Injury characteristics in male youth athletics: a five- season prospective study in a full-time sports academy

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ABSTRACT

Objectives To describe the injury characteristics of male youth athletes exposed to year-round athletics programmes.

Methods Injury surveillance data were prospectively collected by medical staff in a cohort of youth athletics athletes participating in a full-time sports academy from 2014–2015 to 2018–2019. Time-loss injuries (>1 day) were recorded following consensus procedures for athletics. Athletes were clustered into five event groups (sprints, jumps, endurance, throws and non-specialised) and the number of completed training and competition sessions (athletics exposures (AE)) were calculated for each athlete per completed season (one athlete season). Injury characteristics were reported overall and by event groups as injury incidence (injuries per 1000 AE) and injury burden (days lost per 1000 AE).

Results One-hundred and seventy-eight boys (14.9±1.8 years old) completed 391 athlete seasons, sustaining 290 injuries. The overall incidence was 4.0 injuries per 1000 AE and the overall burden was 79.1 days lost per 1000 AE. The thigh was the most common injury location (19%). Muscle strains (0.7 injuries per 1000 AE) and bone stress injuries (0.5 injuries per 1000 AE) presented the highest incidence and stress fractures the highest burden (17.6 days lost per 1000 AE). The most burdensome injury types by event group were: bone stress injuries for endurance, hamstring strains for sprints, stress fractures for jumps, lesion of meniscus/cartilage for throws and growth plate injuries for non-specialised athletes.

Conclusion Acute muscle strains, stress fractures and bone stress injuries were identified as the main injury concerns in this cohort of young male athletics athletes. The injury characteristics differed between event groups.

INTRODUCTION

Athletics is one of the most universal sports at the youth level, with athletes from more than 170 countries participating in the last Youth Olympic Games.[1] Early sports specialisation and intensive training may expose young athletes to a greater risk of injuries,[2–6] and injury surveillance reveals essential for determining injury risks and prevention strategies.[7] However, youth athletes are a difficult population to study due to the autonomous nature of athletics and the lack of structured sports medicine and science programmes for youth categories. As a consequence, youth athletics studies are scarce and most of them rely on self-reported questionnaires[6 8–12] or are included in multiple sport studies,[13–15] while most studies in adult athletes arise from major athletics competitions.[16–18] Although the aetiology of injuries in youth athletes may differ to that of their senior counterparts due to the substantial biological changes happening during adolescence, a causal relationship between growth and injuries remains unclear.[19–22]

Injury definitions and data collection methods vary substantially across youth athletics studies, making comparisons and interpretation of results difficult. Both non time-loss[11 12 15] and time-loss injury definitions have been used, with time-loss cut-offs varying from 1 day[10 13 14 23] to 1 week[8 24] and 3 weeks.[6 9] Many studies rely on retrospective data[6 8 9] and studies applying the recommended prospective design often report athletics injuries for one season or less[10–12 25] or as part of multiple-sports cohorts.[13–15] However, the heterogeneity in samples is probably one of the most important limitations for interpreting results, since athletes from different age groups, training contexts and athletics disciplines are frequently grouped together without considering potential confounding factors.

Large homogeneous cohorts with systems that monitor training exposure (TE) and injury incidence are warranted in youth athletics. While other sports are organised in full-time youth sports academies[26 27] athletics is rarely part of such structured full-time programmes. Most of the injury surveillance data from youth academies is collected in football[28–30] or multiple sports combined,[21 31] therefore, the injury characteristics of youth athletes participating in full-time athletics programmes is unknown. For this reason, a prospective injury surveillance system was implemented in a youth athletics academy as per the athletics consensus[32] to describe the extent and characteristics of injuries of adolescent athletics athletes exposed to year-round training programmes.

METHODS

Study design

A prospective cohort design covering five consecutive seasons (2014–2015 through 2018–2019) of the athletics programme in a youth sports academy based in the Middle East was used for this study. The athletes had direct access to the medical staff both in training and at the onsite medical facilities. A team of five physiotherapists and one Sports Medicine physician working full-time within the academy worked with athletics during the study period and were trained on injury data collection procedures.

Study population

The athletics programme included adolescent athletes ranging from 12 to 18 years recruited through a talent identification programme. Athletes followed comprehensive year-round training plans, typically consisting of eight sessions per week alongside a full-time educational curriculum. Only full-time athletes completing at least one entire season (from September to June, with some extending the season for summer competitions) were included in the study. The time between the beginning of the academic year and the end of season was considered as 'one athlete-season'. Written informed consent for the storage and analysis of data for research purposes was obtained from the athletes' guardians at the start of each season, but the patients did not participate in the study design or interpretation.

Injury and athletic exposure data collection

An injury was defined as 'any recorded medical attention sustained during training or competition that results in an athlete being unable to participate in athletics activities, as planned by coaching staff, for ≥1 day'. A diagnosis based on the Sports Medicine Diagnostic Coding System (SMDCS)[33] was provided by the physician, who had direct access to a fully equipped Sports Medicine Hospital within the same facility. A standardised template was designed following the criteria from the consensus statement for injury data collection in athletics,[32] including information about the date of injury and return to full participation, injury type (an additional category was created for 'non-specific pain'), injured body part, activity during which the complaint was reported (training, competition or non-sport) and mode of onset (acute if the onset could be clearly identified or gradual if the onset could not be identified). Five main tissue types were defined based on the SMDCS[33]: bone, muscle, joint/ligament, tendon and miscellaneous (other). Although labelled as different injury types in this study, bone stress injuries (BSI, categorised under 'other bone injuries') and stress fractures are considered just different stages of the bone stress continuum[34] (BSI=grades 1–3 in MRI[35]; stress fractures=grade 4) and may be referred as 'overuse bone injuries'.

All injury details were subsequently entered into a password-protected electronic athlete management system (Smartabase, Fusion Sport, Australia) that was updated daily by the team physiotherapists. Entries to the database were coded according to the consensus definitions[32] as either an index injury (first recordable episode of a physical complaint sustained by an athlete requiring medical attention), exacerbation (worsening in the state of an existent index injury) or reinjury (a repeat episode of a fully recovered index injury). The athlete was considered fully recovered from an injury when able to complete the planned session with minimal or no limitations. Injury severity was determined based on days lost as minimal (1–3 days lost), minor (4–7 days), moderate (8–28 days), serious (29 days to 6 months) or long term (>6 months).[32] The number of days lost for all exacerbation episodes linked to an index injury were summed; for example, an Achilles tendinopathy with 7 days lost and one exacerbation episode with 10 days lost would be accounted as one injury with 17 days lost.

Athletes were clustered into their respective training groups for each given season; Endurance, Sprints, Jumps, Throws and Non-specialised (athletes following a generic athletic development programme). Athletics exposures (AE) were computed by summing the total number of training sessions and competitions attended during the season for each athlete, based on the attendance recorded by their coaches and further divided into training exposure (TE) and competition exposure (CE). A session was considered 'attended' when the athlete was able to complete normal training or with minimal limitations and AE were not accumulated while injured until back to regular training.

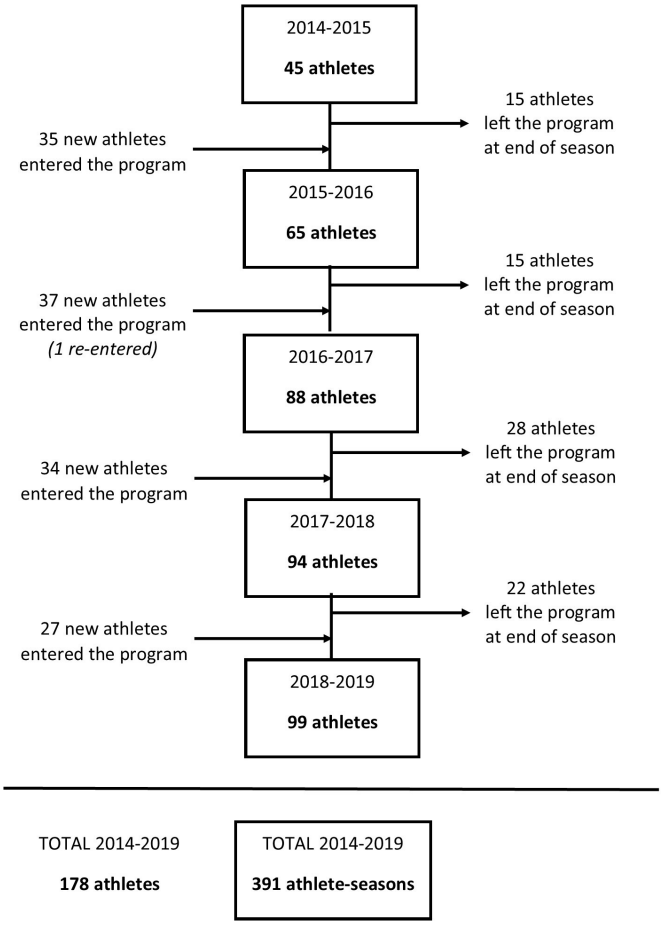

Figure 1 Chart flow of athletes participating in the study for each season.

Statistical analysis

Descriptive statistics included season prevalence, percentage distributions, incidence rate, injury burden,[36] median days lost and injury occurrence by date for the five-season period combined and for each subcategory. Season prevalence was expressed as the proportion of athletes sustaining at least one time-loss injury during a given season. Injury incidence was calculated as the number of injuries per 1000 AE and injury burden as the number of days lost per 1000 AE, both with a 95% CI using Byar's approximation of the exact limits as described by Rothman.[37] The median number of days lost is presented with the 25– 75th percentile.

RESULTS

Two-hundred and thirty-seven male athletes participated in the athletics programme across the five seasons. Fifty-nine athletes did not complete a whole season for non-medical reasons and were excluded from the analyses. A total of 178 athletes were followed for 1–5 seasons (one season: n=63; two seasons: n=51; three seasons: n=39; four seasons: n=20; five seasons: n=5) contributing to 391 athlete seasons (mean age ±SD: 14.9±1.8 years old at season start), (figure 1). In terms of geographical representation (based on United nations area codes as per athlete

Table 1 Athlete distribution, athletic exposure and injury characteristics overall and by event group

	Non-specialised	Endurance	Sprints	Jumps	Throws	Overall
Athlete seasons	185	66	51	55	34	**391**
Mean age (±SD)	13.5 (±1.0)	15.3 (±1.6)	16.7 (±1.0)	16.5 (±1.1)	16.4 (±1.3)	**14.9 (±1.8)**
Athletic exposure						
Total AE	30328	15429	10318	8787	7224	**72086**
Training/competition exposures	29301/1027	14870/559	9886/432	8385/402	6884/340	**69326/2760**
Mean AE per athlete season (±SD)	164 (±43)	234 (±74)	202 (±70)	160 (±57)	213 (±71)	**184 (±64)**
Injury occurrence						
N injuries (training/competition)	130 (117/13)	57 (54/3)	35 (23/12)	43 (33/10)	25 (25/0)	**290 (252/38)**
N acute/N gradual onset	64/66	9/48	22/13	25/18	14/11	**134/156**
Mean season prevalence % (±SD)	60.2 (±16.5)	70.5 (±16.1)	53.1 (±9.4)	57.7 (±6.8)	50.0 (±10.2)	**58.1 (±11.5)**
% 1st/2nd/3rd/4th trimester	49/27/21/3	46/19/30/5	31/40/20/9	46/26/23/5	48/32/16/4	**46/27/22/5**
Injury incidence						
Injuries per 1000 AE (95% CI)	4.3 (3.5 to 5.0)	3.7 (2.8 to 4.8)	3.4 (2.4 to 4.7)	4.9 (3.6 to 6.5)	3.5 (2.3 to 5.0)	**4.0 (3.6 to 4.5)**
Training/competition	3.9/12.7	3.6/5.4	2.4/27.8	4.1/24.9	3.6/0.0	**3.6/13.8**
Injury burden						
Days lost per 1000 AE (95% CI)	70.8 (67 to 73)	84.5 (80 to 89)	81.5 (77 to 88)	101.3 (95 to 109)	72.0 (66 to 78)	**79.1 (77 to 81)**
Acute/gradual onset	32.2/38.5	9.6/74.9	65.9/15.6	34.6/66.7	43.9/28.1	**33.7/45.4**
Body region						
Upper extremities (%)	15 (11.5)	1 (1.8)	1 (2.8)	2 (4.6)	5 (20.0)	**24 (8.3)**
Head and trunk (%)	24 (18.5)	10 (17.5)	5 (14.3)	10 (23.3)	7 (28.0)	**56 (19.3)**
Lower extremities (%)	91 (70.0)	46 (80.7)	29 (82.9)	31 (72.1)	13 (52.0)	**210 (72.4)**

Bold: overall values.
AE, athletic exposures.

nationality)[38] 70% originated from Western Asia and 30% from Africa (18% from Eastern Africa; 9% from Northern Africa and 3% from Western Africa). Overall, 72086 AE were recorded, where 96% corresponded to training and 4% to competitions (table 1). A total of 354 time-loss injuries were recorded and of these, 64 injuries (18%) originated from activities outside of the training programme and were excluded. Therefore, 290 injuries related to participation in athletics were included in the analyses.

Overall injury characteristics

Athletes sustained 0.7±0.2 injuries per season, equating to a season prevalence of 58%±11.5. Only 10% were recurrent injuries and 23% of athletes sustained two or more injuries within the same season. Almost half of all injuries (46%) were recorded during the first trimester of the season (September to November).

A summary of the overall injury characteristics is described in table 1. Most injuries were sustained in the lower extremities (72%). The thigh was the most common location (19%), followed by the knee (14.8%) (online supplemental file). The overall incidence was 4.0 injuries per 1000 AE and the overall burden 79 days lost per 1000 AE. Competition incidence was 3.8 times greater compared with training incidence.

The median time loss per injury was 6 days (25–75th percentile: 3–12). Most injuries (35%) were of minimal severity, 19% were minor, 23% moderate and 23% serious. Most serious injuries were bone fractures (stress or traumatic) (37%), most of the moderate injuries were muscle strains (27%) while contusions, muscle spasm and non-specific pain were the most common types among the minor and minimal ones.

Injury types, tissue type and common diagnoses

Muscle strains, BSI, stress fractures and growth plate injuries were the most common injury types, accounting for 48% of all injuries. The most burdensome injury types were stress fractures (17.6 days lost per 1000 AE), followed by muscle strains (15.8 days lost per 1000 AE) and BSI (10.0 days lost per 1000 AE). A risk matrix combining the incidence and severity for the most relevant injury types overall and by event group is presented in figure 2.

Bone was the most affected tissue type, and most bone injuries (85%) had a gradual onset. The most common diagnoses were spondylolysis and medial tibial stress syndrome (MTSS), with severity depending on the bone stress grade (table 2). Apophysitis of the iliac spine (37%) and tibial tuberosity (Osgood-Schlatter disease; 29%) were the most frequent growth plate injuries. A high variability of time lost according to injury location and the athlete's age at injury was observed for growth plate injuries: calcaneal apophysitis (Sever disease) was diagnosed at a younger age compared with Osgood-Schlatter disease and anterior inferior iliac spine apophysitis (table 2).

For muscle injuries, the thigh was the most common location and hamstring strains the most burdensome diagnosis, accounting for 61% of all muscle strains. Almost half of all hamstring injuries (45%) were sustained during competitions, the majority of them (86%) moderate or serious, although the number of days lost was dependent on injury grade diagnosed by MRI (table 2).

Event group analyses

A complete analysis of injuries for each event group is displayed in tables 1 and 3. Jumps presented the highest incidence and injury burden and sprints the highest incidence of injuries in competition. For most groups, almost half of the injuries occurred during the first trimester of the season, except for sprints in which most injuries occurred in the second trimester.

Endurance athletes accumulated the most AE per athlete season and presented a higher burden of gradual onset injuries. BSI were the most common injury type in endurance, and MTSS the most frequent injury diagnosis (1.0 injuries per 1000 AE). Most injuries in sprinters were acute. Hamstring strains in the sprint group were the diagnosis with the highest incidence and

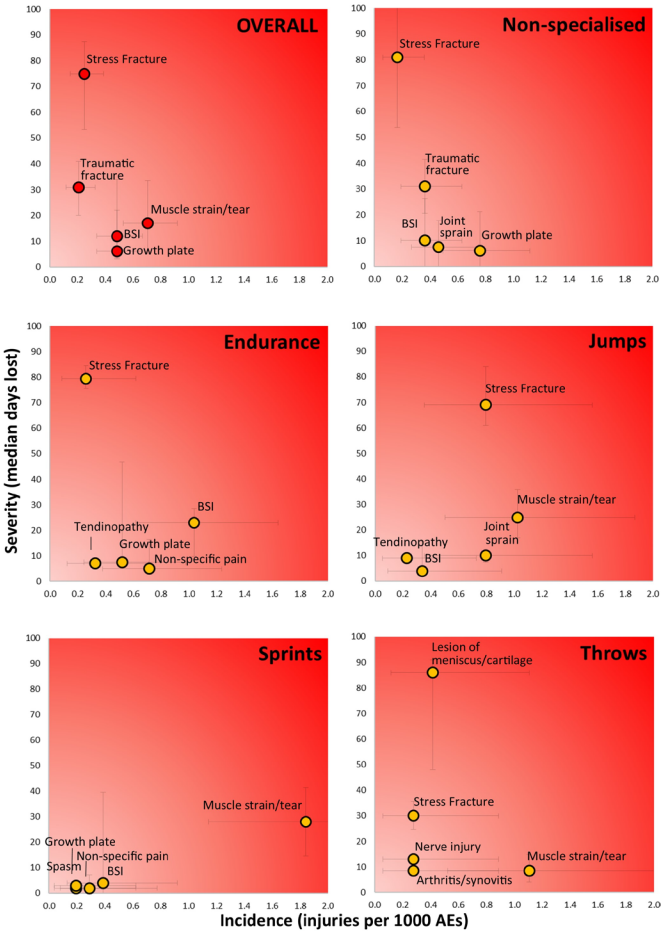

Figure 2 Risk matrix illustrating the burden of different types of injuries overall and for each event group. Incidence is expressed as number of injuries per 1000 AE with a 95% CI and severity as median days lost with a 25th to 75th percentile. AE, athletics exposure; BSI, bone stress injuries.

burden (1.8 injuries per 1000 AE; 62 days lost per 1000 AE) across all event groups. Jumps presented a high incidence of stress fractures, muscle strains and joint sprains, with hamstring strains and lateral ankle sprains as the most common diagnoses, and spondylolysis as the most burdensome (45 days lost per 1000 AE). Throws displayed the highest proportion of trunk and upper extremities injuries (48%), muscle strains being the most common type of injury and lesions of meniscus/cartilage the most burdensome. Most growth plate injuries (89%) occurred in endurance and non-specialised groups, who also had the youngest athletes. A risk matrix with the five most burdensome injury types by event group is presented in figure 2.

DISCUSSION

This is the first prospective study describing the injury characteristics of highly trained youth athletes in a full-time athletics academy following the athletics consensus recommendations.[32] The main findings were the high incidence of overuse bone injuries in such a young cohort and the clear difference observed in injury characteristics across event groups.

Injury impact of highly trained youth athletes

The incidence of injuries in this group (4.0 injuries per 1000 AE) was high compared with the most similar studies in youth athletics in terms of methodology,[10 13 14 23] in which incidence rates were reported between 0.6 and 2.1 injuries per 1000 AE. Minimal time-loss injuries had a high impact on the overall incidence (1.4 injuries per 1000 AE) although their impact on health and performance is dubious (3 days lost per 1000 AE). This would support the use of injury burden instead of incidence to report the actual impact of injuries in sport, as recommended by Bahr *et al*.[36] It is likely that the proximity to medical staff and the involvement of research-invested clinicians in the data collection contributed to a greater number of minimal time-loss injuries being reported.[39] This would partly explain the higher incidence rates in this study compared with those previously reported in youth athletics.

BSIs, stress fractures and acute muscle strains were the most burdensome injury types overall. Although the majority of injuries were associated with training as in previous cohorts[8 10 14 15 23], injury incidence was 3.8 greater in competitions and hamstring strains were the most common diagnosis as already showed in major athletics events.[17 18]

Identifying differences between event groups

Athletics is composed of several disciplines with differing movement patterns and physical demands that may expose athletes to different injury risks. Whether this requires a high degree of specialisation or not is unknown, but the injury characteristics described in this cohort of youth athletes are similar to what has been observed in other athletics studies.[8 10 11 15 16 23 24] Although muscle strains were identified as the most frequent type of injury in this cohort, event group analyses showed they were more common in explosive events such as sprints, jumps and throws but almost negligible in endurance and non-specialised athletes. Conversely, overuse bone injuries were frequent in events requiring repetitive impacts like jumps and endurance while growth plate injuries were frequent in groups with younger athletes (non-specialised and endurance).

The most relevant differences with other studies were: (1) the predominance of overuse bone injuries in endurance in our cohort in contrast to lower leg muscle strains, foot injuries and knee tendinopathy, previously described for distance runners[9 10 15 18 23 24]; (2) the high burden of stress fractures in jumpers; (3) growth plate injuries, under-reported in previous surveillance studies, were described in this cohort; (4) the different pattern for injury occurrence in sprinters, who got most injuries during the second trimester in contrast to the rest of the groups and previous studies in which most injuries happened at the beginning of the season[8 10 11 24 40] and (5) the high burden of meniscus/cartilage injuries in throws.

The main concern: overuse bone injuries

Bone was the most frequently injured tissue type (36%) as opposed to other studies in athletics in which muscle had been reported as the most common.[9 12 18 23] Only two studies had reported higher incidence of bone injuries, but both with retrospective self-report designs and injury definitions of 1 week[41] and 3 weeks[6] lost.

Stress fractures, reported to represent between 0% and 2.3% of all injuries in youth athletics[10 12 13 23 42] accounted for 6.2% in our study and their incidence was 3 to 17 times greater than similar cohorts of youth athletes.[10 23 43] The incidence of MTSS was also 19 times higher than what Pierpoint *et al*[23] reported. This may be due to a more accurate diagnosis thanks to the availability of MRI in our study, but many other factors could also explain this finding. (1) Although female athletes are known to be at higher risk of BSIs,[41 44–47] relative energy deficiency in

Table 2 Injury distribution by location for the most common injury types and diagnoses

	Injuries	Incidence		Median time loss		Burden		Age at injury	
Body Part **Injury type** ***Diagnosi***	**Count**	**Inj. per 1000 AE (95% CI)**		**Days (25–75th percentile)**		**Days lost per 1000 AE (95% CI)**		**Mean (95% CI)**	
Upper extremity	**24**	**0.3**	**0.2 to 0.5**	**4**	**3 to 10**	**3.4**	**3.0 to 3.8**	**15.0**	**14.0 to 16.0**
Traumatic fracture	6	0.1	0.0 to 0.2	15	6 to 34	1.9	1.6 to 2.2	13.7	12.2 to 15.2
Muscle strain/tear	4	0.1	0.0 to 0.1	4	3 to 8	0.4	0.3 to 0.6	17.6	14.3 to 20.9
Head and trunk	**56**	**0.8**	**0.6 to 1.0**	**9**	**3 to 41**	**20.2**	**19.2 to 21.3**	**15.4**	**15.0 to 15.7**
Stress fracture	13	0.2	0.1 to 0.3	69	53 to 83	12.2	11.4 to 13.1	15.5	14.7 to 16.2
Spondylolysis	12	0.2	0.1 to 0.3	72	54 to 85	11.6	10.8 to 12.4	15.6	14.8 to 16.4
Growth plate	17	0.2	0.1 to 0.4	6	3 to 24	5.0	4.5 to 5.6	14.9	14.4 to 15.4
AIIS apophysitis	7	0.1	0.0 to 0.2	12	5 to 39	3.7	3.3 to 4.2	14.6	13.6 to 15.5
ASIS apophysitis	6	0.1	0.0 to 0.2	5	3 to 8	0.7	0.5 to 0.9	15.3	14.3 to 16.3
Non-specific pain	15	0.2	0.1 to 0.3	3	3 to 5	1.0	0.7 to 1.2	15.7	14.7 to 16.7
Hip and groin	**8**	**0.1**	**0.0 to 0.2**	**24**	**6 to 49**	**3.6**	**3.2 to 4.1**	**16.0**	**14.4 to 17.5**
Thigh	**55**	**0.8**	**0.6 to 1.0**	**13**	**3 to 32**	**15.8**	**14.9 to 16.8**	**16.0**	**15.5 to 16.5**
Muscle strain/tear	41	0.6	0.4 to 0.8	20	7 to 38	14.6	13.7 to 15.5	16.6	16.1 to 17.1
Hamstring strain grade 0–1	19	0.3	0.2 to 0.4	13	5 to 23	4.4	4.0 to 5.0	16.7	16.0 to 17.4
Hamstring strain grade 2–3	12	0.2	0.1 to 0.3	41	37 to 66	8.4	7.7 to 9.1	17.3	16.5 to 18.1
Quadriceps strain	6	0.1	0.0 to 0.2	7	6 to 15	0.9	0.7 to 1.2	14.5	13.8 to 15.3
Adductor strain	4	0.1	0.0 to 0.1	17	11 to 21	0.8	0.6 to 1.1	16.8	14.3 to 19.3
Spasm/cramp	11	0.2	0.1 to 0.3	2	2 to 3	0.3	0.2 to 0.5	14.2	13.2 to 15.2
Knee	**43**	**0.6**	**0.4 to 0.8**	**5**	**2 to 12**	**9.6**	**8.9 to 10.4**	**15.3**	**14.8 to 15.8**
Growth plate—*Osgood-Schlatter*	10	0.1	0.1 to 0.3	7	2 to 40	3.9	3.5 to 4.4	14.3	13.7 to 14.9
Tendinopathy	9	0.1	0.1 to 0.2	6	1 to 12	2.1	1.7 to 2.4	15.6	14.7 to 16.5
Lower leg and Achilles tendon	**40**	**0.6**	**0.4 to 0.8**	**9**	**3 to 29**	**11.7**	**10.9 to 12.5**	**15.3**	**14.8 to 15.9**
Other bone injury	28	0.4	0.3 to 0.6	11	3 to 29	7.4	6.8 to 8.1	15.6	14.9 to 16.2
MTSS grade 1	8	0.1	0.0 to 0.2	3	2 to 7	0.5	0.4 to 0.7	15.2	13.5 to 16.8
MTSS grade 2	11	0.2	0.1 to 0.3	10	4 to 28	2.5	2.1 to 2.9	16.5	15.7 to 17.4
MTSS grade 3	8	0.1	0.0 to 0.2	43	27 to 50	4.4	3.9 to 4.9	14.8	13.9 to 15.7
Stress fracture—*MTSS grade 4*	3	<0.1	0.0 to 0.1	89	84 to 90	3.6	3.1 to 4.0	15.7	12.9 to 18.6
Ankle	**28**	**0.4**	**0.3 to 0.6**	**10**	**5 to 15**	**6.1**	**5.5 to 6.7**	**14.7**	**14.0 to 15.5**
Ligament/joint sprain	20	0.3	0.2 to 0.4	9	3 to 11	3.4	3.0 to 3.9	14.8	14.0 to 15.7
Traumatic fracture	3	<0.1	0.0 to 0.1	31	29 to 59	2.0	1.7 to 2.4	14.3	6.6 to 21.9
Foot/toe	**36**	**0.5**	**0.3 to 0.7**	**4**	**2 to 18**	**8.7**	**8.0 to 9.4**	**14.9**	**14.2 to 15.5**
Traumatic fracture	4	0.1	0.0 to 0.1	37	31 to 43	2.0	1.7 to 2.4	14.0	11.3 to 16.7
Stress fracture	2	<0.1	0.0 to 0.1	65	56 to 73	1.8	1.5 to 2.1	15.4	5.9 to 25.0
Growth plate—*Sever disease*	5	0.1	0.0 to 0.2	2	2 to 5	0.2	0.1 to 0.4	13.1	12.2 to 14.1

Bold: overall values by body part.
AE, athletics exposure; AIIS, anterior inferior iliac spine; ASIS, antero-superior iliac spine; MTSS, medial tibial stress syndrome.

sport[48] has been proposed as a major bone injury risk factor in male athletes; (2) early specialised athletes and long distance runners are known to be at higher risk when exposed to high training loads[11 49]; (3) rapid growth in stature and leg length may also represent a risk for bone injuries in male youth athletics[19]; (4) various specific genetic markers have also been associated with a greater risk of fracture, although not in a West Asian population[50]; (5) other contextual and cultural factors like over-scheduling,[51] chronic sleep deprivation[52] and low vitamin D and calcium intake[53 54] may be critical in highly trained athletes.

Growth plate injuries are a unique entity in skeletally immature athletes that often lead to several weeks of rest or activity modification.[55 56] Although they were among the most frequent injury types in this study, a time-loss injury definition may underestimate their real impact. Interestingly, there was an age-related pattern for different growth plate injuries, with distal growth plates provoking symptoms at an earlier age compared with proximal ones, which seems to resemble a distal to proximal apophyseal ossification pattern.[57] An event group analysis is probably not valid for growth apophysitis, as younger athletes are at higher risk regardless of their event specialisation.

METHODOLOGICAL CONSIDERATIONS

One of the strengths of this study is the homogeneity in data collection methods and contextual factors throughout five seasons, as opposed to most athletics studies with shorter surveillance periods and heterogeneous samples. Our unique setting allowed medical staff to work with athletes in a controlled training environment, making it possible to quantify and analyse injuries of youth athletes exposed to intensive year-round training programmes. However, in athletics, it is not easy to define athlete training availability on a daily basis in the same manner as team sports,[58] so we were not able to describe training sessions based on whether the athlete was in full training, modified training or rehabilitation. The main limitation of the study is our inability to monitor training load and volume, important aspects of athlete exposures that have helped identify injury risk

Table 3 Injury distribution and injury burden for different types of injuries by event group

	Non-specialised		Endurance		Sprints		Jumps		Throws	
Tissue type Type of injury	n (%)	Days lost/1000 AE (95% CI)	n (%)	Days lost/1000 AE (95% CI)	n (%)	Days lost/1000 AE (95% CI)	n (%)	Days lost/1000 AE (95% CI)	n (%)	Days lost/1000 AE (95% CI)
Bone										
Fracture (traumatic)	11 (8)	10.8 (9.7 to 12.1)	2 (4)	4.5 (3.5 to 5.6)	0 (0)	0 (NA)	1 (2)	0.2 (0.0 to 0.7)	1 (4)	12.0 (9.7 to 14.8)
Stress fracture	5 (4)	12.1 (10.9 to 13.4)	4 (7)	20.9 (18.7 to 23.2)	0 (0)	0 (NA)	7 (16)	58.8 (53.9 to 64.1)	2 (8)	8.3 (6.4 to 10.6)
Other bone injury	11 (8)	8.8 (7.8 to 9.9)	16 (28)	23.5 (21.1 to 26.0)	4 (11)	5.6 (4.3 to 7.2)	3 (7)	3.9 (2.7 to 5.3)	1 (4)	0.4 (0.1 to 1.1)
Growth plate	23 (18)	14.3 (13.0 to 15.7)	8 (14)	15.9 (14.0 to 18.0)	2 (6)	0.6 (0.2 to 1.2)	1 (2)	0.3 (0.1 to 0.9)	1 (4)	0.1 (0.0 to 0.6)
Muscle										
Strain/rupture/tear	14 (11)	5.1 (4.4 to 6.0)	1 (2)	0.5 (0.2 to 0.9)	19 (54)	65.4 (60.6 to 70.5)	9 (21)	24.7 (21.6 to 28.1)	8 (32)	11.4 (9.1 to 14.0)
Spasm/cramp	12 (9)	0.8 (0.5 to 1.2)	1 (2)	0.1 (0.0 to 0.3)	2 (6)	0.4 (0.1 to 0.9)	1 (2)	0.1 (0.0 to 0.5)	0 (0)	0 (NA)
Joint/ligament										
Sprain	14 (11)	6.1 (5.3 to 7.0)	2 (4)	0.3 (0.1 to 0.6)	0 (0)	0 (NA)	7 (16)	7.3 (5.7 to 9.2)	1 (4)	5.7 (4.1 to 7.6)
Arthritis/synovitis/bursitis	1 (1)	0.2 (0.1 to 0.4)	2 (4)	0.5 (0.2 to 0.9)	2 (6)	0.3 (0.1 to 0.8)	2 (5)	0.6 (0.2 to 1.2)	2 (8)	2.4 (1.4 to 3.7)
Tendon										
Tendinopathy	8 (6)	2.0 (1.5 to 2.5)	5 (9)	4.1 (3.2 to 5.3)	1 (3)	7 (5.5 to 8.7)	2 (5)	2.0 (1.3 to 3.2)	1 (4)	0.1 (0.0 to 0.6)
Miscellaneous										
Contusion	16 (12)	1.7 (1.3 to 2.3)	2 (4)	0.5 (0.2 to 1.0)	1 (3)	0.2 (0.0 to 0.6)	4 (9)	0.9 (0.4 to 1.7)	0 (0)	0 (NA)
Non-specific pain	13 (10)	1.5 (1.1 to 1.9)	11 (19)	9.5 (8.1 to 11.2)	3 (9)	0.8 (0.4 to 1.5)	3 (7)	1.6 (0.9 to 2.6)	1 (4)	0.4 (0.1 to 1.1)
Meniscus/cartilage lesion	0 (0)	0 (NA)	0 (0)	0 (NA)	0 (0)	0 (NA)	0 (0)	0 (NA)	3 (12)	26.6 (23.0 to 30.5)
Other injury	2 (2)	7.3 (6.4 to 8.3)	3 (5)	4.3 (3.3 to 5.4)	1 (3)	1.3 (0.7 to 2.1)	3 (7)	0.8 (0.4 to 1.6)	4 (16)	4.6 (3.2 to 6.3)
Total	**130 (100)**	**70.8 (67.8 to 73.8)**	**57 (100)**	**84.5 (80.0 to 89.1)**	**35 (100)**	**81.5 (76.1 to 87.2)**	**43 (100)**	**101.3 (94.8 to 108)**	**25 (100)**	**72.0 (66.0 to 78.4)**

AE, athletics exposure; NA, not avilable.

in other populations. For this reason, the findings of our study have limited external validity as we cannot compare the training demands in this population to other heterogeneous groups with varying TEs.

CONCLUSIONS

This study highlights the most relevant injury characteristics of youth athletics athletes in a full-time sports academy. This may help addressing specific risk factors in future research studies, as well as targeted prevention measures for different athletics disciplines.

What are the findings?

- Youth male athletes engaged in a full-time athletics programme present high injury rates especially for overuse bone injuries and muscle strains.
- Stress fractures and bone stress injuries are common in endurance and jumps, while muscle strains are common in explosive events and during competitions (especially in sprints).
- The most burdensome injury types were bone stress for endurance, hamstring strains for sprints, stress fractures for jumps, lesion of meniscus or cartilage for throws and growth plate injuries for non-specialised athletes.

How might it impact on clinical practice in the future

- Consistent methodologies for injury definition and data collection may help comparing with other cohorts of youth athletics.
- Practitioners should be especially aware of overuse bone injuries in jumps and endurance and muscle strains in explosive events in youth athletes following intensive training programmes.
- Identifying injury characteristics for each event group may help addressing specific risk factors for future investigations and implementation of injury prevention programmes.

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Supplementary file. Distribution of injuries according to mode of onset for each body part and event-group.

	Overall			**General program**			**Endurance**			**Sprints**			**Jumps**			**Throws**		
Main body part Subcategory	n (%)		Acute/ Overuse	n (%)		Acute/ Overuse	n (%)		Acute/ Overuse	n (%)		Acute/ Overuse	n (%)		Acute/ Overuse	n (%)		Acute/ Overuse
Upper extremity																		
Shoulder/clavicle	**10**	**(3.4)**	**6/4**	4	(3)	3/1	1	(2)	0/1	0	(0)	0/0	1	(2)	0/1	4	(16)	3/1
Elbow	**3**	**(1)**	**3/0**	3	(2)	3/0	0	(0)	0/0	0	(0)	0/0	0	(0)	0/0	0	(0)	0/0
Forearm	**2**	**(0.7)**	**1/1**	1	(1)	1/0	0	(0)	0/0	0	(0)	0/0	0	(0)	0/0	1	(4)	0/1
Wrist	**5**	**(1.7)**	**4/1**	4	(3)	3/1	0	(0)	0/0	1	(3)	1/0	0	(0)	0/0	0	(0)	0/0
Hand	**3**	**(1)**	**3/0**	3	(2)	3/0	0	(0)	0/0	0	(0)	0/0	0	(0)	0/0	0	(0)	0/0
Finger	**1**	**(0.3)**	**1/0**	0	(0)	0/0	0	(0)	0/0	0	(0)	0/0	1	(2)	1/0	0	(0)	0/0
Head and trunk																		
Face	**0**	**(0)**	**0/0**	0	(0)	0/0	0	(0)	0/0	0	(0)	0/0	0	(0)	0/0	0	(0)	0/0
Head	**1**	**(0.3)**	**1/0**	1	(1)	1/0	0	(0)	0/0	0	(0)	0/0	0	(0)	0/0	0	(0)	0/0
Neck/cervical spine	**1**	**(0.3)**	**1/0**	1	(1)	1/0	0	(0)	0/0	0	(0)	0/0	0	(0)	0/0	0	(0)	0/0
Thoracic spine/upper back	**2**	**(0.7)**	**0/2**	1	(1)	0/1	0	(0)	0/0	1	(3)	0/1	0	(0)	0/0	0	(0)	0/0
Lumbar spine/lower back	**32**	**(11)**	**6/26**	8	(6)	2/6	8	(14)	1/7	2	(6)	0/2	8	(19)	1/7	6	(24)	2/4
Abdomen	**2**	**(0.7)**	**2/0**	2	(2)	2/0	0	(0)	0/0	0	(0)	0/0	0	(0)	0/0	0	(0)	0/0
Pelvis/sacrum/buttock	**18**	**(6.2)**	**1/17**	11	(8)	1/10	2	(4)	0/2	2	(6)	0/2	2	(5)	0/2	1	(4)	0/1
Lower extremity																		
Hip	**2**	**(0.7)**	**2/0**	0	(0)	0/0	0	(0)	0/0	0	(0)	0/0	1	(2)	1/0	1	(4)	1/0
Groin	**6**	**(2.1)**	**1/5**	2	(2)	0/2	3	(5)	0/3	0	(0)	0/0	1	(2)	1/0	0	(0)	0/0
Thigh	**55**	**(19)**	**44/11**	22	(17)	12/10	1	(2)	1/0	21	(60)	20/1	8	(19)	8/0	3	(12)	3/0
Knee	**43**	**(14.8)**	**12/31**	18	(14)	6/12	15	(26)	3/12	2	(6)	0/2	3	(7)	2/1	5	(20)	1/4
Lower leg	**36**	**(12.4)**	**3/33**	11	(8)	2/9	16	(28)	0/16	4	(11)	0/4	4	(9)	0/4	1	(4)	1/0
Achilles tendon	**4**	**(1.4)**	**1/3**	2	(2)	1/1	2	(4)	0/2	0	(0)	0/0	0	(0)	0/0	0	(0)	0/0
Ankle	**28**	**(9.7)**	**25/3**	17	(13)	14/3	2	(4)	2/0	0	(0)	0/0	6	(14)	6/0	3	(12)	3/0
Foot/toe	**36**	**(12.4)**	**17/19**	19	(15)	9/10	7	(12)	2/5	2	(6)	1/1	8	(19)	5/3	0	(0)	0/0
Total	**290**	**(100)**	**134/156**	**130**	**(100)**	**64/66**	**57**	**(100)**	**9/48**	**35**	**(100)**	**22/13**	**43**	**(100)**	**25/18**	**25**	**(100)**	**14/11**