Compelling overuse injury incidence in youth multisport athletes

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Abstract

The present investigation was carried out to examine the incidence and pattern of injuries in adolescent multisport athletes from youth sports academy. Injury data were prospectively collected from 166 athletes during the seasons from 2009 to 2014. A total of 643 injuries were identified, 559 (87.0%) were time-loss injuries. The overall injury incidence was 5.5 (95% confidence interval CI: 5.1–6.0), the incidence of time-loss injuries was 4.8 (95% CI: 4.4–5.2), the incidence of growth conditions was 1.2 (95% CI: 1.0–1.4) and incidence of serious injuries was 0.6 (95% CI: 0.5–0.8) per 1000 h of exposure. The prevalence of overuse injuries was 50.3%. Growth conditions represented 20.0%. Most of the injuries (67.0%) involved the lower extremities, and both foot and ankle were the most predominant injured body parts (22.0%). Knee injuries were mostly from overuse (50 *vs.* 23, $p = .02$), whereas foot and ankle injuries resulted from an acute mechanism (94 *vs.* 31, $p < .0001$). Minor and moderate injuries accounted for 87.0%. Muscle, tendon and osteochondrosis injuries accounted for 52.0% of all injuries. Comparing groups, squash sport was having the highest injury incidence (8.5 injuries per athlete). Higher exposure was associated with greater overuse relative risk (RR = 1.03, 95% CI: 1.01–1.014, $p < .001$). In conclusion, the results of this study identified a high incidence of injuries in this youth sports population. Striking was the prevalence of overuse injuries of 50%, which suggests the need for injury prevention protocols for adolescent highly trained athletes.

Keywords: *Youth, training, injury and prevention*

Introduction

Physical activity improves the overall health status of adolescents. However, the growing involvement of adolescents in sports gives rise to concerns regarding the risk of sports injuries (Bastos, Vanderlei, Vanderlei, Júnior, & Pastre, 2013). Injuries can counter the beneficial aspects related to sports activities, especially if an athlete is unable to continue to participate because of long-term consequences of injury (Maffulli, Longo, Spiezia, & Denaro, 2010; Roos, 2005). Compared to other age groups, youth are more involved in sports activities and have a higher rate of the sport injuries (Emery, Roy, Whittaker, Nettel-Aguirre, & van Mechelen, 2015). Sport participation in childhood and adolescence is an established cause of acute and overuse injuries. Longer exposure to training is one of the main risk factors for injury, and constant exposure to repetitive athletic actions and overload place the integrity of bodily structures at risk (Bastos et al., 2013; Myer et al., 2009). Bergeron et al. (2015) reported that extensive high intensity sports training can alter growth rates. Higher training volumes have consistently been shown to increase the risk of overuse injury in multiple sports (DiFiori et al., 2014), and load has been shown to be one of the most important predictors for injury. The determination of injury rates based on time-at-risk exposure data is also important (Maffulli et al., 2010). Little is known about injury epidemiology among young elite athletes (Steffen & Engebretsen, 2010). Pressured adolescent athletes in different disciplines across all sports are often halted by sports injuries with varying time-loss (TL) (Johnson, Doherty, & Freemont, 2009).

The incidence and severity of the sports injury problem need to be established as a first step of injury prevention (Emery, 2003). Therefore an injury epidemiology study in youth athletes is

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required for the development of prevention strategies (Steffen & Engebretsen, 2010).

The primary aim of this study was to examine the injury incidence in highly trained adolescent athletes using an injury surveillance record to prospectively collect injury data. The secondary aim was to investigate the association of exposure and the risk of injury occurrence.

Methods

A total of 166 male adolescent athletes 12–18 years from different sports (track and field [$n = 84$], squash [$n = 18$], table tennis [$n = 20$], fencing [$n = 20$], gymnastics [$n = 13$], swimming [$n = 4$], golf [$n = 3$] and shooting [$n = 4$]) were included in this prospective study. Twenty-one participants were being followed-up during 5 years, 28 during 4 years, 42 during 3 years and 33 during 1 year. Athletes were considered eligible if they were granted a six-year scholarship by the Middle Eastern Youth Sports Academy, which combines sport training and school (Figure 1).

Data from medical records were used to document all sports-related injuries during the study. Every athlete had direct access to medical facilities of the academy. Each different sports group had a dedicated full-time physiotherapist and a full-time employed medical doctor was available at the sporting academy.

The medical record used an injury reporting system, based upon the football injury reporting system described by Junge et al. (2008) and Sport Medicine Diagnostic Coding System (Meeuwisse & Wiley, 2007). Information was gathered concerning all injuries related to sports activity, including several related variables (e.g. type, location, affected structure, mechanism [acute *vs.* overuse], date of injury, TL and severity). Injuries not sustained in the context of the sport program or any data related to sickness or other general medical conditions were excluded from use in this study.

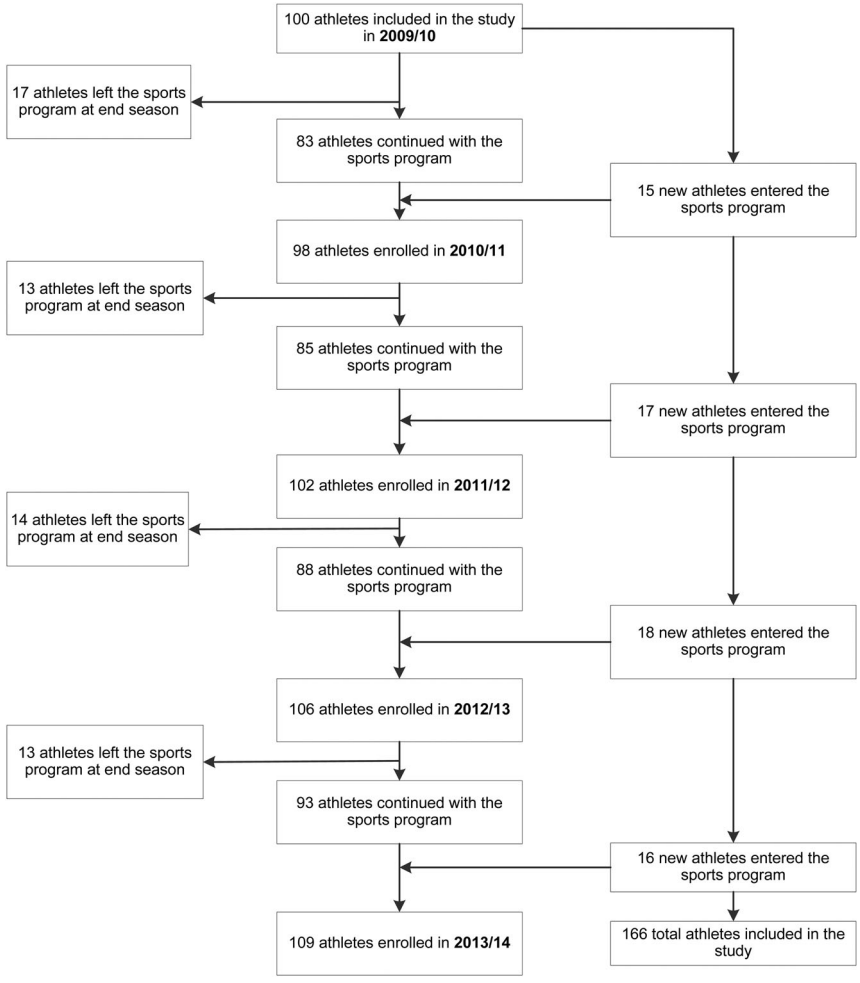

Figure 1. Flowchart describing the inclusion and flow of participants throughout the study.

Written informed consent was sought and obtained from all participants and their parents. The study was reviewed and approved by the Institutional Review Board for Human Subjects, by the local research ethics committee (SCH-ADL-070) and conformed to the recommendations of the Declaration of Helsinki.

Definition of injury

An injury was recorded as a physical complaint requiring the attention of the medical staff resulting from either a sports training, a strengthening and conditioning training or from a competition. Injuries were divided into time-loss injuries and no time-loss (NTL) injuries. A visit to physiotherapy unit, requiring a clinical examination and/or treatment without missing full training session or competition was described as "Medical attention" with NTL injury. A visit resulting in an athlete being unable to fully take part in training session or competition, the following day(s) was labelled as a TL injury (Fuller, 2006). The lay-off was calculated by the number of days missed from the date of injury (Day zero) until the day before the return to full participation in training availability. A traumatic injury was defined as any injury resulting from a specific and identifiable mechanism, including contact and non-contact circumstances with acute onset (Yang et al., 2012). Overuse injuries were defined as injuries resulting from insidious onset without a recognizable mechanism (van Wilgen & Verhagen, 2012). Growth conditions injuries are unique to young athlete and resulted from an increase in the involvement in sports activities by children and adolescents (Gillespie, 2010).

Injury severity was defined, based on days of absence from usual sport participation, as slight (1 day), minimal (2–3 days), mild (4–7 days), moderately serious (8–28 days), serious (>28 days–6 months) or long-term (>6 months) in accordance with Timpka et al. (2014) definition.

Exposure

Training diaries were collected, and expressed in hours and minutes, on a daily basis by respective coach. On average, every student, irrespective of the sport they have been selected for, were given 8 training sessions/week (5 technical, 2 strength and 1 conditioning), with a duration of 120 min/session; total of 16 h per week. Training exposure data from ill athletes were not accounted. The exposure periods (46 weeks) were during the school years, from mid-September until the end of June. The total training time is around 740 h per season per adolescent.

Statistical analysis

Descriptive statistics were presented as frequencies, proportions (%) and incidence rates were expressed as number of injuries/1000 h of exposure with 95% confidence intervals. The injury rates were described for each region independently, by injury type, injury severity and type of sport. Generalized estimating equations were used only for comparing the risk of injuries by sport type, injury type and severity as Poisson regression after accounting for individual exposure. For *post hoc* comparisons for injury type and sport type, Bonferroni correction was applied. Analyses were performed with IBM SPSS statistics v. 21. The results were presented with mean and standard deviation. The significance level was set at 5%.

Results

The mean age of the athletes at the time of injury was 15.1 ± 1.9 years. Throughout the 5-season study period, 166 athletes were subjected to 116,473 h of training exposure time. From these 166 players, 152 (91.6%) reported one or more injuries totalling 643 injuries. The overall injury incidence was 5.5 (95% confidence interval [CI]: 6.4–7.4) per 1000 h exposure and accounting for 3.9 injuries per athlete. Of these, 559 (87.0%) were TL injuries with an incidence of 4.8 (95% CI: 4.4–5.2) per 1000 h exposure. The incidence of injuries with NTL was 0.7 (95% CI: 0.6–0.9) per 1000 h exposure. Overuse injuries accounted for 50.3%, from all the TL injuries. The overall growth-related injuries incidence was 1.2 (1.0–1.4).

Further details on injury incidence are presented in Table I.

Location and diagnosis of injury

Most injuries with TL were located in the lower extremities ($n = 329$, 67.0%) and most often in the foot and ankle (22%, 95% CI: 17–27); knee; (13.0%, 95% CI: 9.0–17.0) and in hip and groin (10%, 95% CI: 6–13). Anterior thigh is predominantly affected by acute injury mechanism ($p = .005$). Overuse is the main mechanism of injury of lumbar spine. The knee was the most common region for serious overuse injuries (34.0%), while foot and ankle were the most common locations for the serious acute injuries, accounting for 22.0%. Further details on the distribution of injuries with TL are presented in Table II.

In this study, the highest incidence of injury was sustained in squash athletes (8.5, 95% CI: 7.2–10.0) and lowest in the fencing athletes (3.99, 95%

Table I. Injury incidence.[a]

Variable	Injuries, *n* (%)	Exposure, *h*	Incidence/1000 h (95% CI)
All injuries	643 (100.0)	116,473	5.5 (5.1–6.0)
No time-loss	84 (13.0)	116473	0.7 (0.6–0.9)
Time-loss	559 (87.0)	116,473	4.8 (4.4–5.2)
Acute time-loss	278 (43.0)	116,473	2.4 (2.1–2.7)
Overuse time-loss	281 (44.0)	116,473	2.4 (2.1–2.7)
Growth conditions	140 (20.2)	116,473	1.2 (1.0–1.4)

[a]Incidence is given as the number of injuries per 1000 h of exposure.

CI: 2.85–5.43). Further squash reported higher overuse injuries (4.7, 95% CI: 3.8–5.6) compared to acute injuries (3.3, 95% CI: 2.6–4.1) which was also similar in other sports group (table tennis, fencing and gymnastics). It is only among the track and field group where the incidence rate of acute injuries (3.4, 95% CI: 3.0–3.7) was higher than the incidence of overuse injuries (2.4, 95% CI: 2.1–2.7). Figure 2 shows the incidence of TL injuries by sports group (injuries/1000 h). Most frequently injured body structures were muscle and tendon (30.1%), with an incidence of 1.67 (95% CI: 1.44–1.92), and osteochondrosis (21.7%), with an incidence of 1.20 (95% CI: 1.01–1.42).

Injury severity

Our results showed that the most reported injuries (53.0%) were minor. Within the minor injuries, the mild were most frequent, accounting for 21.0%, 34.4% of all injuries were moderately serious injuries, while serious injuries accounted for 13.0%.

Risk by volume of exposure, mechanism of injury and sports group.

Training volume exposure was significantly associated with risk of injury. The relative risk (RR) was found 1.01 and can be interpreted as for every 10 h increase in volume of exposure training, the risk of injury increased by 1% ($p < .001$). Using fencing athletes as a reference, the RR of injuries in squash athletes was 2.15 (95% CI: 1.55–2.98, $p < .001$), gymnastics 1.37 (95% CI: 0.90–2.10, $p = .174$); track and field 1.35 (95% CI: 0.99–1.83, $p = .060$); and table tennis 1.04 (95% CI: 0.72–1.51, $p = .821$). Training volume exposure was significantly associated with risk of overuse injury. The RR of overuse injuries was found 1.03 (95% CI: 1.01–1.014, $p < .001$).

Discussion

The present investigation was carried out to examine the incidence and pattern of injuries in young elite multisport athletes. Major findings were the high rate of injuries with subsequent TL, the high rate of overuse injuries (50.3%), and high prevalence of growth-related conditions, and that most of injuries were minor and in the lower limbs.

In our study, the rate of injury with TL was 87% and an incidence of 4.8 per 1000 h of exposure. Beachy and Rauh (2014) reported a rate of TL injuries of 45.1% with an incidence of 2.7 per 1000 athletic exposures. The discrepancy between the two studies may be explained by inconsistencies with respect to possibility of reporting bias. Beachy and Rauh (2014) reported that some athletes may have had self-treated injuries that were not reported to athletic training staff. Therefore, approximation of the number of injuries with TL could have led to an underestimation of injury rates. Comparing our results with other investigations on elite youth soccer players, the prevalence of injuries with TL (87.0%) is higher than those previously reported (Clausen et al., 2014) (63.4%), (Dompier, Powell, Barron, & Moore, 2007) (41.4%) and (Materne, Farooq, Johnson, Greig, & McNaughton, 2015) (66.5%). The discrepancies between rates of injuries with TL in youth soccer players may be caused by differences in data collection methods, through the Short Message Service system (Clausen et al., 2014), or parents reports (Dompier et al., 2007) which had the potential to lead to a significant underestimation of the number of injuries. These discordances may also be due to the urge demand to return to training and or competition soon after injury for soccer players (Le Gall, Carling, & Reilly, 2006; Materne et al., 2015).

The prevalence of overuse injuries acquisition in the present study was 50.3%, and consistent with other studies in youth, where estimates of the proportion of sports injuries that are due to overuse ranging from 45.9% to 54.0% (Luke et al., 2011; Watkins & Peabody, 1996). However, our finding was higher than previously observed in elite youth soccer players, 29.8%, (Materne et al., 2015), 22.9%, (Clausen et al., 2014) and 13.4% (Le Gall et al., 2006). The reduced rates of overuse injury in

Table II. Incidence, proportion and severity of injuries by body part and mechanism.

Injured region	No. of time-loss injuries	Percentage of all time-loss injuries (95% CI)	Incidence[a] (95% CI)	*p*-Value ratio	Serious injuries[b], *n* (%)
Upper limbs					
Shoulder	34	6 (3–9)	0.3 (0.2–0.4)		3/34 (9)
Acute	11	2 (0–4)	0.1 (0.1–0.2)	.040	3/11 (27)
Overuse	23	4 (2–6)	0.2 (0.1–0.3)		0/23 0
Hand &wrist	57	10 (7–14)	0.5 (0.4–0.6)		3/57 (5)
Acute	39	7 (4–10)	0.3 (0.2–0.5)	.005	3/39 (8)
Overuse	18	3 (1–5)	0.2 (0.1–0.2)		0/18 (0)
Lower limbs					
Hip/groin	54	10 (6–13)	0.5 (0.4–0.6)		6/54 (11)
Acute	20	4 (1–6)	0.2 (0.1–0.3)	.057	2/20 (10)
Overuse	34	6 (3–9)	0.3 (0.2–0.4)		4/34 (12)
Thigh (Ant.)	29	5 (3–8)	0.3 (0.2–0.4)		4/34 (12)
Acute	22	4 (2–6)	0.2 (0.1–0.3)	.005	4/34 (12)
Overuse	7	1 (0–3)	0.1 (0.0–0.1)		0/34 (0)
Thigh (Post.)	48	9 (5–12)	0.4 (0.3–0.6)		6/48 (15)
Acute	23	4 (2–6)	0.2 (0.1–0.3)	.773	3/23 (13)
Overuse	25	4 (2–7)	0.2 (0.1–0.3)		4/25 (16)
Knee	73	13 (9–17)	0.6 (0.5–0.8)		20/73 (27)
Acute	23	4 (2–6)	0.2 (0.1–0.3)	.002	3/23 (13)
Overuse	50	9 (6–12)	0.4 (0.3–0.6)		17/50 (34)
Lower leg	43	8 (5–11)	0.4 (0.3–0.5)		5/43 (12)
Acute	19	3 (1–6)	0.2 (0.1–0.3)	.446	1/19 (5)
Overuse	24	4 (2–7)	0.2 (0.1–0.3)		4/24 (17)
Foot & ankle	125	22 (17–27)	1.1 (0.9–1.3)		24/125 (19)
Acute	94	17 (12–21)	0.8 (0.7–1.0)	<.0001	21/94 (22)
Overuse	31	6 (3–8)	0.3 (0.1–0.4)		3/31 (10)
Spine					
Lumbar	46	8 (5–12)	0.4 (0.3–0.5)		1/46 (2)
Acute	9	2 (0–3)	0.1 (0.0–0.2)	<.0001	0/9 (0)
Overuse	37	7 (4–10)	0.3 (0.2–0.4)		2/37 (5)
Thoracic	20	4 (1–6)	0.2 (0.1–0.3)		0/20 (0)
Acute	5	1 (0–2)	0.1 (0.0–0.1)	.025	0/5 (0)
Overuse	15	3 (1–5)	0.1 (0.1–0.2)		0/15 (0)
Cervical	7	1 (0–3)	0.1 (0.0–0.1)		0/7 (0)
Acute	3	1 (0–1)	0.0 (0.0–0.1)	.025	0/3 (0)
Overuse	4	1 (0–2)	0.0 (0.0–0.1)		0/4 (0)
Others[c]					
Other	24	4 (2–7)	0.2 (0.0–0.4)		1/24 (4)
Acute	11	2 (0–4)	0.1 (0.1–0.2)	.683	1 /11 (9)
Overuse	13	2 (1–4)	0.1 (0.1–0.2)		0/13 (0)
Total	559	100	5.0 (4.4–5.2)		74/559 (13)
Acute	278	50 (44–56)	2.4 (2.1–2.7)	.899	40/73 (55)
Overuse	281	50 (44–56)	2.4 (2.1–2.7)		33/73 (45)

[a]Number of injuries per 1000 h of exposure.
[b]Serious injury is an injury with reported absence of four calendar weeks.
[c]Chest/trunk ($n = 9$), elbow ($n = 8$) and forearm/arm ($n = 1$).

soccer may be due in part to regular recovery periods within the annual calendar (Fuller, 2006), but could be also attributed to the characteristics of the sport, contact and team sport versus individual sport, as the frequency and type of overuse injuries in elite young athletes vary by sport, and sports-related training and conditioning (DiFiori et al., 2014). The higher incidence of traumatic injuries could be context-dependent, because contacts between players and teammates are generally more frequent in team sports (Theisen et al., 2013). The dissimilarities could be also due to data recording method as most studies (Kakavelakis, Vlazakis, Vlahakis, & Charissis, 2003; Rumpf, Cronin, Pinder, Oliver, & Hughes, 2012) consider only overuse injuries if these are associated with TL and this most likely led to under-reporting overuse injuries (Palmer-Green & Elliott, 2015). It has been suggested that traditional injury registration methods, based on TL, underestimate the true rate and impact of injury (Pluim, Loeffen, Clarsen, Bahr, & Verhagen, 2016). Therefore, all complaints

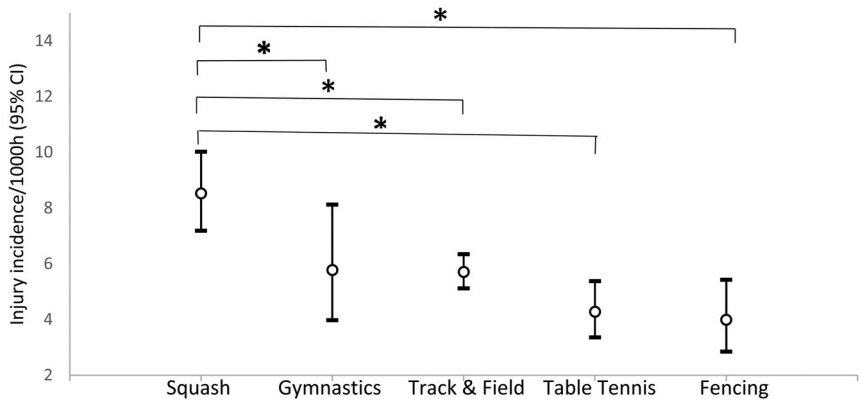

Figure 2. Incidence of TL injuries by sports group (injuries/1000 h). *Incidence significantly higher than all other sports ($p < .05$).

should be reported, regardless of TL, as a consistent method to capture overuse injuries (Clarsen et al., 2015).

On this basis, our findings are a cause of concern and suggest that previously reported overuse injury rates in adolescent athletes may be substantially underestimated, and advised that "any physical complaint sustained by a player" injury definition should be considered in future study methodologies.

The prevalence of growth-related conditions (20.0%) observed in this study, differs from previously reported studies where an incidence ranging from 0% to 16.8% was reported (Kakavelakis et al., 2003; Le Gall et al., 2006; Materne et al., 2015). The discrepancies between studies are more likely attributed to our enhanced reporting of early signs of growth-related conditions through an implemented monitoring plan, instead of the usual athlete reporting complaints to the healthcare provider. Growth conditions injuries do occur more common during sudden growth periods (d'Hemecourt, 2009). These cause some concerns and require prevention strategies such as growth monitoring for long-term consequences (Dompier et al., 2007).

In our training centre, recognized as a high-performance sports environment, with its structured weekly training, the demands of high-level sport are imposed on athletes during periods of growth and maturation, which may have caused high rate of growth injuries. This is a compelling example where a closer look at injury inciting factors and prevention plans for youth athletes are needed.

The majority of injuries in our study were located in the lower extremity (67.0%), this result is roughly similar to the findings from a study at a middle school for multisport evaluation of injuries (70.0%) (Beachy & Rauh, 2014) but our result is lower to findings corresponding to other investigations on youth soccer players where lower extremity injuries were reported ranging from 83.4% to 86.0% (Clausen et al., 2014; Le Gall et al., 2006). These discrepancies may have depicted the difference between soccer injuries (Wong & Hong, 2005) and non-soccer injuries. Therefore, injury prevention measures should focus evenly on upper and lower limbs in non-soccer athletes. Foot and ankle injuries accounted for 22.0% and this is in line with similar reports figures (20.0%) of the National Collegiate Athletic Association. A possible reason for the vulnerability of the ankle to injury is reduced motor coordination and proprioceptive skills (Hertel, 2000). Measures to prevent acute ankle sprains could include stabilization exercises, bracing, foot muscle strengthening (Fourchet, Kuitunen, Girard, Beard, & Millet, 2011) and ensuring a good match between shoes and surface characteristics (Damm et al., 2013; Janssen, Hendriks, van Mechelen, & Verhagen, 2014). Also considering the evidence, there is consistency across the literature to support the preventative effect of multifaceted neuromuscular training programmes inclusive of strength, balance and agility components in reducing the risk of lower extremity injuries in youth sport (Emery et al., 2015).

Fortunately most injuries were minor (53.0%). The results for injury severity are similar to those reported for youth elite soccer players. Most of the injuries resulted in an absence of fewer than seven days (51.9%).

To our knowledge, this study is the first to examine the injury characteristics of youth non-soccer athletes in Middle East. The main limitations of this study were the inhomogeneous participants' sample of highly trained youth athletes, inaccuracy of records of exposure time duration and the lack of data of organized competition.

Conclusion

The rate of overuse and growth-related conditions injuries among youth in multisport in our sports

academy is high. Youth athletes have peculiarities; these findings could be cause for concern and merit further studies to establish the risk factors leading to these injuries and to plan strategies of prevention to limit long-term consequences.

Disclosure statement

No potential conflict of interest was reported by the authors.

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