

Apophysitis Among Male Youth Soccer Players at an Elite Soccer Academy Over 7 Seasons

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Background: Apophyseal injuries are common in children and adolescent athletes. These injuries are believed to be caused by repetitive overloading, which can create inflammatory and degenerative conditions in growing bone prominences. However, their prevalence, diagnosis, and treatment in young soccer players have been understudied.

Purpose: To evaluate characteristics of apophyseal injuries in adolescent athletes at an elite soccer academy.

Study Design: Case series; Level of evidence, 4.

Methods: All apophyseal injuries between July 2008 and June 2015 were evaluated. For each injury, the authors recorded the type and location, age of the player, injury date, imaging modalities, and time absent from training/competition.

Results: Over the 7 seasons of this study, 210 apophyseal injuries were documented, including 172 simple apophyseal injuries and 38 apophyseal avulsion fractures. The rate of apophyseal injuries was 0.35 per 1000 hours of training exposure. A total of 196 (93.3%) cases were primary injuries, and the rest (6.7%) were reinjuries. Ultrasonography was the most commonly used imaging modality for diagnosis (172 cases; 81.9%). The most common location of apophyseal injuries was the anterior inferior iliac spine (AIIS). Return to sport was faster in athletes with apophyseal injury at the ischiopubic ramus, those with simple apophyseal injuries, and younger athletes.

Conclusion: The most common location for apophyseal injury among soccer players was the AIIS. Return to training and competition differed according to injury location, type of apophyseal injury, and age.

Keywords: football (soccer); pediatric sport medicine; epidemiology; apophysitis

According to the Federation Internationale de Football Association (FIFA), 240 million people (4% of the world's population) actively play soccer,¹⁴ and most registered soccer players are teenagers (54.7% and 69.6% among male and female players, respectively).² Although playing soccer is linked with various health benefits, musculoskeletal injuries often occur, mainly due to direct contact involvements.¹⁴ Among children, most soccer injuries (60%-90%) occur in the lower extremities, of which 2.3% to 40.0% are caused by overexertion.^{9,10,21} Furthermore, overuse injuries may also be growth-related, especially during growth spurts, while other potential underlying mechanisms involve excessive exercise loads (eg, Sever disease, calcaneal apophysitis; or Osgood-Schlatter disease, apophysitis of the tibial tubercle—the latter requires players to rest for a longer period²⁴). Moreover, it has been reported that youth players are more prone to injuries involving the apophyses because of skeletal immaturity.⁶

The apophyses are secondary growth centers that serve as attachment sites for tendons.^{7,25} It has been theorized that apophysitis may have multifactorial origins in nature, including rapid growth, genetics, anatomic properties, and accumulation of microscopic avulsions.^{3,7,18,19} However, none of these factors appear to be predominant, and it is likely that all are somehow involved in generating both an inflammatory and a degenerative response in the apophyseal cartilage.² When an apophysis is subject to strong traction, the bone can be fractured and displaced; this is called an avulsion fracture.⁷ Classically, diagnosing apophyseal injuries includes (1) history, especially with the presence of a traumatic mechanism and considerations of differential diagnoses; (2) physical examination, particularly with the tendon attachment sites associated with pain, swelling, and/or tenderness¹⁵; and (3) imaging modalities, including radiographs, ultrasound (US), and magnetic resonance imaging (MRI).

Although clinical decision-making regarding apophyseal injuries is well-solidified, there have been few publications describing apophysitis incidence, diagnosis, and treatments among adolescent athletes, especially in elite soccer players.

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Examining clinical the decision-making process, including clinical modalities, apophysitis locations, and return to sport (RTS), will likely enhance the knowledge and treatment process of apophysitis, especially in competitive adolescent soccer players. Thus, the purpose of this paper was to evaluate characteristics of apophyseal injuries in adolescent athletes at an elite soccer academy.

METHODS

Setting and Study Population

Our medical department is responsible for the healthcare of soccer players aged 7 to 19 years at the Futbol Club (FC) Barcelona soccer academy. We carried out a prospective observational study of apophyseal injuries among players at the elite soccer academy. Data were collected throughout 7 seasons, from July 2008 to June 2015. During each season, the academy cohort consisted of 250 players under 19 years of age (U-19). Before entering the academy, the players' parents gave written consent to use their children's test results and injury data based on the Declaration of Helsinki. This study was approved by the Catalan Sport Council's Clinical Research Ethics Committee.

Injury Definition

Our study adhered to consensus recommendations on definitions and data collection procedures in studies of soccer injuries from FIFA's Medical Assessment and Research Centre (F-MARC).¹² An apophysitis diagnosis was made by a sport medicine physician with extensive experience. Adolescent athletes who had a chief complaint of tendon insertion and were unable to participate fully in subsequent trainings or matches were primarily treated as apophyseal injury cases. As a clinical team, we suspected apophyseal injury if there was an acute onset of pain during soccer activity, with fingertip pressure to the location causing pain. Other differential diagnoses include Legg-Calvé-Perthes disease, acetabular labral tear, and femoral neck epiphysiolysis, which all usually have a gradual onset of pain and whereby localization of pain is not common. Additionally, an apophyseal injury is usually not accompanied by a limited range of motion, especially in hip rotation, abduction, and adduction.

In most cases, licensed physicians performed US evaluation to further examine apophyseal injury. The typical

findings were the presence of a hypoechoic zone superficial to the apophysis representing cartilage swelling; a fragmented and hypoechoic ossification center; and in a few cases, dislocation and tilting of the apophysis indicating an avulsion. Most apophyses with isometric contraction lead to a suspected unstable avulsion. Doppler US is usually positive at the painful attachment sites of tendons. In cases in which apophyseal avulsion or an obvious diagnosis was not confirmed by US examination, radiographs or an MRI were performed. The radiographs show irregular shapes with separation from the attachment sites, which are notable characteristics in the early stages, later often progressing to fragmentation. US often demonstrates the following characteristics: (1) the presence of a hypoechoic zone superficial to the apophysis representing cartilage swelling; (2) a fragmented and hypoechoic ossification center, in addition to the abovementioned findings^{5,8}; (3) dislocation and tilting of the apophysis indicating an avulsion; and (4) mobility of the apophysis with isometric contraction that leads to a suspected unstable avulsion.¹⁶ MRI can often detect apophyseal widening with edema in the contiguous bone, as depicted by increased signal intensity (SI) on water-sensitive sequences and low SI on T1-weighted images.⁴ MRI is also employed to rule out other differential diagnoses, including neoplastic diseases and osteomyelitis.^{2,18}

Once apophyseal injury was confirmed, it was classified into 1 of 2 categories: simple apophysitis and apophyseal avulsion fracture. We considered simple apophysitis as an inflammation of the growth plate cartilage at the apophysis caused by overuse. Conversely, apophyseal avulsion fracture was defined as a displacement of the apophysis caused by sudden major traction during sport activity. We excluded any other diagnoses related to pathology of the articulation, muscle, or tendon in the study.

Data Collection

The medical department of the study institution has a rigorous online tracking database (Gestió Esportiva Mèdica [GEM]) system, which was programmed to register all injuries and illnesses in all registered athletes at the FC Barcelona soccer academy. All apophyseal injuries were filtered and identified according to the Orchard Sports Injury Classification System (OSICS) Version 10.1.²² Collected data were organized based on demographic variables, incidence rate (1000 hours of exposure), imaging modalities (radiography, US, and MRI), and injury types

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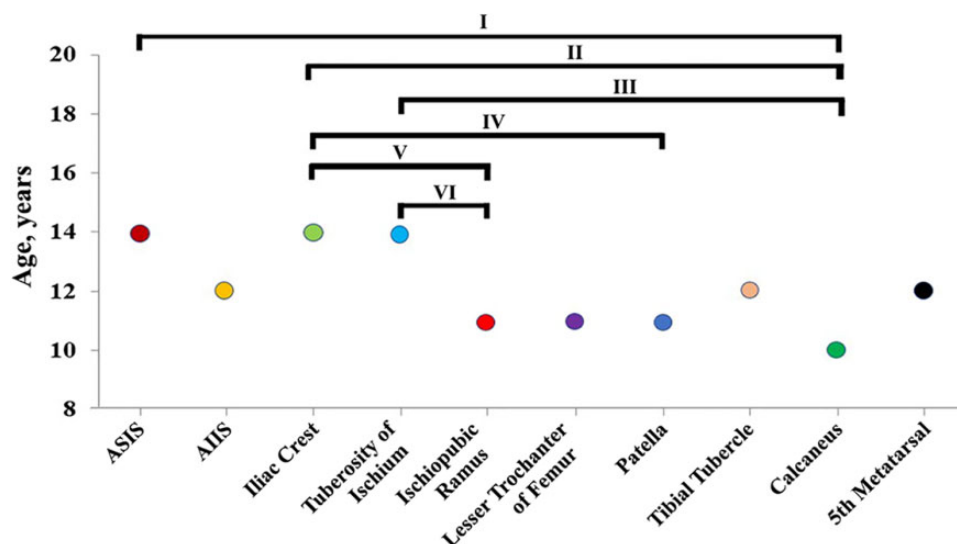


Figure 1. All apophyseal injuries ($n = 210$): locations and ages. Statistically significant differences according to Bonferroni post hoc pairwise comparison: I ($P = .013$), II ($P = .009$), III ($P = .014$), IV ($P = .032$), V ($P = .012$), and VI ($P = .021$). AIIS, anterior inferior iliac spine; ASIS, anterior superior iliac spine.

per body locations. The RTS data were calculated as the number of missing or absent days due to apophyseal injury until the team medical staff allowed the player to return to training and matches.

Statistical Analysis

Demographic variables, injury type, body locations, and imaging modalities were analyzed descriptively. Analyses of variance (ANOVA) was used for comparisons of age and RTS by body locations for all apophyseal injuries, simple apophyseal injuries, and apophyseal avulsion fractures. A pairwise comparison (Bonferroni correction) was performed when a significant difference was detected by ANOVA. The Mann-Whitney U test was also used to compare RTS training and RTS competition based on injury types (simple apophyseal injuries and apophyseal avulsion fractures) and chronological ages (7-10 years and 11-17 years). The a priori significance level was set at $P < .05$. Analyses were conducted using SPSS Version 21.0 (IBM).

RESULTS

Demographics, Injury Characteristics, and Incidence Rates

Initially, 181 players were included in the study; however, 8 players were excluded because of missing variables, which resulted in a total of 173 players with 210 apophyseal injuries. The mean age was 12.0 ± 2.0 years. A total of 5.3% of the apophysitis cases had bilateral involvement of the same location, while 48.1% affected only the right side and 46.6% the left side. The most common body location of apophyseal injuries was the anterior inferior iliac spine (AIIS) (43.3%), and the lesser trochanter was the least

common (1.4%). A total of 196 (93.3%) cases were primary injuries, and the rest (6.7%) were reinjuries. None of these cases required surgical/operative treatment. The apophyseal injury proportion relative to all other musculoskeletal injuries ranged from 5.1% to 15.3% over the course of the study period (season 2007-2008, 5.6%; 2008-2009, 6.3%; 2009-2010, 10.6%; 2010-2011, 6.1%; 2011-2012, 5.1%; 2012-2013, 15.3%; 2013-2014, 15.0%; 2014-2015, 10.0%). During the study period, we recorded 1963 player-seasons, accounting for 599,834 hours of exposure to soccer play, with 0.35 apophysitis injury incidence rates per 1000 hours of exposure.

Clinical Symptoms and Imaging Modalities

Although some athletes were asymptomatic (no pain) during physical activities, the majority of the athletes (62%) reported pain after running, sprinting, passing, quick turning/cutting, shooting a ball, and jumping. The pain was mostly persistent during training (42.8%), competition (20.5%), warm-up before competition (2.5%), and in other situations, such as performing physical activity at school, playing other sports, and participating in other recreational/leisure games (34.3%). For the diagnosis, US was employed in 172 (81.9%) cases, while radiographs were taken in 107 (51.0%) cases. MRI was performed for a total of 5 (2.4%) cases.

All Apophyseal Injuries

ANOVA identified age differences based on the body locations of all apophyseal injuries (Figure 1). There were no differences in RTS training timeline (days) within all apophyseal injury locations (Table 1). However, there were differences in RTS competition. RTS competition of athletes

who sustained apophyseal injury at the ischiopubic ramus was faster than that for athletes with an injury at the lesser trochanter ($P = .008$), iliac crest ($P = .015$), fifth metatarsal ($P = .021$), anterior superior iliac spine (ASIS) ($P = .026$), AIIS ($P = .035$), or tuberosity of ischium ($P = .048$) (Table 1). Also, athletes who had an apophyseal injury at the tibial tuberosity showed quicker RTS competition compared with athletes with lesser trochanter ($P = .019$) and iliac crest ($P = .039$) injuries (Table 1).

Simple Apophyseal Injuries

Age differences in simple apophyseal injury locations were detected by ANOVA (Figure 2). There were no significant

differences in either RTS training or RTS matches based on simple apophyseal injury (Table 2).

Apophyseal Avulsion Fractures

ANOVA testing revealed age-based differences in apophyseal avulsion fractures (Figure 3). There were no statistical differences in RTS training, yet there were differences in RTS matches with apophyseal avulsion injury by body locations. RTS matches of athletes who sustained apophyseal avulsion fracture at the AIIS was quicker than that of athletes with apophyseal avulsion fracture at ASIS ($P = .035$) and tuberosity of ischium ($P = .048$) (Table 3).

RTS Training and Competition Based on Injury Types and Ages

Mann-Whitney U tests revealed that the RTS timeline for athletes with simple apophyseal injuries was faster than that for athletes with apophyseal avulsion fractures in both to training ($P < .001$) and competition ($P < .001$) (Figure 4A). Additionally, analysis of all apophyseal injuries indicated that younger athletes (7-10 years) recover more quickly than older athletes (11-17 years) for RTS training ($P = .011$) and RTS competition ($P = .006$) (Figure 4B).

DISCUSSION

There have been few previous reports about apophyseal injuries, especially among young soccer players in the elite academic club setting. This may be because apophyseal injuries are often underdiagnosed,¹⁸ commonly being treated as strain.²⁰ Le Gall et al¹⁷ reported 33 apophyseal disorders during a 10-season period, compared with the 210 apophyseal injuries during 7 seasons reported in our study. Our study found that an apophyseal injury occurs at a rate

TABLE 1
All Apophyseal Injuries (n = 210): Location, Return to Training, and Return to Competition^a

Injury Location	No. of Injuries (%)	Return to Training, d ^b	Return to Competition, d ^b
ASIS	17 (8.1)	17 (3-30)	22 (3-40)
AIIS	91 (43.3)	13 (7-17)	14 (7-22)
Iliac crest	5 (2.4)	15 (13-36)	18 (16-40)
Tuberosity of ischium	21 (10.0)	14 (7-34)	15 (7-37)
Ischiopubic ramus	13 (6.2)	7 (4-11)	7 (4-15)
Lesser trochanter of femur	3 (1.4)	31 (14-31)	33 (21-36)
Patella	9 (4.3)	13 (6-28)	13 (6-33)
Tibial tubercle	29 (13.8)	11 (4-18)	11 (5-18)
Calcaneus	13 (6.2)	10 (4-24)	10 (4-24)
Fifth metatarsal	9 (4.3)	27 (4-31)	28 (5-43)

^aAIIS, anterior inferior iliac spine; ASIS, anterior superior iliac spine.

^bValues are shown as median (interquartile range).

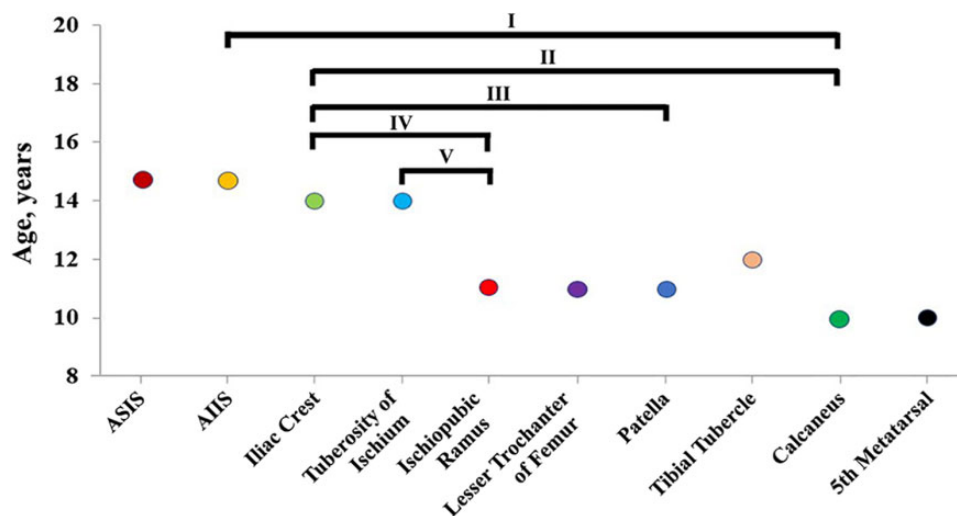


Figure 2. Simple apophyseal injuries (n = 172): locations and ages. Statistically significant differences according to Bonferroni post hoc pairwise comparison: I ($P = .024$), II ($P = .046$), III ($P = .046$), IV ($P = .030$), and V ($P = .020$). AIIS, anterior inferior iliac spine; ASIS, anterior superior iliac spine.

TABLE 2
Simple Apophyseal Injuries (n = 172): Location, Return to Training, and Return to Competition^a

Injury Location	No. of Injuries (%)	Return to Training, d ^b	Return to Competition, d ^b
ASIS	13 (7.6)	8 (1-30)	8 (1-35)
AIIS	74 (43.0)	10 (7-16)	11 (7-22)
Iliac crest	3 (1.7)	14 (2-14)	18 (14-18)
Tuberosity of ischium	17 (9.9)	7 (7-22)	7 (7-22)
Ischiopubic ramus	13 (7.6)	7 (4-11)	7 (4-15)
Lesser trochanter of femur	2 (1.2)	23 (14-23)	27 (21-27)
Patella	6 (3.5)	7 (3-20)	7 (3-20)
Tibial tubercle	27 (15.7)	10 (4-16)	10 (4-16)
Calcaneus	13 (7.6)	10 (1-24)	10 (1-24)
Fifth metatarsal	4 (2.3)	5 (3-23)	5 (3-23)

^aAIIS, anterior inferior iliac spine; ASIS, anterior superior iliac spine.

^bValues are shown as median (interquartile range).

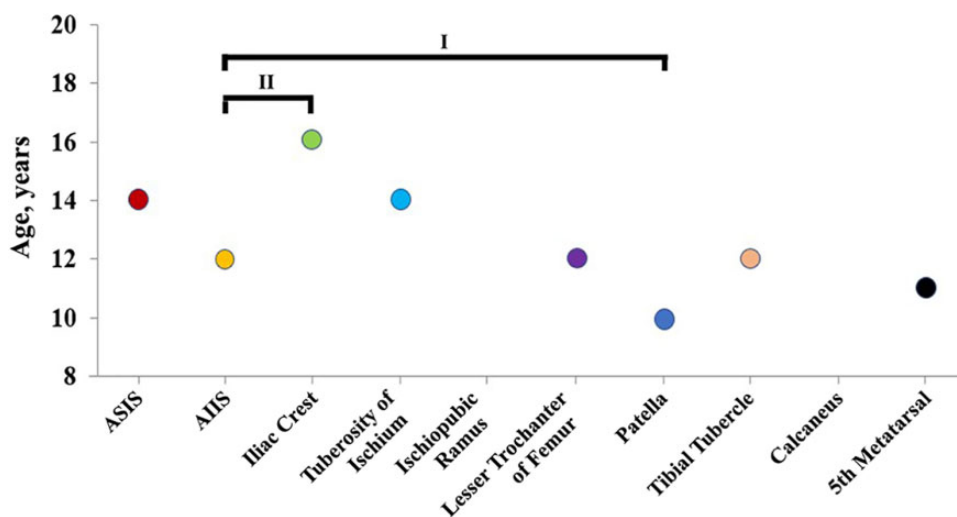


Figure 3. Apophyseal avulsion injuries (n = 38): locations and ages. There were no apophyseal avulsion fractures at the ischiopubic ramus or calcaneus. Statistically significant differences according to Bonferroni post hoc pairwise comparison: I ($P = .048$) and II ($P = .046$). AIIS, anterior inferior iliac spine; ASIS, anterior superior iliac spine.

TABLE 3
Apophyseal Avulsion Fractures (n = 38): Locations, Frequencies, RTS Training, and RTS Competition^a

Location	No. of Injuries (%)	Return to Training, d ^b	Return to Competition, d ^b
ASIS	4 (10.5)	25 (18-71)	38 (32-74)
AIIS	17 (44.7)	14 (14-25)	21 (15-33)
Iliac crest	2 (5.3)	36 (21-36)	40 (28-40)
Tuberosity of ischium	4 (10.5)	42 (34-61)	49 (38-49)
Ischiopubic ramus	0 (0)	—	—
Lesser trochanter of femur	1 (2.6)	23 (—)	48 (—)
Patella	3 (7.9)	28 (14-28)	35 (14-35)
Tibial tubercle	2 (5.3)	17 (14-17)	17 (14-17)
Calcaneus	0 (0)	—	—
Fifth metatarsal	5 (13.2)	31 (27-47)	42 (26-48)

^aAIIS, anterior inferior iliac spine; ASIS, anterior superior iliac spine.

^bValues are shown as median (interquartile range).

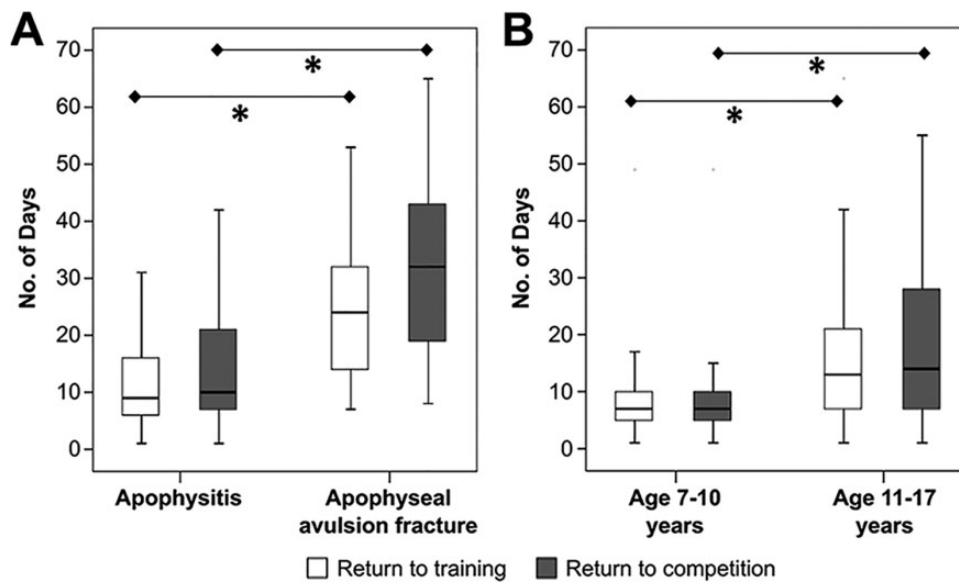


Figure 4. Comparison of return to training and return to competition times between (A) simple apophysitis vs apophyseal avulsion fractures and (B) athletes aged 7 to 10 years vs 11 to 17 years. * indicates statistically significant with P -value $< .05$.

of 0.35 per 1000 hours of exposure. Also, our study identified that most apophyseal injuries (93.3%) in this group were primary (first-time) incidence, while 6.7% were reinjury cases. Furthermore, although soccer is an asymmetrical movement sport, except for the goalkeeper, apophyseal injuries were observed almost equally from right (48.1%) and left (46.6%) limbs. The rest (5.3%) were bilateral cases at the same body locations.

One of the main findings of the current study is the body location of the apophyseal injury. Previously, Peck²³ and Le Gall et al¹⁷ reported that the most common location of apophyseal injury was the tibial tubercle. However, in our study, the most common body location was AIIS (43.3%), including both simple apophyseal (43.0%) and apophyseal avulsion fracture (44.7%) injuries. Our study results were supported by a recent systematic study. In the systematic review, the most common location of avulsion fracture was identified as AIIS.¹ Furthermore, clinical treatments such as pain reduction of apophyseal injuries have previously been reported.^{13,20} However, to our knowledge, comparisons between age and body locations based on specific apophyseal injury types (simple apophyseal and apophyseal avulsion fracture) have not been documented. According to our results, apophyseal injuries of the hip, including ASIA, AIIS, iliac crest, and tuberosity of the ischium, occur in 12- to 14-year-olds, while apophyseal injuries of the leg, such as the femur, patella, tibia, and foot, appear to happen more frequently in 10- to 12-year-olds (Figures 1–3).

Clinically, apophyseal injuries with less than 2 cm of bony displacement are traditionally not surgically treated. Conversely, if the bony displacement is more than 2 cm, it is typically treated with surgical fixation.²⁶ In our study, none of the apophyseal injuries showed a displacement of more than 2 cm; thus, they were treated nonoperatively. In many cases, the apophysis may not become ossified until the end

of the final growth spurt; therefore, it is not visible on plain radiographs.¹¹ For this reason, US is a useful option. Additionally, US application would reduce radiographic exposures compared with radiography. One unique attribute of our study was the high utility of US, along with clinical presentation and physical examination. US was the imaging modality choice in 81.9% of participants, while radiographs were employed in 50.9% of all cases.

Another salient finding was the effect of body location on return to training and competition. We found that there are differences in RTS training and competition based on the injured location. Among 10 body locations, athletes with an injury to the ischiopubic ramus where the adductor longus muscle attaches had the shortest duration to RTS training and competition (Table 1). On the other hand, athletes with an injury to the lesser trochanter of the femur had the longest duration (Table 1). The current study data on RTS training and competition need to be interpreted with caution, however. The study hosting institution (the FC Barcelona soccer academy) has a well-organized system to facilitate the timely RTS of adolescent athletes. For example, there are therapists who provide clinical care, and there is another group of experts who specialize in cross-training. In addition to those clinicians, there is a medical advisor who oversees the overall progress of each adolescent athlete. This helps the athlete to achieve a speedy recovery and smoothly transition from training to competition. When adolescent athletes return to competition, they are usually substituted into the middle of the soccer game for a short duration. This tactic, from gradual/partial participation to full return in competition, is commonly used in soccer, especially at the youth level.

Lastly, another novel part of the current study was a comparison of simple apophysitis and apophyseal avulsion fracture. Apophyseal injuries have not been systematically

classified in the literature. Therefore, we classified apophyseal injuries into 2 groups: simple apophysitis and apophyseal avulsion fractures. It had been anecdotally theorized, but our data confirmed that athletes with apophyseal avulsion fracture injuries take longer to RTS in both training and competition (Figure 4A). This evidence is crucial for adolescent players since the elite soccer academy setting often prefers as little time loss as possible from adolescent players. Our findings emphasize the importance of providing adequate rest to adolescent players. Regular follow-up evaluations with close communication with the injured players, coaches, and other personnel (eg, team physicians, physical therapists, and fitness specialists) would facilitate safe return to play, reduce the likelihood of missing training, and help avoid reinjury.

Limitations

There are several limitations in our study. One of major limitations is that the current data were collected in 1 soccer club. For future studies, multiclub and multicenter approaches would help the generalizability of the current findings. Also, the current results may not be generally applicable to young soccer players since the data were collected by an elite soccer academy. Finally, the current data consisted of only male soccer players. Future studies need to include a female population as well as other sports. Although apophyseal injuries are unique in young athletes, a specific diagnostic algorithm is required and must be validated by a prospective longitudinal cohort, in order to ascertain whether early diagnosis could prevent young athletes from sustaining reinjury. Furthermore, future studies should investigate possible structural and functional risk factors. The diagnostic value of US for apophyseal injuries among young players requires further prospective investigation to determine its sensitivity and predictive value for these injuries.

CONCLUSION

Our 7 years of data identified that an apophysitis injury happens as a rate of 0.35 per 1000 hours of exposure among male, young, and elite soccer players. Also, our results indicated that the AIIS was the most common apophyseal injury location. Moreover, the apophyseal injury locations influence RTS. Finally, our study confirmed that athletes with apophyseal avulsion fractures take longer to RTS in both training and competitions than simple apophyseal injuries. Apophyseal injuries are unique in the physically active population, which still has a few more years of growth remaining. Therefore, more studies are necessary to identify the long-term effects, including for female and a variety of other athletes.

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