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Research Article

Incidence and Imaging Patterns of Growth Plate Injuries in Pediatric Athletes

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ABSTRACT

Background: Injuries to the growth plate are frequent among young athletes and they are typically accompanied by vague signs on imaging studies. Being aware of how these injuries are different in the upper and lower limbs serves to sharpen the diagnostic process and subsequently enhances the approach taken to manage these injuries.

Objective: To assess the incidence and imaging patterns of growth plate injuries in pediatric athletes and compare clinical, radiological, and recovery profiles between upper- and lower-limb injuries.

Methods: Between October 2024 and October 2025,at Timergara Medical College 72 young sports players with injuries affecting their growth plates were included in this observational study. Data were collected from clinical examinations, from X-ray images, from MRIs, and from ultrasounds. Outcomes of treatment and outcomes of injuries were classified using the Salter-Harris system and management outcomes of injuries within the upper and lower limbs were compared using appropriate statistical analyses.

Results: Injuries to the upper limb were most frequently associated with the distal radius and had heightened rates of metaphyseal fracture lines, while injuries to the lower limb were associated with the distal tibia and distal femurs. XRays demonstrated lower limb injuries as having significantly increased garnered regions of cartilage disruption ($p = 0.02$) injuries to lower limb the (0.02). Return-to-sport time was longer in lower-limb injuries (7.9 vs 6.9 weeks, $p = 0.03$), and complications were more common in weight-bearing joints.

Conclusion: Growth plate injuries differ markedly between limb regions, with lower-limb injuries showing greater cartilage involvement and prolonged recovery. Awareness of these patterns can strengthen early diagnosis and guide safer return-to-sport decisions for young athletes.

Keywords: Growth plate injury, pediatric athletes, Salter–Harris, X-ray, MRI, return-to-sport, physeal fracture.

INTRODUCTION

Injuries to the growth plate of the bone form an important part of the trauma suffered to the musculoskeletal system among children, especially those children involved in organized competitive sports. The injuries suffered at the microstructural level of the physis, and the trauma sustained from sports injuries, are becoming increasingly common due to the expanding competitive athletic participation among children. The growth plate is more susceptible to acute trauma and overuse injuries as they are histologically and structurally weaker than the surrounding bone and ligaments. Settlement and overuse injuries are especially important to identify and manage appropriately, as unrecognized injuries to the growth plate may lead to growth abnormalities, angular malalignment, or loss of function in the growing child [1-4].

Radiology is a key player in assessing the aforementioned injuries within this domain. Although plain radiographs are indeed the first step in this process, initial findings like physeal widening or early metaphyseal lines are indicative of the need for further investigation. MRI is the modality of choice to appreciate the cartilage, bone marrow edema, early changes of stress reaction, and other findings that prove to be very helpful in diagnosing such conditions. Ultrasounds detailing superficial physeal irregularities are particularly helpful in young children. Since the upper and lower extremities in children's sports are subjected to different forces, it is important to know how these imaging features differ in the various regions of the limbs [5-7].

Prior research outlines frequently occurring locations and types of physeal injury, but very few research studies have examined differences in involvement of the upper versus lower limbs among pediatric athletes. This differentiation is clinically relevant as upper limb injuries occur due to falls and impact, while lower limb injuries occur due to weight-bearing, high impact, and rapid movements such as running, pivoting, and jumping.Differences in biomechanics may influence imaging findings, severity, and recovery time [8-10].

The purpose of this study is to assess the growth plate injuries incurred by child athletes, concerning the frequency, imaging features, and sequelae of these injuries. Understanding the injury pattern and behavior across specific regions of the limb will help reach a more accurate diagnosis, develop better management plans, and help in outlining safe return to sport protocols for these young athletes.

METHODOLOGY

This research focused on conducting observational cross-sectional studies to determine the prevalence and imaging features of injuries of the growth plates in children and young athletes, Timergara Medical College

Between October 2024 and October 2025, we performed a one year longitudinal cohort study involving 72 pediatric athletes who consecutively presented with clinical symptoms of a physeal injury. Those athletes who presented with sports-related trauma or overuse injuries, and who were aged 5 to 16 years, were included in this study. Cases that had prior fractures at the same anatomical site, chronic disorders of the muskuloskeletal system, chronic disorders of the bones, or incomplete imaging studies were eliminated from the analysis for the purposes of diagnostic clarity.

Every participating subject was evaluated clinically by an orthopedic expert, who carried out a uniform clinical examination, which focused on the participant's medical history, injury mechanism, sport, and symptom duration, and injury history. For all patients, we computerized radiographs

and, if the radiographs were inconclusive or if we suspected a soft tissue injury, we completed an MRI evaluation. Ultrasound was employed selectively to evaluate superficial physeal irregularities and peri-physeal swelling of soft tissue. For the study, two radiologists with experience in the area interpreted the results independently, and in the case of differences in their conclusion, they reconciled their opinions together.

The Salter-Harris system was utilized to categorize the injuries, while staff recorded limb dominance, injury site, and soft-tissue changes. The attending orthopedic surgeon determined if treatment was to be conservative or surgical based on the factors of displacement, joint involvement, and functional limitation. The participants were counseled until the radiological union and the duration to return to the sport was recorded in weeks. Study participants were evaluated using standard statistical techniques and comparisons were made between the upper and lower limb injuries while keeping the significance level at p below 0.05.

RESULTS

Both the upper and lower limb groups had no significant demographic difference as they were comparable on age and sex. The mechanism of trauma was also comparable in most respects as both groups demonstrated an acute injury pattern. Even though there was a higher occurrence of overuse injuries in the lower limbs, this difference was not statistically significant.

Table 1. Distribution of Injury Location and Mechanism (n = 72)

Variable	Upper Limb (n=39)	Lower Limb (n=33)	p-value
Mean age (years)	12.1 ± 3.0	12.8 ± 3.2	0.28
Gender (Male)	24 (61.5%)	22 (66.7%)	0.63
Mechanism: Acute trauma	24 (61.5%)	17 (51.5%)	0.37
Mechanism: Overuse	9 (23.1%)	13 (39.4%)	0.12
Mechanism: Fall/Twist	6 (15.4%)	3 (9.1%)	0.41

There was a strong association overall with upper limb injuries involving the distal radius and proximal humerus and in the lower limb injuries this predominated with the distal tibia and distal femur. There was a statistically significant difference in these anatomical distributions for all the categories of bone. This pattern mirrors the naturally occurring distribution of growth plate stress across various sporting movements.

Table 2. Bone-Specific Injury Distribution (Upper vs Lower Limb)

Bone Involved	Upper Limb (n=39)	Lower Limb (n=33)	p-value
Distal radius	22 (56.4%)	0	<0.001
Proximal humerus	9 (23.1%)	0	<0.001
Distal tibia	0	18 (54.5%)	<0.001
Distal femur	0	12 (36.4%)	<0.001
Proximal tibia	0	7 (21.2%)	<0.001

Injuries to the upper limbs exhibited greater incidence of metaphyseal fracture lines as revealed by X-ray. While injuries to the lower limbs showed significantly greater disruption of the cartilage based on the MRI results. Already noted was that lower limb injuries had slightly greater incidence of bone marrow edema, although the finding was not statistically significant. Overall, the imaging findings highlight different stress and loading patterns in upper versus lower limb injuries.

Table 3. Imaging Findings (Upper vs Lower Limb)

Finding	Upper Limb (n=39)	Lower Limb (n=33)	p-value
X-ray: Physeal widening	13 (33.3%)	15 (45.5%)	0.29
X-ray: Metaphyseal line	17 (43.6%)	7 (21.2%)	0.04
MRI: Bone marrow edema	17 (43.6%)	19 (57.6%)	0.22
MRI: Cartilage disruption	7 (17.9%)	14 (42.4%)	0.02
MRI: Physeal irregularity	12 (30.8%)	15 (45.5%)	0.19
Ultrasound: Soft-tissue swelling	16 (41.0%)	17 (51.5%)	0.37

Salter-Harris Type II remained the most common patterns in both limb groups and was in line with the overall pediatric trauma trends. Compared to the upper limb, the lower limb was found to have a bit more Type III and Type IV injuries, but the differences were not statistically significant. This overall pattern suggests that injury severity is broadly similar in both limb regions.

Table 4. Salter–Harris Classification by Limb (n = 72)

Type	Upper Limb (n=39)	Lower Limb (n=33)	p-value
Type I	13 (33.3%)	6 (18.2%)	0.14
Type II	17 (43.6%)	11 (33.3%)	0.36
Type III	4 (10.3%)	9 (27.3%)	0.06
Type IV	3 (7.7%)	6 (18.2%)	0.19
Type V	2 (5.1%)	1 (3.0%)	0.66

Most of the children in both groups were treated through a conservative approach, demonstrating that injuries to the growth plate tend to have a favorable prognosis with non-invasive treatment. Injuries to the lower limbs took a longer time and were of greater significance to the return of the child to the practive of the sport. Complications were more frequent in lower limbs, reflecting the importance of monitoring weight-bearing joints during healing.

Table 5. Treatment and Outcomes (Upper vs Lower Limb)

Outcome	Upper Limb (n=39)	Lower Limb (n=33)	p-value
Conservative treatment	33 (84.6%)	24 (72.7%)	0.22
Surgical treatment	6 (15.4%)	9 (27.3%)	0.22
Return-to-sport (weeks)	6.9 ± 1.9	7.9 ± 2.2	0.03
Complications present	4 (10.3%)	9 (27.3%)	0.05

Figure 1 shows the comparison of mean return-to-sport time between upper- and lower-limb growth plate injuries among pediatric athletes (n = 72).

Lower-limb injuries required a longer recovery period (7.9 weeks) compared with upper-limb injuries (6.9 weeks), reflecting higher biomechanical load and delayed functional recovery in weight-bearing joints. The difference was statistically significant ($p = 0.03$).

DISCUSSION

This study examined growth plate injuries among pediatric athletes over a one-year period and compared how upper- and lower-limb injuries differ in their clinical and imaging patterns. The findings show that although both groups experienced similar mechanisms of trauma, the anatomical distribution of fractures followed predictable sports-related patterns. Injuries to the arms were most often related to the distal radius and proximal humerus, likely caused by the common fall-on-hand patterns associated field sports. On the other hand, injuries related to the legs often involved the distal tibia and distal femur, which is probably the result of the significant impact and weight bearing forces observed during running and jumping activities [10-12].

The two groups showed a significance disparity in the results from the imaging as well. The finding of upper limb injuries reported the greatest numbers of

metaphyseal fracture line occurrences further confirming previous studies as the proximal wrist and proximal humerus growth plate have been identified as highly susceptible to the effects of anterior-posterior shear forces. Lower limb injuries showed greater signs of cartilage disruption on MRIs. This parallels the pediatric sports medicine literature that suggests the ankle and knee physes experience greater compressive stress during pivoting and landing activities. [13-15].

Type II injuries were the most abundant in both extremities when examined through the lens of the Salter-Harris classification system. This finding is consistent with the results in larger pediatric trauma collections. Type III and IV injuries may be present in minor excess within the lower limbs although the difference is not statistically meaningful. Nonetheless, the distribution is consistent with higher rates of intra-articular lesions observed in knees and ankles in traumatized child athletes. These injuries require careful evaluation because they have greater potential to disturb the mechanical axis of the lower limb, particularly during active growth years [16-18].

There was also some analysis of outcome results with treatment concerning differences. Most of them were still undergoing full conservative management, but the children with the lower-limb injuries had substantially longer time intervals before the returning to sport, due to the greater functional demands and weight-bearing issues with those joints. There was also a higher complication rate in the lower limb group, which coincides with previous results which show that physeal injury around the tibia and the distal femur have a significantly higher risk of developing premature physeal closure or an angular deformity. Thus, the importance of diligent follow-up, especially in the lower-limb growth plate injury children who also engage in high-impact sports, is evident from these results [19, 20].

To sum up, these findings are relevant to previous work and continue to enhance the local knowledge of the epidemiology and behaviour of physeal injuries in active children. Comparing different groups of limbs helps strengthen comprehension of how anatomical site, weight-bearing, and the specific stresses of certain sporting activities affect the severity and recovery of injury.

CONCLUSION

Growth plate injuries in pediatric athletes show distinct anatomical and imaging patterns between upper and lower limbs. Lower-limb injuries demonstrate more cartilage involvement, longer recovery, and a higher complication tendency, highlighting the importance of close radiological and clinical monitoring. Recognizing these differences supports more accurate diagnosis, timely management, and safer return-to-sport decisions for young athletes.

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