Upper Extremity Injuries in Field Athletes: Targeting Injury Prevention


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Abstract

Track and field is one of the most widely practiced sports amongst young athletes throughout the world with athletes participating since the ancient Olympic games. Despite this, there has not been much research on upper extremity injuries in the field thrower. Relevant articles published using the search terms track and field, javelin, discus, shot put, hammer throw and upper extremity injuries were identified using PubMed. Various studies report upper extremity injury rates amongst athletes from 1-10%. Cases of penetrating neurovascular injury from javelin have been reported. UCL injuries of the elbow can be reconstructed similar to baseball players with return to play rates ~90%. Small case series of wrist and hand injuries such as distal radial physical arrest, extensor retinacular impingement, carpal tunnel syndrome and TFCC injuries are present in the literature, however the most common injuries reported were blisters and small lacerations. Track and field athletes have a propensity for overuse injuries of the upper extremity. Based on evidence provided in other throwing sports, monitoring of the athlete’s overall conditioning including core strength, training intensity and volume of throws, and technique is crucial for injury prevention.

ABBREVIATIONS

AC: Acromioclavicular; SC: Sternoclavicular; EMG: Electromyography; UCL: Ulnar Collateral Ligament; MRI: Magnetic Resonance Imaging

INTRODUCTION

Athletic field competitions have origins dating back to the ancient Olympic games. Many modern track and field events have roots to the 13th century Scottish Highland Games. Indeed, past events like the “stone throw” have played a role into what is now known as the shot put, whereas the “blacksmith’s hammer toss” has become the modern hammer throw [1]. Despite the sports’ long history, there is a paucity of information on the injuries they produce. The purpose of this review is to document the current knowledge regarding path mechanics and upper extremity injury patterns in field throwing sports. Our goal is to identify common injury patterns in the upper extremity and potential targets for injury prevention as it pertains to specific field events, or a knowledge gap which may lead to future research on the prevention of upper extremity injuries sustained during throwing field events.

Etiology & Epidemiology

All throwers, regardless of the event, share common fundamentals of the kinetic chain. The forces used to throw a discus, shot put, hammer, or javelin begin with the ground reaction forces that are transferred up the lower extremities, through the core and torso, across the scapula, shoulder and elbow, and ultimately the hand. An injury at any link along the kinetic chain will lead to abnormally increased forces and predispose the athlete to injuries further distal along the kinetic chain [2].

Overall, track and field athletes appear to sustain a lower rate of upper extremity injuries as compared to other sports. For instance, a study by Sallis et al looking at injuries amongst 100 athletes in various sports found a rate of 1.2 hand and wrist injuries and 1.81 shoulder injuries amongst men per 100 track and field athletes. This compares to 12.18 hand and wrist injuries per 100 collegiate men playing basketball, and 7.22 shoulder injuries per 100 male tennis players [3]. Yang et al, however, noted that male track and field athletes suffer amongst the highest rates of overuse injuries of all college sports at 10.4% of study participants [4]. This apparent disconnect with Sallis’ study can be explained by the predominance of chronic injuries occurring in the lower extremity; however, this finding also suggests that further research is needed into how injuries along the kinetic chain may impact overuse and acute injuries of the upper extremity.

There are a handful of studies focusing on track and field athletes in particular. According to a study of 48 high school field athletes over three years, the participants sustained 19 acute injuries and 52 injuries of gradual onset, with some athletes sustaining repeat injuries [5]. Between 75-98% of these injuries occurred during training sessions rather than competition [6]. In a study of 278 elite Swedish track and field athletes, Jacobsson et al found that most injuries involved muscular strains of the lower extremities, as often as 35% of the time over a one-year period. If untreated these injuries will increase the risk of upper extremity injuries [7]. D’Souza’s study reviewed 21 track and field throwing athletes and found a 61.9% rate of injury, with nearly a quarter of those injuries occurring in the upper extremities [8].

**Kinetic Chain**

The sequence of events in the standard throwing motion differ slightly from the throws required for hammer throw and discus, which involve several spins towards the front of a throwing circle before transferring kinetic energy from the lower extremities to the discus or hammer. These differ from the throw for shot put, which entails either two backward steps followed by a spin and release, or a series of spins followed by extension of the elbow, shoulder, and release of the shot put [9]. The twisting and ballistic nature of these throwing events can place large torques and axial loads across the glenohumeral joint and can predispose to injury within the shoulder as well as further distal in the kinetic chain.

Unlike other field throwing events, there is a fair amount of literature on javelin throwing biomechanics. [10-12]. The javelin throw involves 4 phases: approach run, cross steps, delivery stride and the thrust phase [10, 12]. Javelin throw begins with the javelin in the palm of the hand, horizontal to the ground over the throwing shoulder with the elbow flexed to approximately 90 degrees and the forearm supinated. Additional variation from traditional throwing occurs as there are 3 different types of javelin grips which include American, Finnish and fork style. The athlete will begin running with their hips square to the direction in which they are throwing. With the final two strides, the contra lateral leg should be forward while the throwing arm is extended at the elbow and the javelin held at shoulder height. This elbow extension allows for maximum acceleration and therefore throwing distance. During the thrust phase (final foot strike to release) the elbow will flex from 40 degrees to 60 degrees (high level athletes) and this places angular velocities of up to 1900 degrees per second on the elbow.

**Shoulder**

Javelin, hammer toss, discus, and shot put place axial, translational and distraction forces across the glenohumeral, Acromioclavicular (AC), and Sternoclavicular (SC) joints. This can lead to overuse injuries such as muscle strains, degenerative joint disease, ligament sprains, instability, and occasionally more acute injuries such as dislocation. Moreover, the strength training regimen required for these events also places athletes at risk for injury to the aforementioned joints [7].

The stresses and torques required for javelin throwing are generated through the lower body and is progressively transferred to the arm. Initially, a stride is converted into pelvic rotation, which leads to rotation of the torso, shoulder internal rotation, elbow extension, and wrist flexion and pronation [2]. Along various points in the kinetic chain, the dynamic and static stabilizers are subject to large stresses and torques, which can lead to chronic and acute injuries of the stabilizing structures. Dysfunction of the shoulder girdle muscles, such as in scapular winging, can affect motion of the shoulder as well as throwing velocity, and can cause the micro trauma seen in rotator cuff disease [13, 14].

Shoulder injuries in collegiate javelin throwers have been reported in up to 29% of athletes [3]. In javelin there is not as much motion at the elbow compared to traditional throwing sports, with the bulk of the motion occurring at the shoulder, the torso and the lumbar spine [11]. Javelin throwers demonstrate signs similar to chronic impingement, such as an inflammatory thickening of the structures above the humeral head, which decreases the clearance of the humeral head. The affected structures include the rotator cuff, biceps tendon, and subacromial bursa. Posterior capsulitis and capsular rents can also be seen in javelin throwers [15, 16]. Posterior rotator cuff muscles such as the teres minor and infraspinatus can become strained, especially as they restrict anterior translation of the humerus during follow through. The posterior capsule can become impinged between the humeral head and glenoid during the thrust phase of the throwing motion, which can lead to chronic micro trauma and scarring, posterior shoulder pain, and pain with internal rotation. EMG activity from javelin throwers demonstrates an increased activity in posterior rotator cuff and deltoid muscles, which supports the theory of internal impingement present in these athletes [17]. Scapulothoracic injuries can occur due to eccentric loading of the scapula stabilizers during the follow through phase, which typically occur at the musculotendinous junction of the medial scapular border [18].

Neurovascular injuries can also occur from the javelin, however typically not to the thrower. There are instances of piercing injuries to the shoulder from a javelin throw, with the sub clavian artery beneath the ducilece at risk [19]. Damage to the sub clavian artery has been shown to cause significant bleeding, hemothorax, and decreased blood flow to the arm. A detailed neurovascular exam should be performed for any penetrating injury to the shoulder or chest due to a javelin, as the brachial plexus lies anteriorly to the sub clavian artery. A summary of the common shoulder pathologies can be found in (Table 1).

**Elbow**

Similar to the shoulder, during training and competition in field sports the elbow is subjected to potential pathologic repetitive loads which can lead to injury. The elbow is the next step along the kinetic chain after the shoulder and any mechanical abnormality proximal in the kinetic chain can lead to overuse and injury at the elbow [2,13,14]. Like the shoulder the actual forces across the elbow joint depend on the event. The hammer throw tends to be a distraction force across the elbow forcing the elbow into full extension risking posterior impingement of the olecranon [20]. The shot put is primarily an axial load through the elbow joint as the triceps forcefully fires to achieve full extension. These compressive loads can lead to osteochondral injuries, either at the radio capitellar or ulnohumeral joint. The forced extension can lead to posterior impingement of the
Table 1: Injury breakdown based on field event and body part.

<table>
<thead>
<tr>
<th>Body Part</th>
<th>Injury</th>
<th>Sport</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC Joint</td>
<td>Osteolysis and Instability</td>
<td>Javelin, Hammer toss, Discus, Shot put</td>
</tr>
<tr>
<td>Glenohumeral Joint</td>
<td>Chronic glenohumeral internal impingement, SLAP tears, Posterior capsulitis, capsular rents, Posterior rotator cuff strains, Scapulothoracic injuries</td>
<td>Javelin</td>
</tr>
<tr>
<td>Glenohumeral Joint</td>
<td>Chronic rotator cuff tendinopathy</td>
<td>Hammer toss, Discus, Shot put</td>
</tr>
<tr>
<td>Humerus</td>
<td>Fracture</td>
<td>Shot put</td>
</tr>
<tr>
<td>Elbow</td>
<td>UCL tear, Ulnar neuritis, Medial epicondylitis, Medial elbow instability, Posterior impingement, Olecranon stress fracture</td>
<td>Javelin</td>
</tr>
<tr>
<td>Elbow</td>
<td>Posterior impingement</td>
<td>Hammer toss</td>
</tr>
<tr>
<td>Elbow</td>
<td>Osteochondral injuries</td>
<td>Shot put</td>
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<tr>
<td>Radius</td>
<td>Distal physeal growth arrest</td>
<td>Javelin</td>
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<tr>
<td>Wrist</td>
<td>DeQuervain’s tenosynovitis, TFCC injuries</td>
<td>Hammer Toss</td>
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<tr>
<td>Wrist</td>
<td>Carpal tunnel syndrome, Extensor retinacular impingement</td>
<td>Shot Put</td>
</tr>
<tr>
<td>Carpus</td>
<td>Scaphoid nonunion</td>
<td>Javelin</td>
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<tr>
<td>Fingers</td>
<td>Dislocation</td>
<td>Hammer toss</td>
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**Abbreviations:** AC: Acromioclavicular; SLAP: Superior Labrum from Anterior to Posterior; UCL: Ulnar Collateral Ligament; TFCC: Triangular Fibrocartilage Complex.

Olecranon or overuse tendinopathy of the triceps [8]. The javelin, while slightly non-traditional in throwing motion, places the elbow at risk of valgus extension overload similar to traditional throwing sports. Inherent to valgus extension overload of the elbow there is an associated risk of traction injury to the medial ulnar collateral ligament, as well as axial injury of the capitellum and radial head, and posterior impingement with full extension [21]. There is limited evidence based literature which correlates elbow biomechanics of field events with clinical injury. Most clinicians extrapolate the available literature on other throwing sports to the care of shot put, discus, and hammer throw athletes. There have been two case reports of humerus fractures occurring in shot put athletes; one treated conservatively in a cast and the other underwent an open reduction internal fixation, with each going onto union [22,23]. There are few biomechanical studies that evaluate the throwing motions involved in shot put and discus, but there is no discussion on the cause of these specific injuries or ways to prevent them [24,25]. McLennan et al. performed a survey of participants in Scottish heavy athletics, and found a 13% injury rate in the Scottish heavy athletic sport of stone throw, a predecessor of shot put [26]. Although most upper extremity javelin injuries occur in the shoulder, there are several case series demonstrating elbow injuries. In elite athletes, 70% of javelin release speed is developed in the last tenth of a second before release [10,11]. This puts a significant valgus force on the medial side of the elbow, and repetitive use can lead to failure of the ulnar collateral ligament (UCL) and valgus extension overload. The first reported UCL injury was reported in javelin throwers in 1946 [27]. Dines et al reviewed 10 javelin throwing athletes who underwent UCL reconstruction using the docking technique [11]. They obtained excellent outcomes based on the Conway scale in 9 out of 10 athletes, and found the average return to previous level of competition was 15 months. Athletes with UCL injury can expect a similar timeframe for recovery after surgical reconstruction. In addition to UCL tears, javelin throwers occasionally have symptoms of ulnar neuritis related to attenuation of the UCL [11]. There have been several reports of olecranon stress fractures occurring in javelin throwers [27, 28]. Lavallee et al reported a case of an elbow dislocation in a javelin thrower but failed to provide any further details regarding the case [29]. There is limited data on long-term outcomes in career javelin throwers. Schmitt et al evaluated 21 elite level (including a gold medalist and former world record holders) athletes via clinical, radiographic and magnetic resonance imaging (MRI) studies with an average of 19 year follow-up [18]. Sixteen of these patients had medial epicondylitis and one had gross medial elbow instability. Ten patients (48%) had a deficit in extension of greater than 5 degrees and four patients (19%) were unable to flex the elbow greater than 120 degrees. They found the loss of extension to correlate with the duration of high performance (p<0.03) and training with weights of more than 3 kg (p=0.08). No patients were found to have a deficit in pronation or supination. All dominant elbows showed increased radiographic degenerative changes when compared to the non-dominant side and joint space narrowing was more frequently seen in patients who trained with weights greater than 3 kg (p=0.07). A summary of the common elbow pathologies can be found in (Table 1).

**Wrist and Hand**

The terminus of the kinetic chain in all throwing athletes is the hand and wrist. Forces generated via the kinetic chain culminate at the wrist and hand to transfer energy to the object being thrown. Since the weight of the shot put, javelin, discus, and hammer vary, the actual energy delivered to the object will vary. Indeed, the gripping mechanism and biomechanics of delivery also play a key role in how the energy is transferred across the wrist and hand. For example, the javelin is held with multiple grips, but all have a circular grip in common with the primary load across the wrist being radial to ulnar. The shot put is held deep in the hand leading to wrist and finger extension during cocking and acceleration phases. The hammer and discus will create distraction loads across the wrist but the fingers maintain a flexed position until release. Field events in general appear to have a very low rate of hand and wrist injury as compared to the shoulder and elbow [30]. One survey reviewed 147 track and field athletes finding no hand and wrist injuries at all [8]. What is not clear is whether this demonstrates an actual reduced injury risk or, more likely, a paucity of literature or reporting on hand and wrist injuries in field athletes.

Walaszek reported a remote history of one asymptomatic scaphoid nonunion in a competitive adult javelin thrower in Europe [31]. The patient was previously treated non operatively with immobilization for 2 months. He returned to his level
previous play, winning a national championship for Javelin throwing. His grip strength was 98% of the contra lateral side. De Smet et al described a case of distal radial physeal arrest in a 14 year old female who had trained in javelin throwing for 2 years [32]. The arrest resulted in 5mm ulnar positive variance, decreased inclination of the radius, and a radical shift of the carpus, all which can alter the load distribution across the wrist joint and lead to chronic injuries. This patient was asymptomatic and no operative treatment was needed. More commonly fingertip lacerations and blisters can occur due to abrasion between the athlete’s hand and the grip cord at release [33]. These injuries can typically be prevented by limiting the number of practice throws, as they are exacerbated by fatigue.

Amongst hammer throw athletes, Lalavee et al., suggested several potential injury patterns leading to DeQuervain’s tenosynovitis and triangular fibro cartilage complex (TFCC) injuries [29]. These athletes are also susceptible to finger dislocations and sprains [34]. In addition, they are susceptible to blisters, an injury which can be prevented by wearing gloves or taping the fingers. Care must be taken to not inadvertently disqualify the athlete through the use of tape, and therefore it is advisable to have it inspected prior to competition [33]. Unfortunately, there is very little literature describing these injuries in further detail.

Shot put athletes are susceptible to carpal tunnel syndrome due to repetitive gripping, a claim supported by Banks et al, [35]. Additionally, shot put athletes are particularly susceptible to wrist and hand sprains due to the weight of the shot and the wrist extension required to throw [36]. Early in the season most athletes hold the shot deep in their hand, making them more prone to wrist sprains. As the season progresses and balance improves, most hold and propel the shot from their fingertips, placing them at risk of volar plate injury, collateral ligament sprain or tear, and intrinsic hand muscle strains. Van Heest et al, reported one case of extensor retinaculum impingement in a shot putter due to repeated wrist extension in their series of eight wrists [37]. The athlete noted pain while holding the shot put with the wrist in extension. On exam, he had tenderness to palpation over the distal retinaculum, aggravated by extension. A trial of anti-inflammatory medications and rest or a corticosteroid injection was recommended for extensor retinaculum impingement. In this case, however, the athlete still had pain in competition after conservative measures were undertaken, and was therefore treated with distal retinaculum excision. The athlete returned to competition, winning a conference championship at the collegiate level.

As with other field throwing events, the most common injury amongst discus throwers is blistering or lacerations of the fingers. Most are superficial, but care must be taken to make sure no flexor tendon, digital artery or nerve is injured. Discus athletes are prone to wrist sprains and de Quervain’s tenosynovitis, particularly if wrist snap at time of release is overemphasized. A summary of the common hand and wrist pathologies can be found in (Table 1).

Targeting Injury Prevention & Discussion

Based on the van Mechelen model of injury prevention, one must first identify the problem through a study of epidemiology and biomechanics [21]. Once the problem has been identified, then a prevention program can be instituted which targets the injury risk. Ultimately, one must review the impact of each intervention by re-assessing outcomes and alterations in injury patterns based on the intervention. Regarding throwing athletes in field sports, some foundational epidemiology is available but significant data collection through prospectively designed research would be necessary to assure an effective impact of intervention. What we do know is that the intervention will need to be sports specific and will likely focus on the kinetic chain mechanics. Modeling after other sports such as baseball would suggest that pre-participation evaluation of kinetic chain function will be a key component, although the throwing styles in field events differ compared to baseball. This may be especially true for track and field, as many of these athletes participate in multiple events (i.e. decathletes). Many of the non-throwing events in the track and field arena predispose athletes to lower extremity injury. While the specifics of the lower extremity injuries in track and field athletes is beyond the scope of this article, preventing lower extremity injuries is critical in maintaining a healthy kinetic chain from top to bottom. Assessment of core function via single leg squats and scapular function via pre-participation side-to-side comparison would be a good start.

Injury patterns in younger or less elite field athletes may be associated with poor mechanics. It is clear in other sports that altered throwing mechanics along the kinetic chain will increase the load at subsequent segments increasing the risk of injury. Trunk-Scapular kinesis and proper form is imperative to prevention of valgus overload and MCL injuries at the elbow. Throwing sports where the MCL is at risk should focus on both flexor-pronator strengthening and throwing mechanics. As always, young field athletes should be evaluated by quality coaches to assure proper techniques. Finally, as in most sports, the most common injuries in field athletes can be correlated to repetitive overuse. It is recommended to avoid throwing weights in javelin training more than 3 kg, and to incorporate preventive practices into training, such as throwing with lighter weights or elastic bands to increase power in the thrust phase. Monitoring training intensity and the number of throws, especially in skeletally immature athletes is essential. Younger athletes with an open proximal humerusphyseal can demonstrate remodeling to allow increased external rotation in the shoulder. This can lead to internal rotation deficits and posterior capsular impingement. As such, programs emphasizing posterior capsular stretching are important for prevention of glenohumeral injuries. Bilateral arcs of motion of the glenohumeral joint should be monitored to screen for rotation deficits and strengthening of the scapular stabilizers is important for any throwing program as well.

The best method of prevention of wrist injuries amongst shot putters consists of wrist strengthening programs, taping, and strict attention to proper technique including the avoidance of wrist hyperextension. Likewise, finger injuries are best prevented by good technique and avoiding premature progression to fingertip push-off or other advanced maneuvers [36]. Blisters and lacerations can be avoided with glove or tape use, but should be carefully inspected to prevent risk of disqualification from competition. Similarly, discus throwers are also subject to blisters and finger lacerations. Such lacerations can be best prevented.
through proper care of the discus itself, ensuring that all spurs on the metallic surface are filed immediately. In wet conditions, compounds to improve grip on the discus, such as tincture of benzoin, can also be helpful. Additionally, wrist sprains and overuse tendonopathies such as de Quervain’s tenosynovitis are common in discus throwers. As with other overuse injuries, these are best prevented through attention to form and avoidance of fatigue [36-38].

CONCLUSION

While field athletes including shot putters, javelin, hammer, and discus throwers, place their upper extremities at risk of overuse injuries, there is surprisingly limited literature available to be serve as a foundation for injury prevention plans. The most commonly described injury is the UCL tear in javelin throwers, which is successfully treated with ligament reconstruction; however, the most common body part involved in most field throwers is the shoulder. Based on evidence provided in other throwing sports, it is appropriate to begin injury prevention for field throwers with a focus on optimizing technique and the kinetic chain as well as avoiding overuse by monitoring the number of repetitions. More high level studies are needed to improve our understanding of both the epidemiology and pathomechanics of injury patterns in field sports. This knowledge will be an important foundation to establish injury prevention programs in the future.

CONFLICT OF INTEREST

Mark Hutchison: AAOS: Board or committee member, Am J Sports Med: Editorial or governing board, American Board of Orthopaedic Surgery, Inc.: Board or committee member, American College of Sports Medicine: Board or committee member, American Orthopaedic Society for Sports Medicine: Board or committee member, Arthroscopy Association of North America: Board or committee member, Br J Sports Med: Editorial or governing board, Phys & Sports Med: Editorial or governing board

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