This weekly load typically comprised 6–8 football training sessions, 1 strength training session, 1–2 conditioning sessions and 1 domestic game per week. In addition, the players were engaged with the academy in two invited international games every 3 weeks. The younger age groups, from U-9 to U-12, participated in an average of 9 hours per week of combined football-specific training and competitive play. This typically comprised 5 football training sessions including agility and coordination, and one domestic game per week. In addition, the younger players participated in a
1-day tournament on a monthly basis. Written informed consent to use regularly collected injury data for research purposes was sought and obtained from the player’s guardians.

Data collection
All musculoskeletal injuries sustained were prospectively recorded by the academy medical staff in an electronic standardised format established on the consensus of Fuller et al. Each squad had an experienced dedicated physiotherapist and all injuries were examined in cooperation with the Academy sports physician. Referral to a surgeon, specialist or imaging was requested on a case-by-case basis if required/necessary to consolidate the diagnosis. Each team’s physiotherapist submitted their injury information of all discharged injured players to the senior physiotherapist who reviewed and consolidated all data on a weekly basis. Injuries not sustained in the context of the football programme, or any data related to sickness or other general medical conditions were excluded from this study.

Definition of injury
An injury was recorded as a result of any physical complaint resulting from a game or training, that required the attention of the medical staff. A visit to the physiotherapy department requiring a clinical examination without missing a full training session or game was termed ‘medical attention’ (MA). A visit resulting in a player being unable to fully take part in the training session or game the following day, was labelled ‘time-loss injury’ (TLI). The lay-off (or player unavailability) was calculated by the number of days missed from the date of injury (day 0) until the day before the return to training participation and game selection availability. The consensus statement from Fuller et al was not explicitly considering the physis. Therefore, aiming to collect prospectively and uniformly all physis injuries, the injury surveillance system was customised by adding ‘Growth related injuries’ and ‘physeal fracture’ as new injury types. Similarly, other items have been added and muscle injuries were classified as per the Munich consensus statement (see online supplemental table 1 for all categories terminology details).

Anthropometric measurements
Anthropometry measures were taken in the morning three times during each season by an ISAK (International Society for the Advancement of Kinanthropometry) practitioner. Measures included standing and sitting height (±0.1 cm Holtain, Crosswell, UK) and body mass (±0.1 kg ADE Electronic Column Scales, Hamburg, Germany). The skinfold land marking and the Σ 7 skinfold measurements (±0.1 mm Harpenden skinfold calliper, Baty International, Burgess Hill, UK) were taken in accordance with international standards. Maturity offset was obtained by a non-invasive method previously used in paediatric research comprising age and anthropometric measurements to predict maturational status (SE of approximately 6 months).

Data analysis
Descriptive statistics of variables were presented as mean±SD and percentage for categorical variables to compare the injury incidence (II) for all injury types and locations between age groups. Poisson-based 95% CIs were calculated. The injury burden (IB) was calculated using the following equation:

\[ IB = \text{mean type injury incidence} \times \text{Lay-off median per type of injury} \]

IB was expressed as the number of injury days lost per squad season (squad of 25 players) and 95%CI. Because of the skewed distribution of time-loss injuries by types, we used the median to calculate the severity.

RESULTS
All age groups from U-9 to U-18 were observed over four seasons, while the U-19 group over one season only. Demographic characteristics are described in table 1. A total of 2204 injuries were recorded, of which 40% (n=882) were MA and 60% (n=1322) were TLI, resulting in 25 034 lay-off days absence from training or game participation. A mean incidence of 30.3 injuries per squad season was sustained with an IB of 573.6 days lost per squad season. The prevalence of time-loss recurrent injuries was 4.1% (n=55) and 3.5% (n=47) within the same season. Lay-off and severities of all type of injuries are displayed in table 2. The distribution of injuries by location was as follows: Lower limbs 83.7% (n=1844), upper-limbs 8.4% (n=185) and trunk/head 7.9% (n=175). Table 3 presents all type and location of TLI incurred across all age groups during the four seasons. The burden of age groups (figure 1) and type of injuries (figure 2) are illustrated by the risk matrix.

Training injuries accounted for 51.1% (n=1127) and 48.9% (n=1077) occurred in the games. A total of 920 records (41.7%) were the results of contact circumstances, while 1284 (58.3%) were non-contact. The top-5 diagnoses by location are displayed in figure 3 with substantial differences if considered by age
# Table 2: Frequency (%), incidence per squad season*, lay-off (mean±SD, sum) and severities of all type of medical attention and time-loss injuries

| Type of injuries                                      | Frequency | Incidence | Lay-off | Severity of injuries |
|-------------------------------------------------------|-----------|-----------|---------|----------------------|
|                                                       | Overall   | Per squad*/season | Overall | Time-loss injuries | Mean±SD (min-max) | Sum | Medical attention (0 day) | Minor (1–3 days) | Moderate (4–7 days) | Major (8–28 days) | Severe (>28 days) |
|                                                       | N (%)     | N (%)     | Per squad*/season | N (%)     | (Days) | N days (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) |
| Contusion/bruise/hematoma                             | 778 (35.3)| 337 (25.5) | 17.8 | 7.7 | 4.6±6.9 (1–67) | 1567 (6.3) | 441 (56.7) | 210 (62.3) | 77 (22.8) | 46 (13.7) | 4 (1.2) |
| Sprain/ligament injury                                | 284 (12.9)| 215 (16.3) | 6.5 | 4.9 | 31.3±54.3 (1–401) | 6732 (26.9) | 69 (24.3) | 41 (19.1) | 40 (18.6) | 70 (32.5) | 64 (29.8) |
| Growth related condition                              | 269 (12.2)| 208 (15.7) | 6.2 | 4.8 | 19.1±26.0 (1–241) | 3973 (15.9) | 61 (22.7) | 35 (16.8) | 41 (15.7) | 92 (44.3) | 40 (19.2) |
| Functional muscle disorder/neural irritation          | 385 (17.5)| 190 (14.4) | 8.8 | 4.4 | 4.2±4.4 (1–27) | 796 (3.2) | 195 (50.6) | 116 (31.0) | 45 (23.7) | 29 (15.3) | – |
| Muscle strain/rupture                                 | 127 (5.8) | 126 (9.5) | 2.9 | 2.9 | 22.5±17.8 (2–151) | 2836 (11.3) | 1 (0.8) | 3 (2.4) | 10 (7.9) | 84 (66.7) | 29 (23.0) |
| Overuse unspecific                                    | 115 (5.2) | 67 (5.1) | 2.6 | 1.5 | 6.7±9.0 (1–56) | 448 (1.8) | 48 (41.7) | 35 (25.2) | 16 (23.9) | 14 (20.9) | 2 (3.0) |
| Physseal fracture                                     | 38 (1.7)  | 37 (2.8) | 0.9 | 0.8 | 78.1±73.9 (1–352) | 2889 (11.5) | 1 (2.6) | 2 (5.4) | – | 9 (24.3) | 26 (70.3) |
| Fracture (non physseal)                               | 38 (1.7)  | 37 (2.8) | 0.9 | 0.8 | 43.8±48.3 (1–286) | 1621 (6.5) | 1 (2.6) | 5 (13.5) | 5 (13.5) | 25 (67.6) |
| Other limb injury                                     | 36 (1.6)  | 29 (2.2) | 0.8 | 0.7 | 37.4±38.1 (1–122) | 1084 (4.3) | 7 (19.4) | 6 (20.7) | 1 (3.5) | 9 (31.0) | 13 (44.8) |
| Other injury                                          | 47 (2.1)  | 21 (1.6) | 1.1 | 0.5 | 13.7±19.0 (1–83) | 288 (1.2) | 26 (55.3) | 5 (23.8) | 6 (28.6) | 8 (38.1) | 2 (9.5) |
| Lesion of meniscus and cartilage                      | 19 (0.9)  | 19 (1.4) | 0.4 | 0.4 | 128.8±153.4 (3–655) | 2448 (9.8) | 2 (10.5) | – | 3 (15.8) | 14 (73.7) |
| Tendinopathy                                          | 28 (1.3)  | 10 (0.8) | 0.6 | 0.2 | 17.6±17.0 (1–54) | 176 (0.7) | 18 (41.3) | 2 (20.0) | 2 (20.0) | 4 (40.0) | 2 (20.0) |
| Concussion                                            | 14 (0.6)  | 10 (0.8) | 0.3 | 0.2 | 3.1±2.6 (1–9) | 31 (0.1) | 4 (28.6) | 7 (28.6) | 2 (20.0) | 1 (10.0) | – |
| Synovitis/effusion                                    | 16 (0.7)  | 9 (0.7) | 0.4 | 0.2 | 5.7±7.5 (1–25) | 51 (0.2) | 7 (43.8) | 6 (66.7) | 2 (22.2) | 1 (11.1) | – |
| Abrasion/laceration                                   | 7 (0.3)   | 4 (0.3) | 0.2 | 0.1 | 7.5±4.0 (0–11) | 30 (0.1) | 3 (42.9) | 1 (25.0) | 1 (25.0) | 2 (50.0) | – |
| Dislocation/subluxation                               | 3 (0.1)   | 3 (0.2) | 0.1 | 0.1 | 21.3±13.3 (6–29) | 64 (0.3) | – | – | 1 (33.3) | – | 2 (66.7) |
| Total                                                | 2004 (100)| 1322 (100)| 50.5 | 30.3 | 18.9±40.3 (1–655) | 25 034 (100) | 882 (40.0) | 476 (36.0) | 246 (18.6) | 377 (28.5) | 223 (16.9) |

*The incidence per squad per season is established on a squad of 25 players.*
Table 3 Frequency (%), incidence per squad season* for type and location of time-loss injuries

| Type of injuries          | U-9 (n=96) | U-10 (n=103) | U-11 (n=114) | U-12 (n=111) | U-13 (n=98) | U-14 (n=112) | U-15 (n=115) | U-16 (n=112) | U-17 (n=106) | U-18 (n=108) | U-19 (n=17) | Total (n=204) |
|--------------------------|------------|---------------|---------------|---------------|-------------|--------------|--------------|--------------|--------------|--------------|-------------|----------------|
| Concussion               | -          | -             | -             | -             | -           | -            | -            | -            | -            | -            | -            | -              |
| Lesion of meniscus and cartilage | - | -             | -             | -             | -           | -            | -            | -            | 2 (1.1)      | 0.7          | -            | -              |
| Fracture (non physeal)   | 2 (10.0)   | 0.5           | -             | -             | 1 (2.1)     | 0.2          | 2 (4.3)      | 0.5          | 10 (5.6)     | 2.2          | 9 (4.2)      | 1 (4.0)        |
| Muscle strain/rupture    | -          | -             | 1 (2.1)       | 0.2           | 7 (6.3)     | 1.8          | 12 (6.7)     | 2.7          | 22 (10.3)    | 4.8          | 22 (8.3)     | 9 (4.9)        |
| Abrasion/laceration      | -          | -             | -             | -             | -           | -            | 2 (1.1)      | 0.4          | 1 (0.5)      | 0.2          | -            | -              |
| Other bone injury        | 1 (5.0)    | 0.3           | -             | -             | -           | -            | 1 (0.9)      | 0.3          | 1 (0.6)      | 0.2          | 2 (1.0)      | 0.5            |
| Tendinopathy             | -          | 1 (3.4)       | 0.2           | -             | -           | -            | 1 (0.9)      | 0.3          | 1 (0.6)      | 0.2          | 1 (0.4)      | 0.2            |
| Dislocation/subluxation  | -          | -             | -             | -             | -           | -            | -            | -            | 2 (1.0)      | 0.5          | -            | -              |
| Synovitis/effusion       | 1 (5.0)    | 0.3           | -             | -             | -           | -            | -            | -            | 1 (0.6)      | 0.2          | 1 (0.5)      | 0.2            |
| Overuse unspecific       | -          | 1 (3.4)       | 0.2           | 2 (4.2)       | 0.4         | 2 (4.3)      | 0.5          | 4 (3.6)      | 1.0          | 11 (6.2)     | 2.5          | 8 (3.7)        |
| Other injury             | 2 (10.0)   | 0.5           | -             | 3 (6.3)       | 0.7         | -            | -            | -            | 3 (1.7)      | 0.7          | 4 (1.9)      | 2 (1.1)        |
| Functional muscle disorder | -         | -             | 3 (6.3)       | 0.7           | 5 (10.6)    | 1.1          | 14 (12.6)    | 3.6          | 35 (19.7)    | 7.8          | 41 (19.2)    | 38 (14.4)      |
| Physeal fracture          | -          | -             | 1 (3.4)       | 0.2           | 1 (2.1)     | 0.2          | 2 (4.3)      | 0.5          | 8 (7.2)      | 2.0          | 4 (2.2)      | 1 (0.5)        |
| Sprain/ligament injury   | 6 (30.0)   | 1.6           | 2 (6.9)       | 0.5           | 4 (8.3)     | 0.9          | -            | -            | 17 (15.3)    | 4.3          | 14 (7.9)     | 33 (15.4)      |
| Growth related condition | 1 (5.0)    | 0.3           | 4 (13.8)      | 1.0           | -           | -            | -            | -            | 12 (25.0)    | 2.6          | 12 (25.5)    | 25 (22.5)      |
| Physeal fracture          | -          | -             | 1 (3.4)       | 0.2           | 1 (2.1)     | 0.2          | 2 (4.3)      | 0.5          | 8 (7.2)      | 2.0          | 4 (2.2)      | 1 (0.5)        |
| Knee                     | 4 (20.0)   | 1.0           | 9 (31.0)      | 2.2           | 9 (18.8)    | 2.0          | 6 (12.8)     | 1.4          | 16 (14.4)    | 4.1          | 15 (8.4)     | 3.3            |
| Lower leg                | 1 (5.0)    | 0.2           | 3 (15.0)      | 0.8           | 6 (20.7)    | 1.5          | 16 (33.3)    | 3.5          | 37 (15.0)    | 8.3          | 39 (13.8)    | 9.4            |
| Calf/Achilles tendon     | 2 (10.0)   | 0.5           | 1 (3.4)       | 0.2           | 2 (4.2)     | 0.4          | 1 (2.1)      | 0.2          | 5 (4.5)      | 1.3          | 4 (2.2)      | 0.9            |
| Foot/toes                | 3 (15.0)   | 0.8           | 6 (20.7)      | 1.5           | 16 (33.3)   | 3.5          | 10 (21.3)    | 2.3          | 20 (11.2)    | 4.5          | 29 (11.0)    | 6.5            |

*The incidence per squad per season is established on a squad of 25 players.
DISCUSSION

This is the first prospective study investigating injury epidemiology in elite youth football players from the Middle East with the largest cohort from a single academy. We found a mean incidence of 30 injuries per squad season, with an IB of 574 days lost per squad season. U-16 players had the highest injury incidence (59 injuries per squad season) while U-18 had the worst burden (1408 days per squad season). After ligament/sprain, growth plate injuries (growth-related conditions plus physeal fractures) were the most prevalent TLI accounting for 27% (6862 days) of the entire lay-off in our study.

Injury characteristics

The lower limb was the most commonly injured location as described in previous studies. Consistent with a recent systematic review, the ankle in combination with foot/toes had the highest prevalence (23%). The knee (11%) and pelvis-hip-groin (11%) were also prevalent and within the range. Although not being reported in all studies, the proportion of MA seems similar to other studies that have reported this. The prevalence of severe injuries in our study was 17%, which is very close to the median of 18% found in a systematic review. Similarly to some investigations from English and Dutch professional football academies, the incidence of 30 TLI per squad season indicates that the academy is in the middle range of the reported incidence from other studies (ranging from 10 to 50 injuries per squad season), involving a wide variety of different age groups. The differences with previous studies may be due to the evolution in youth football as the game has developed over time. The apparent discrepancy between results may also arise from different methodological issues. The incidences of MA and/or minor injuries can be affected by clinicians invested in research relying on the data collection. Also, some authors have differing injury definitions where some consider only non-contact injuries or define injuries as not able to participate at 48 hours postinjury onset.

Injury incidence and age groups

Similar to other youth football epidemiology reports, the incidence of injuries increases with the age. In recent years, in elite youth football, the under 15-year age group was found to have the highest probability of suffering a TLI, which is slightly different from recent audits and the present study, where the highest injury incidence was found in U-16. The U-15 had the third (after U-17) highest incidence of TLI in our study. The contextual difference among studies is important to consider, as almost all investigations were performed in professional club academy settings and only a few in National team settings. In Asia, U-16 is the first age group to be involved in official Asian Football Confederation competition (U-16 Championship qualifiers) which requires a dedicated international preparation including training camps and friendly tournaments, which is very different compared with club footballers playing matches once a week. Interestingly, the incidence in the youth players (30 injuries/squad season) was higher than the 23.6 injuries/squad season reported in the adult’s first division football league of Qatar. The youth’s higher injury incidence compared with senior players is not unusual and is in-line with a previous study from English professional football.

Figure 1 Risk matrix based on the duration of time-loss illustrating the burden for all age groups. Severity (mean of days lost) and incidence of injury per squad season (25 players). The curved grey lines represent point with equal burden (days per squad season). The vertical and horizontal error bars represent 95% CI (all dataset is available in online supplemental table 2).

Figure 2 Risk matrix based on the duration of time-loss illustrating the burden for all type of injuries. Severity (median of days lost) and incidence of injury per squad season (25 players). The curved grey lines represent point with equal burden (days per squad season). The vertical and horizontal error bars represent 95% CI. The 95% CI upper bound for the median of meniscus/cartilage injuries is 181 days (all dataset is available in online supplemental table 2).
football players are more likely to suffer TLI than adults in the domestic professional league.17 32 33

Injury burden and age groups

When the injury data of our study is further compared, the findings indicate a low IB in the childhood age groups (U-9 to U-12), increasing substantially through early- and middle- (U-13 to U-17) to reach the highest values in late- adolescence (U-18 and U-19) (figure 1). IB has not been extensively investigated in youth football and the results of the present study are not in line with the trend found in a Dutch cohort, where the peak overall IB was 357 days lost/squad season in U-16. 6 17 The findings were aligned with Belgian’s professional academies, reporting a greater IB in older (U13-15) in comparison with the youngest age groups (U9-12).11 The latter study’s IB (652 days/squad season in U13-15) is similar to the 627 days found in the present study for equivalent age groups. However, the IB of their youngest age group (275 days/squad season) was threefold greater than ours (83 days/squad season). The increased burden of injuries across the age group potentially hinder the optimal developmental processes. The burden of each age group is an important consideration as it might have detrimental consequences on the individual development and long-term performance by missing certain optimal “window of trainability” of physical and technical characteristics.34

Type of injuries and age groups

The most prevalent TLI obtained from this study, differs from most of the literature on elite youth football players, apart from the work of Kemper et al with comparable outcomes.12 17 The growth related injuries accounted for 19% of all severe injuries (>4 weeks) and is within the prevalence range (11% and 29%) of two other youth elite academy studies.7 33 Growth related injuries are recognised to be underreported and mistakenly diagnosed as muscle injuries.36 37 In youth football, they have not been well categorised and reported underneath overuse injuries.6 7 11 From U-10 to U-13, the growth-related injuries were the second most frequent type of TLI and in U-14 they were the leading cause. In Elite French players,4 the U-14 had the most osteochondral disorders and a recent study in youth elite football players from different countries observed similar overall trend.8 Sprains have been observed to be very common in youth football.25 In this cohort, sprain was the leading diagnosis in U-17 and U-18. Another unusual result in our study, is the low prevalence of muscle tear (6%) and the large amount of functional muscle disorders (14%). Muscular tears in youth elite male football has been found to be the most common type of injuries in English football academy,4 10 and accounted for 15% to 46% of all injuries.8 13 25 A Swedish study reported similar frequency of muscle tear,38 while a Brazilian study found muscle tears had the highest incidence in the oldest age groups (U-18 and U-19).7 Several interacting factors might play a role in this soft tissues outcome. Direct access to imaging (ultrasonography and MRI) probably played a significant role in the accuracy and consistency of clinical investigation and diagnosis, where actual tears were ruled out and then classified as functional muscle disorders.21 39 During the study period, all teams had a systematic individualised injury prevention plan alongside the football programme. Such a framework was perhaps different from past research when injury prevention was not as popular and poorly implemented.45

Burden of type of injuries

The impact of injuries can be considered in relation to its burden using a risk matrix.19 The overall two most burdensome type of injuries were sprain/ligament (Median lay-off: 14 days;
incidence: 4.9 injury per squad season) and growth-related condition (Median lay-off: 12 days; incidence: 4.8 injury per squad season). Growth-related injuries were more common and burdensome than in previous studies,\textsuperscript{17,23} where they were reported to have a prevalence between 5% to 7% and an incidence per squad season between 0.8 to 2.1.\textsuperscript{4,5,10} The overall higher incidence and burden of growth related condition in this current youth elite population, in comparison to the literature, might reflect an increase of weekly football practice participation and higher intensity.\textsuperscript{46} Meniscus-cartilage injuries had the longest lay-off. While meniscus injuries did occur in different age groups, U-18 was the most impacted and it plays an important role in the total burden of this age group. Meniscal tear incidence in adolescents has increased in recent years because of increased sports participation and more widespread use of MRI as a diagnostic tool.\textsuperscript{44} Loss of meniscus integrity in young players leads to a greater prevalence of osteoarthrosis development.\textsuperscript{45} Looking after the knee in paediatric sports medicine is of prime importance, longer lay-offs and a more conservative approach to promote healing is required.\textsuperscript{42,43} Fractures accounted for 3% of all injuries similar to what is usually found in youth football (2%-9%).\textsuperscript{17} Half of the fractures were physeal fractures (1.7%), accounting for 12% of all severe injuries. There are no epidemiological studies from football academies reporting on physeal fractures, but they are accounting in paediatric medicine for 15%-30% of all fractures in children and for 30% in a football tournament.\textsuperscript{44,45} Interestingly, the burden of physeal fractures (2889 days; 12% of the total lay-off) was double that of mature bone fractures. This is not surprising, as the return to sport of young skeletally immature players from severe injuries involving the physis is considerably longer than adults.\textsuperscript{46}

**Common diagnosis**

The most common diagnosis for the upper limb was non-physeal fractures, with an important number of physeal fractures of the forearm and wrist. In the trunk, spondylolysis accounted for the most significant burden. A comparable trend of diagnosis for the spine and upper limb was found in a general paediatric sports population.\textsuperscript{48} Sprain and tendinopathy were the most frequent knee diagnosis reported in a English youth academy.\textsuperscript{47} In the present study, apophyseal osteochondroses were the primary diagnosis for the knee and the hip-pelvis. However, sprain, Osgood-Schlatter and meniscus tear were the three most prevalent diagnosis of severe injuries. In line with a previous study, the three foremost diagnosis of the foot/ankle were: sprain/ligament, contusion/bruise and apophyseal osteochondroses.\textsuperscript{46} In the calf/lower leg, contusions were the most common, the physeal fractures were only ranked as the fifth most prevalent diagnosis, but accounted for the greatest burden. Growth plate injury was in the top five diagnosis of all location, except the head/face and the thigh locations. The outcomes highlight the difference of injury pattern between age groups, youth and adult football players, emphasising the importance for clinicians to be acquainted with and suspicious of growth plate injuries in youth elite football whenever an injury is located around a physis.\textsuperscript{45} Injury patterns were different than the current literature from other regions in the world.

**Strengths and limitations**

We note at least one limitation, individual exposure time is missing from this work and therefore the incidence of injury in relation to exposure time are not presented. However, as suggested by latest international Olympic committee consensus statement, expressing the incidence of injury per number of players per period of the concerned sports has been used.\textsuperscript{19} The inclusion of specific additional items related to paediatric injuries in the injury surveillance system, provides a more accurate and consistent record, probably leading to a greater clinical contribution as previously recommended.\textsuperscript{19,49}

**What are the findings?**

- The mean time-loss injury incidence was 30 injuries/squad season, with an injury burden (IB) of 574 days lost/squad season.
- While peak of time-loss injuries incidence (59 per squad season) occurred in U-16 players, the peak of IB (1408 days lost/squad season) occurred in U-18 players.
- Growth plate injuries were the second most prevalent time-loss injuries, accounting for 27% of the total lay-off time.
- Apophyseal injuries was the most prevalent diagnosis for the knee and the hip/pelvis.
- 50% of all fractures involved the physis, with a recovery period that was twice as long as mature bone fractures.

**How might it impact on clinical practice in the future?**

- The field of paediatric sports medicine should distinguish physeal injuries from mature bone injuries.
- Researchers should need not to only consider incidence when reporting injuries in youth sport and football academy. Express the injury burden by age group, injury type and diagnosis will provide an enhanced understanding of the impact of injuries and will guide injury prevention.

**SUMMARY**

The mean incidence of TLI was 30 per squad season, with an IB of 574 days lost/squad season. The highest injury incidence was found in U-16 and the greatest IB in U-18, emphasising that although the peak injury incidence occurred earlier during middle adolescence, the IB seems to increase throughout the academy period to reach its peak in late-adolescence. Growth plate injuries were prevalent, accounting for almost one third of the total lay-off. A high proportion of fractures involved the physis, highlighting the need for specific consideration in future prospective studies. We emphasise the necessity for more dedicated epidemiology studies in youth Asian elite football players.

**Correction notice** This article has been corrected since it published Online First. The first sentence in the methods section has been amended.

**Twitter** Olivier Materne @oliviermaterne, Karim Chamari @ProfChamari and Abdulaziz Farooq @razifar

**Acknowledgements** The authors thankfully the commitment of all football physiotherapists of Aspire Academy for their uniform accuracy and consistency over the years in regard of the data collection. The authors are extremely grateful to the artist, Mr Raphael Demarteau (Belgium) for his artwork and drawings.

**Contributors** OM, AF, MG and LRM designed the investigation. All data collection was achieved and/or supervised by OM. The data analysis and interpretation were achieved by OM, AF, AW, PH, RB and KC. The burden tables were designed by RB. The draft of the article was completed by OM and the critical revision of the article was performed by KC, AF, AW, PH, RB, MG and LRM. Final submitted version was suggested by OM and final approval of the version to be published was provided by KC, AF, AW, PH, RB, MG and LRM.

**Funding** The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.
Competing interests None declared.
Patient consent for publication Not required.
Ethics approval All procedures performed in this original study involving human participants were in accordance with the ethical standards. This research was approved by the scientific boards of ASPER and ASpIRE Academy and the ethics was granted by Qatar Anti-Doping Laboratory Ethics-Committee (SCH-ADL-070), conforming to the recommendations of the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.
Provenance and peer review Not commissioned; externally peer reviewed.
Data availability statement No data are available.
Supplemental material This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

ORCID iDs
Oliver Materne http://orcid.org/0000-0002-6518-6112

REFERENCES
1. Kanmekens R, Effenrink-Gemser MT, Visscher C. Tactical skills of world-class youth soccer teams. J Sports Sci 2009;27:807–12.
2. Gonaus C, Birklbauer J, Lindinger SJ, et al. Changes over a decade in anthropometry and fitness of elite Austrian youth soccer players. Front Physiol 2019;10:133.
3. Mountjoy M, Armstrong N, Bizzi L, et al. IOC consensus statement: “training the elite child athlete.” Br J Sports Med 2008;42:163–4.
4. Price RJ, Hawkins RD, Hulse MA, et al. The football association medical research programme: an audit of injuries in Academy youth football. Br J Sports Med 2004;38:466–71.
5. Le Gall F, Carling C, Reilly T, et al. Growth and peak height velocity among Talented male youth soccer players. Orthop J Sports Med 2018;6:1725967118188104.
6. Zecearnig LG, Grüninger BldAS, Scattone Silva RR. Injury profile in a Brazilian first division youth soccer team: a prospective study. J Athl Train 2020;55:295–302.
7. Hall ECR, Larruskain J, Gil SM, et al. An injury audit in high-level male youth soccer players from English, Spanish, Uruguayan and Brazilian academies. Phys Ther Sport 2020;44:53–60.
8. Johnson DM, Williams S, Bradley B, et al. Growing pains: maturity associated variation in injury risk in academy football. Eur J Sport Sci 2020;20:1–9.
9. Read PJ, Oliver JL, De Ste Croix MBA, et al. An audit of injuries in six English professional soccer academies. J Sports Sci 2018;36:1–7.
10. Rommers N, Rössler R, Goossens L, et al. Risk of acute and overuse injuries in youth elite soccer players: body size and growth matter. J Sci Med Sport 2020;23:246–51.
11. Kerper GJJ, van der Sluis A, Brijk MS, et al. Anthropometric injury risk factors in Elite-standard youth soccer. Int J Sports Med 2015;36:1112–7.
12. Renshaw A, Goodwin PC. Injury incidence in a premier League youth soccer using the consensus statement: a prospective cohort study. BMJ Open Sport Exerc Med 2016;2:e000132.
13. Ardern CL, Ekas GR, Grindem H, et al. Involving research-invested clinicians in prospective three-year study. Br J Sports Med 2013;47:339–46.
14. Müller-Wohlfahrt H-W, Haensel L, Mithoefer K, et al. Terminology and classification of muscle injuries in sport: the Munich consensus statement. Br J Sports Med 2012;47:342–50.
15. No data are available.
16. Fosdike KE, Goehrke JL, Harvey B, et al. Shoulder injuries in male youth soccer players from English, Spanish, Uruguayan and Brazilian academies. Phys Ther Sport 2020;44:53–60.
17. van der Sluis A, Effenrink-Gemser MT, Brijk MS, et al. Importance of peak height velocity timing in terms of injuries in talented soccer players. Int J Sports Med 2015;36:327–32.
18. van der Sluis A, Effenrink-Gemser MT, Coelho-e-Silva MJ, et al. Sports injuries aligned to peak height velocity in talented pubertal soccer players. Int J Sports Med 2014;35:351–5.
19. Geffroy L, Lefevre N, Thevenin-Lemoine C, et al. Importance of peak height velocity in talented pubertal soccer players. Br J Sports Med 2018;52:422–38.
20. Fuller CW, Ekstrand J, Junge A, et al. Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. Scand J Med Sci Sports 2006;16:83–92.
21. Müller-Wohlfahrt H-W, Haensel L, Mithoefer K, et al. Terminology and classification of muscle injuries in sport: the Munich consensus statement. Br J Sports Med 2012;47:342–50.
22. Nordt K, Marfell-Jones M, Nea W. Anthropometric assessment protocols. In: Physiological testing for elite athletes: human kinetics, 2000: 66–85.
23. Fosdike KE, Checkoway H. Epidemiologic programs for computers and calculators. Use of poison regression models in estimating incidence rates and ratios. Am J Epidemiol 1985;121:309–23.
24. Faude O, Rößler R, Junge A. Football injuries in children and adolescent players: are there clues for prevention? Sports Med 2013;43:819–37.
25. van der Sluis A, Effenrink-Gemser MT, Brijk MS, et al. Importance of peak height velocity timing in terms of injuries in talented soccer players. Int J Sports Med 2015;36:327–32.
26. van der Sluis A, Effenrink-Gemser MT, Coelho-e-Silva MJ, et al. Sports injuries aligned to peak height velocity in talented pubertal soccer players. Int J Sports Med 2014;35:351–5.
27. Ergin M, Denereli HN, Binnet MS, et al. Injuries in elite youth football players: a prospective three-year study. Acta Orthop Traumatol Turc 2013:7399–45.
28. Larruskain J, Gil SM, et al. An injury audit in high-level male youth soccer players: team risk analysis. Int J Sports Med 1996;17:229–34.
29. Ford P, De Ste Croix M, Lloyd R, et al. The long-term athlete development model: physiological evidence and application. J Sports Sci 2011;29:389–402.
30. Voigt P, Pozzone R, Galli M. The major traumas in youth football. Knee Surg Sports Traumatol Arthrosc 2003;11:399–402.
31. Carl R. Apophysitis and Apophyseal avulsion of the pelvis. International Journal of Athletic Therapy & Training 2012;17:5–9.
32. DiFiori JP, Benjamin HJ, Brenner JS, et al. Osteonecrosis in youth: a prospective study from the American medical Society for sports medicine. Br J Sports Med 2010;44:213–5.
33. Inklaar H, Bol E, Schmikli SL, et al. Injuries in male soccer players: team risk analysis. Int J Sports Med 1996;17:229–234.
34. Hawkins RD, Hulse MA, Wilkinson C, et al. The football association medical research programme: an audit of injuries in professional football. Br J Sports Med 2001;35:43–7.
35. Prien R, Herbst M, Ingelligenger P, et al. Analysis of injury incidences in male professional adult and elite youth soccer players: a systematic review. J Athl Train 2016;51:410–24.
36. DiFiori JP, Benjamin HJ, Brenner JS, et al. Osteonecrosis in youth: a prospective study from the American medical Society for sports medicine. Br J Sports Med 2010;44:213–5.
37. DiFiori JP, Benjamin HJ, Brenner JS, et al. Osteonecrosis in youth: a prospective study from the American medical Society for sports medicine. Br J Sports Med 2010;44:213–5.
38. Geffroy L, Lefevre N, Thevenin-Lemoine C, et al. Importance of peak height velocity in talented pubertal soccer players. Br J Sports Med 2018;52:422–38.