A RETURN TO SPORT FUNCTIONAL REHABILITATION PROGRAM FOR THE JAVELIN ATHLETE FOLLOWING ULNAR COLLATERAL LIGAMENT INJURY

A Case Report

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Gina M. Moreno

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APPROVAL SHEET

This case report paper is submitted in partial fulfillment of
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Gina M. Moreno

Approved: May 7th 2014

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Shawn D. Felton, EdD, ATC, LAT
Committee Chair

_____

Eric Shamus, DPT, PhD, CSCS
Committee Member

The final copy of this case report has been examined by the signatories, and we find that both the content and the form meet acceptable presentation standards of scholarly work in the above mentioned discipline.

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Abstract

The following case report discusses a javelin athlete undergoing rehabilitation for an ulnar collateral ligament injury. The ulnar collateral ligament (UCL) of the elbow is a frequently injured structure in the overhead throwing athlete. In critically reviewing the case, the athlete did not go through a sport specific rehabilitation throwing program. A javelin interval throwing program, that has been preliminarily reviewed but requires further research and validation, is compared to a validated baseball interval throwing program. Baseball throwing programs have been utilized and reviewed. The javelin athlete should go through a similar throwing program specific to javelin athletes.

Introduction

The prevalence of injury to the ulnar collateral ligament (UCL) of the elbow in overhead throwing athletes has been clearly documented.[3-13] Serious injury arises to the ligament as a result of the repetitive and forceful valgus strain that is placed on this structure throughout the throwing motion. In fact, research has determined that the overhead throw by an elite athlete can place a load on the UCL which approaches the tensile strength of the ligament.[3,13]

To effectively rehabilitate the throwing athlete following upper extremity injury, an interval throwing program is essential to incorporate into a standard rehabilitation program in order to prevent re-injury. However, unlike the sport of baseball, the sport of javelin did not have a documented return to sport interval throwing program following injury. Due to this finding, the purpose of this case report was to identify and document an interval throwing program for the injured javelin athlete in order to rehabilitate the athlete back to competition level.

Literature Review

The UCL complex is comprised of three ligamentous bundles, the anterior oblique bundle, the posterior oblique bundle, and the transverse oblique bundle. As the elbow is extended, the anterior oblique bundle becomes taut while the posterior oblique bundle gains slack. As the elbow is flexed, the opposite is true. As a complex, the UCL resists valgus, or abduction, force of the proximal ulnar and radius on the distal humerus.[3]

The following is an overview of the Olympic Games' rules set for the sport of javelin and the competitors of the sport. The javelin itself does not have a set required length, but rather can range in length from 2.6 to 2.7 meters for males and 2.2 to 2.3 meters for females. The maximum weight of the javelin is left up to the competitor, as there is no rule for this. However, for males, the minimum weight of the javelin must be at least 800 grams, and for females, it must weigh at

least 600 grams. The grip, which must be made out of cord, is to be placed at the center of mass of the javelin. The javelin must be held at the grip and thrown over the shoulder. The runway ranges from 30 to 36.5 meters in length and measures 4 meters in width. The athlete is not permitted to go outside of the runway during the throw and the must remain within the confines of the runway until the javelin has landed. The athlete is permitted to place as many as two markers within the runway as cues. Spinning upon the approach or prior to the release of the javelin is considered to be illegal. For the throw to be considered legal, the metal tip of the javelin must break the ground. When this rule was implemented, it effectively reduced the throwing distances up to 10%. The javelin must land within a 29 degree sector of the end of the runway for it to be considered a legal throw. Otherwise, it is ruled a foul.[29]

The Early Cocking Stage

In the early cocking stage, the throwing arm will externally rotate to 100 degrees. Herrington states that this degree of external rotation is not uncommon for throwing athletes to exhibit in the dominant extremity.[21] Scapular stabilizing muscles are allowing scapular rotation to maintain joint congruency while providing stability. This is accomplished by a co-contraction of the trapezius and serratus anterior force couple, upwardly rotating the scapula and positioning the glenoid fossa in alignment with the head of the humerus. The serratus anterior also contracts to stabilize the scapula at the scapulothoracic joint against the posterior portion of the ribs to provide increased mobility at the glenohumeral joint. The deltoid and supraspinatus muscles are also co-contracting and working as a force couple to flex and abduct the upper extremity, while maintaining congruency and creating a compression force on the joint to stabilize of the head of the humerus in the glenoid fossa.[7,9,20-21]

The Late Cocking Stage

During the late cocking stage, hip and trunk rotation begin in order to help assist the body transfer its stored energy to the javelin. The humerus is now externally rotated 180 degrees and abducted 90 degrees which creates increased stress on the anterior capsule of the glenohumeral joint. The external rotation is accomplished by the contraction of the teres minor and infraspinatus, which consequently help to decrease the amount of stress on the anterior capsule and labrum of the joint by pulling the head of the humerus posteriorly. Therefore, these muscles need to have sufficient strength and an elite level of endurance to prevent an anterior translation of the head of the humerus on the glenoid fossa and thereby prevent injury.[7,9,20]

During this stage, stresses on the elbow are increasing as the elbow flexes up to 75 degrees. However, the elbow flexor muscles are not especially active at this point, other than the extensor carpi radialis longus and brevis which are very active in preparing the wrist for the throw. The valgus torque that is being produced by the forces of the elbow is largely resisted by the UCL.[7,9,20]

The Acceleration Stage

In the stage of acceleration, the humerus continues to move forward to release the javelin. At the point of release, the humerus quickly rotates internally which generates increased torque and compressive forces at the shoulder and elbow. The elbow undergoes high valgus and extension forces simultaneously. Also, the energy that was being stored in the lower extremities and core musculature, made up of large muscles, is transferred to the javelin through the upper extremity. This is accomplished by the athlete bracing the lower extremities and core musculature, which assists to accelerate the upper extremities. Furthermore, the athlete continues the throw by them bracing the upper body and the throwing upper extremity, which transfers

energy to the forearm, hand, and javelin, thus increasing the velocity of the throw. The only shoulder muscles that are thought to assist in the acceleration of the javelin are the pectoralis major and the latissimus dorsi. The other muscles of the upper extremity are also contracting, but for stabilization rather than the production of momentum.[7,9,20]

Three force couples are contracting during the acceleration stage. These include the posterior deltoid and supraspinatus to provide posterior stability to the humeral head as it internally rotates, the stabilizing pectoralis major and the teres minor which internally rotate and adducts the humerus while preventing it from translating anteriorly, and the upper fibers of the subscapularis and the latissimus dorsi which extend, adduct, and internally rotate the humerus while maintaining the head of the humerus in contact with the glenoid fossa.[7,9,20]

Also during this stage, the pronator teres, flexor carpi radialis, flexor digitorum superficialis, and flexor carpi ulnaris are contracting around the elbow joint in order to stabilize it against the high valgus stress being generated by the throwing motion. In order to maximize the distance of the throw, the athlete will maintain an extended elbow until the final foot strike. This technique enables the athlete to increase the path of acceleration of the javelin. After the final foot strike, the elbow will flex forty degrees while releasing the javelin.[5,7,9,20]

The Deceleration Stage

During the stage of deceleration and follow-through, the throwing arm will end on lateral side of the stride leg. The muscles of the posterior shoulder, especially the teres minor, remain active in order to control the position of the humerus in space during the deceleration of the upper extremity. At this time, the humeral head has a distraction of 80% body weight.[8] The elbow flexor muscles are at their greatest level of contraction during this stage in order to

compress the elbow joint and resist the distraction force pulling the ulna distally away from the humerus, thus forcing the olecranon into the olecranon fossa.[7,9,20]

Injuries

Cain et al. stated that the most common injuries sustained by throwing athletes included UCL "tears, ulnar neuritis, flexor-pronator strain, tear, or tendinitis, medial epicondyle apophysitis or avulsion, valgus extension overload syndrome with olecranon osteophytes, olecranon stress fractures, osteochondritis dissecans of the capitellum, and loose bodies."[4] Miller, stated a common injury sustained by javelin athletes is a tear of the UCL, also termed "javelin throwers' elbow."[10] It is an injury experienced by most javelin athletes and baseball players at some point in their careers. Most therapists relate a UCL tear primarily with baseball athletes, but interestingly, the first reported diagnosis of a UCL tear was made in a javelin thrower.[5]

Although a UCL injury is usually seen in unskilled or untrained athletes, it can develop in an elite athlete as well. The injury is thought to be related to poor technique. Correct technique during the throw is essential, and is the key to preventing UCL injury. If the athlete is unable to maintain the correct throwing technique and the elbow in an elevated position, which can be cause by improper form or fatigue, the athlete is likely to throw it by quickly jerking the upper extremity, putting a greater amount of stress on the elbow. This is also true for the baseball pitcher. Over time, this can result in severe pain and possible ligamentous tearing because the weight of the javelin is supported directly through the UCL.[5,8]

The anterior bundle of the UCL is the primary restraint to valgus movements of the elbow. As stated earlier, the valgus forces produced by a javelin thrower during each throw often reach the tensile strength of the ligament. However, unlike a baseball player whose UCL is stressed by an elbow extension angular velocity, a javelin thrower's UCL is stressed by an elbow

flexion angular velocity. At near full extension and flexion past 120 degrees, the bony articulation of the humerus and ulna assist the ligaments and muscle tissue to resist the stresses placed on the joint. However, throughout the remaining range of motion, the anterior and posterior bands of the UCL are responsible for resisting valgus stress. The posterior band of the UCL is responsible for stabilizing the joint beyond 90 degrees of flexion, whereas the anterior band is responsible prior to 90 degrees of flexion. The repeated stress caused by the throwing motion can cause microtrauma to the ligament and ultimately complete failure of the tissue.[5,11-12,22]

Case Patient

The case patient was a 21 year old female javelin athlete who reported a complaint of a popping sensation and pain over the right ulnar collateral ligament after throwing the javelin. Following an MRI of the right elbow, it was determined that the athlete had sustained a partial thickness tear of the posterior fibers of the ulnar collateral ligament with soft tissue swelling and joint effusion. Although the athlete underwent physical therapy following surgical repair of the UCL, an interval throwing program was not included in her rehabilitation plan of care.

Examination

A thorough examination of the medial portion of the humeroulnar joint is imperative to differentiating between possible diagnoses. Examination of the medial portion of the humeroulnar joint in the patient with UCL injury will present with tenderness to palpation of the anterior band of the UCL. This key quality differentiates UCL pathology from flexor-pronator/medial epicondyle pathology. (Appendix A) The examiner should note any pain or asymmetrical laxity during the valgus stress test of the UCL. Any point tenderness of the medial epicondyle or musculoskeletal junction should be noted, which is indicative of flexor-pronator

strain. The patient should also be assessed for valgus extension overload syndrome of the elbow using the valgus extension snap maneuver as well as palpation of the posteromedial humeroulnar joint for tenderness or osteophyte formation.[3]

The lateral, posterior, and anterior portions of the joint should then assessed for any osteophyte formation, effusion, epicondylitis, instability, fractures, loose bodies, or tendinitis or partial muscular tears.[3]

Evaluations tools that should be utilized to assist the therapist in diagnosing a tear of the UCL include palpation (Appendix B), special tests (Appendix C), and diagnostic imaging, if available. The special tests that can be utilized include the moving valgus stress test, the valgus stress test, the ligamentous valgus instability test, the milking manoeuver, and the stand up test. The types diagnostic imaging that can be utilized to view a tear of the UCL include radiographic imaging, CT scan, MRI, and diagnostic ultrasound. Radiographs usually appear to be normal; however calcification and osteophytes are sometimes visible on the tip of the olecranon.[5,8,23-26]

Intervention

General conservative rehabilitation interventions for the throwing athlete following UCL injury have been well documented. Brotzman & Wilk described a four-phase protocol, which was included in Appendix D.[3]

Rettig et al. researched a non-operative treatment method for UCL injuries. The researchers stated that throwing athletes tend to injure the anterior bundle of the ligament, causing medial elbow pain and difficultly throwing. They found that 42% of the athletes who did not receive surgical intervention returned to their previous level of competition, which is comparable to the percentage of athletes who received surgical treatment and returned to their

previous level of competition. The researchers were not able to find a clinical predictor to predict the success of the non-operative treatment.[11]

The final phase of any rehabilitation program following UCL injury is a return-to-sport program (Appendix E). However, as seen in Appendix E, the interval throwing programs for the javelin athlete versus the baseball athlete vary vastly. The javelin program is designed to progress the athlete from throwing the light-weight baseball a short distance to throwing the competition-weight javelin as far as possible. Comparatively, the baseball program is designed to progress the athlete in order to increase the distance of the throw, the speed of the throw, as well as the athlete's endurance. Furthermore, the baseball program has been researched and critiqued over time to include specific instructions for the athlete and the therapist. The instructions include the step each athlete should begin the program at, which is dependent on the type of injury that was sustained. The javelin program, however, has not been specifically studied and lacks specific instructions.[14]

Comparison of the Javelin Interval Throwing Program to the Baseball Interval Throwing Program

The javelin interval throwing program is similar to that of baseball players' interval throwing program post-UCL repair. The final phase of any rehabilitation program following UCL injury is a return-to-sport program. However the interval throwing programs for the javelin athlete versus the baseball athlete vary vastly. The javelin program is designed to progress the athlete from throwing the light-weight baseball a short distance to throwing the competition-weight javelin as far as possible. Comparatively, the baseball program is designed to progress the athlete in order to increase the distance of the throw, the speed of the throw, as well as the athlete's endurance. Furthermore, the baseball program has been researched and critiqued over time to include

specific instructions for the athlete and the therapist. The instructions include the step each athlete should begin the program at, which is dependent on the type of injury that was sustained. The javelin program, however, has not been specifically studies and lacks specific instructions.

Outcome

The outcome of this case report exposed an important missing component in the rehabilitation of a javelin athlete returning from UCL injury. Unlike in the sport of baseball, even though general rehabilitation was in place, it did not include a return to sport throwing program. The outcome of this case report helped identify the missing component. Future studies need to test the validity of the return to sport throwing program for javelin athletes..[27]

Discussion

Ulnar collateral injuries of the elbow are common in javelin throwers. It is important to have a rehabilitation program that addresses the proper biomechanics and progressive strengthening of the javelin athlete. This case report provides an overview of the biomechanics and a discussion of the progressive strengthening and return to sport interval throwing program that can be followed by the sports medicine professional and incorporated during the return to sport phase of the conservative treatment plan for the javelin athlete recovering from a UCL injury.

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Appendix A

Differentiating UCL Sprain/Tear from Flexor-Pronator Strain/Medial Epicondylitis[3]

UCL strain or tear

- Medial elbow joint pain in a thrower
- Complete tears open on valgus stress testing compared to non-involved side
- Incomplete tears are tender to palpation but will not open with valgus stress testing

Flexor-pronator strain/medial epicondylitis

- Tenderness over the medial epicondyle of the humerus
- Reproduction of pain with resisted wrist flexion
- Reproduction of pain with forearm pronation

Appendix B

Palpation of the Ulnar Collateral Ligament[23]

The ulnar collateral ligament can be palpated by first finding its origin and insertion. The UCL originates at the medical epicondyle of the humerus. The fibers run in a relatively vertical direction and insert on the coronoid process of the ulna and the olecranon process of the humerus. It should be noted that the ligament is deep to the common flexor tendon, but superficial to the ulnar nerve.

To palpate the ligament, the patient's elbow should be flexed. The clinician locates the origin and insertions of the ligament. The clinician then places his/her first phalange between these landmarks and palpates through the soft muscle tissue. The clinician strums his/her thumb back and forth in a medial/lateral direction to palpate the fibers of the UCL.

Appendix C

Physical Therapy Special Tests

Moving valgus stress test

The moving valgus stress test is used to detect chronic ulnar collateral ligament tear of the elbow. The perform the test, the patient is either standing, sitting, or supine with the affected shoulder abducted to 90 degrees and the elbow in 120 degrees of flexion. A valgus torque is then applied at the elbow until the shoulder reaches total available PROM of external rotation. At this point, the examiner quickly extends the elbow. The test is considered to be positive if it reproduces the medial elbow pain between 120 and 70 degrees when the joint if forcibly extended.[24-25]

In their text, Cook & Hegedus determined that the sensitivity of this test is 100 with a specificity of 75, meaning that this test is better at ruling out a diagnosis. However, the authors noted that evidence moderately supports the use of this test in the clinical setting.[24]

Valgus stress test

The valgus stress test is used to detect elbow instability. To perform the test, the patient is in the sitting position. The examiner grasps the patient's affected elbow with one hand and the wrist with the other. The elbow should be fully extended. The examiner applies an abduction or valgus force to the fully extended elbow, while simultaneously palpating the ulnar collateral ligament. The patient's elbow is then passively flexed to 20-30 degrees. Again, the examiner applies the valgus force to the affected elbow while simultaneously palpating the ulnar collateral ligament. The test is considered to be positive if there is a reproduction of pain medially and a compression pain laterally in the elbow joint when the valgus stress is applied.[24]

In their text, Cook & Hegedus explain they were unable to determine the sensitivity or specificity of this test. Furthermore, the authors noted that there is little evidence to support the use of this test in the clinical setting.[24]

Ligamentous valgus instability test

The ligamentous valgus instability test is designed to detect instability in the ulnar collateral ligament of the elbow. To perform the test, the patient is in the sitting position. The examiner grasps the patient's affected elbow with one hand and slightly proximal to the wrist with the other. An abduction or valgus force is placed through the distal hand while the examiner palpated the ligament with the proximal hand. It is suggested that the humerus be is full external rotation when applying the valgus force. The examiner notes any laxity, decreased mobility, or altered pain that may be present in the affected elbow compared to the unaffected elbow.[25]

According to Magee, there have not been any diagnostic accuracy studies performed to determine the sensitivity and specificity of this test.[25]

Milking maneuver

The milking manoeuver is designed to detect a partial tear of the ulnar collateral ligament of the elbow. To perform the test, the patient is in the sitting position with the affected elbow flexed to at least 90 degrees with the forearm fully supinated. The examiner grasps the patient's thumb from the dorsal side with one hand and stabilizes the distal humerus with the other. With the distal hand, the examiner pulls the thumb laterally to inflict a valgus stress on the elbow. The test is considered to be positive if there is a reproduction of symptoms.[25]

According to Magee, there have not been any diagnostic accuracy studies performed to determine the sensitivity and specificity of this test.[25]

Stand up test

The stand up test is designed to detect injury to the posterior band of the ulnar collateral ligament. To perform the test, the patient is seated in a chair without arm rests. The examiner asks the patient to push up on the seat with his/her hands, while maintaining the forearms in the supinated position, to standing. The test is considered to be positive if the patient reports a reproduction of symptoms.[25]

According to Magee, there have not been any diagnostic accuracy studies performed to determine the sensitivity and specificity of this test.[25]

Appendix D

Conservative Treatment Protocol following UCL Injury[3]

Phase 1: Immediate Motion Phase

Goals
- Increase ROM
- Promote healing of UCL
- Inhibit muscular atrophy
- Decrease pain and inflammation

ROM
- Perform AAROM and PROM of elbow and wrist throughout non-painful range

Exercises
- Wrist and elbow isometrics
- Shoulder strengthening in all directions except external rotation

Ice and compression

Phase 2: Intermediate Phase

Goals
- Increase ROM
- Increase strength and endurance
- Decrease pain and inflammation
- Promote joint stability

ROM
- Gradually increase ROM to 0-135 degrees, increasing 10 degrees per week

Isotonic Exercises
- Wrist curls
- Wrist extension
- Pronation/supination
- Biceps/triceps
- Shoulder external/internal rotation
- Supraspinatus
- Rhomboids

Ice and Compression

Phase 3: Advanced Phase

Criteria for Progression to Phase 3
- Full elbow ROM
- No pain or tenderness
- No increase in laxity
- Strength of elbow flexors and extensors

Goals

- Increase strength, power, and endurance
- Increase neuromuscular control

Exercises

- "Thrower's Ten" program (Appendix E)
- Shoulder program
- Biceps/triceps program
- Supination/pronation program
- Wrist extension/flexion program

Phase 4: Return to Sport Phase

Criteria to Progress to Return to Sport Phase

- Full, non-painful ROM
- No increase in joint laxity
- Isokinetic testing fulfills criteria
- Adequate clinical exam

Exercises

- Initiate interval throwing program
- Continue "Thrower's Ten" program
- Continue plyometrics

Appendix E

Table 1. Comparison of Javelin and Baseball Interval Throwing Programs

Javelin Interval Throwing Program (Steve Lemke, BS, e-mail communication, November 13, 2013)		*Baseball Interval Throwing Program*[14]	
- Steps 1 through 6 are performed with a baseball.		- Phase 1: Return to Throwing; All throws are at 50% effort.	
Step 1	A) warm-up throwing B) 45 feet (25 throws) C) rest 10 minutes D) warm-up throwing E) 45 feet (25 throws)	**Step 1**	A) warm-up toss to 60 feet B) 15 throws at 30 feet* C) 15 throws at 30 feet* D) 15 throws at 30 feet E) 20 long tosses to 60 feet
Step 2	A) warm-up throwing B) 45 feet (25 throws) C) rest 10 minutes D) warm-up throwing E) 45 feet (25 throws) F) rest 10 minutes G) warm-up throwing H) 45 feet (25 throws)	**Step 2**	A) warm-up toss to 75 feet B) 15 throws at 45 feet* C) 15 throws at 45 feet* D) 15 throws at 45 feet E) 20 long tosses to 75 feet
Step 3	A) warm-up throwing B) 60 feet (25 throws) C) rest 10 minutes D) warm-up throwing E) 60 feet (25 throws)	**Step 3**	A) warm-up toss to 90 feet B) 15 throws at 60 feet* C) 15 throws at 60 feet* D) 15 throws at 60 feet E) 20 long tosses to 90 feet
Step 4	A) warm-up throwing B) 60 feet (25 throws) C) rest 10 minutes D) warm-up throwing E) 60 feet (25 throws) F) rest 10 minutes G) warm-up throwing H) 60 feet (25 throws)	**Step 4**	A) warm-up toss to 105 feet B) 15 throws at 75 feet* C) 15 throws at 75 feet* D) 15 throws at 75 feet* E) 20 long tosses to 105 feet
Step 5	A) warm-up throwing B) 90 feet (25 throws) C) rest 10 minutes D) warm-up throwing E) 90 feet (25 throws)	**Step 5**	A) warm-up toss to 120 feet B) 15 throws at 90 feet* C) 20 throws at 90 feet* D) 15 throws at 90 feet* E) 20 long tosses to 120 feet
Step 6	A) warm-up throwing B) 90 feet (25 throws) C) rest 10 minutes D) warm-up throwing E) 90 feet (25 throws) F) rest 10 minutes G) warm-up throwing H) 90 feet (25 throws)	**Step 6**	A) warm-up toss to 120 feet B) 20 throws at 105 feet* C) 20 throws at 105 feet* D) 15 throws at 105 feet* E) 20 long tosses to 120 feet

Table 1. (continued)

Javelin Interval Throwing Program (Steve Lemke, BS, e-mail communication, November 13, 2013)		*Baseball Interval Throwing Program*[14]	
- Steps 7 through 18 are performed with a 400 gram safety javelin.		**Step 7**	A) warm-up toss to 120 feet B) 20 throws at 120 feet* C) 20 throws at 120 feet* D) 20 throws at 120 feet* E) 20 long tosses to 120 feet F) throws at effort level given
Step 7	A) warm-up throwing B) 45 feet (25 throws) C) rest 10 minutes D) warm-up throwing E) 45 feet (25 throws)	- Phase 2: Return to Pitching†	
Step 8	A) warm-up throwing B) 45 feet (25 throws) C) rest 10 minutes D) warm-up throwing E) 45 feet (25 throws) F) rest 10 minutes G) warm-up throwing H) 45 feet (25 throws)	**Step 8**	A) 15 throws at 60 feet 6 inches (75%)* B) 20 throws at 60 feet 6 inches (75%)* C) 20 throws at 60 feet 6 inches (75%)* D) 15 throws at 60 feet 6 inches (75%)*
Step 9	A) warm-up throwing B) 60 feet (25 throws) C) rest 10 minutes D) warm-up throwing E) 60 feet (25 throws)	**Step 9**	A) 20 throws at 60 feet 6 inches (75%)* B) 20 throws at 60 feet 6 inches (75%)* C) 20 throws at 60 feet 6 inches (75%)* D) 20 throws at 60 feet 6 inches (75%)*
Step 10	A) warm-up throwing B) 60 feet (25 throws) C) rest 10 minutes D) warm-up throwing E) 60 feet (25 throws) F) rest 10 minutes G) warm-up throwing H) 60 feet (25 throws)	**Step 10**	A) 20 fastballs (50%)* B) 20 fastballs (50%)* C) 20 fastballs (50%)* D) 20 fastballs (50%)* E) 25 throws at 60 feet 6 inches (75%)*
Step 11	A) warm-up throwing B) 90 feet (25 throws) C) rest 10 minutes D) warm-up throwing E) 90 feet (25 throws)	**Step 11**	A) 20 fastballs (50%)* B) 20 fastballs (75%)* C) 20 fastballs (50%)* D) 15 fastballs (75%)* E) 25 throws at 60 feet 6 inches (75%)*

Table 1. (continued)			
Javelin Interval Throwing Program (Steve Lemke, BS, e-mail communication, November 13, 2013)		*Baseball Interval Throwing Program*[14]	
Step 12	A) warm-up throwing B) 90 feet (25 throws) C) rest 10 minutes D) warm-up throwing E) 90 feet (25 throws) F) rest 10 minutes G) warm-up throwing H) 90 feet (25 throws)	**Step 12**	A) 25 fastballs (50%)* B) 20 fastballs (75%)* C) 20 fastballs (75%)* D) 20 fastballs (75%)* E) 20 fastballs (75%)*
Step 13	A) warm-up throwing B) 50% (25 throws) C) rest 10 minutes D) warm-up throwing E) 50% (25 throws)	- Phase 3: Intensified Pitching‡	
Step 14	A) warm-up throwing B) 50% (25 throws) C) rest 10 minutes D) warm-up throwing E) 50% (25 throws) F) rest 10 minutes G) warm-up throwing H) 50% (25 throws)	**Step 13**	A) 25 fastballs (75%)* B) 20 fastballs (100%)* C) 10 fastballs (75%)* D) 15 fastballs (100%)* E) 25 fastballs (75%)*
Step 15	A) warm-up throwing B) 75% (25 throws) C) rest 10 minutes D) warm-up throwing E) 75% (25 throws)	**Step 14**	A) active rest B) 20 throws at 80 feet C) 20 throws at 80 feet D) 20 throws at 80 feet E) 20 throws at 80 feet
Step 16	A) warm-up throwing B) 75% (25 throws) C) rest 10 minutes D) warm-up throwing E) 75% (25 throws) F) rest 10 minutes G) warm-up throwing H) 75% (25 throws)	**Step 15**	A) 20 fastballs (75%)* B) 20 fastballs (100%) C) 5 off-speed pitches* D) 15 fastballs (100%) E) 5 off-speed pitches* F) 20 fastballs (100%) G) 5 off-speed pitches* H) Field bunts and comebacks
Step 17	A) warm-up throwing B) 100% (25 throws) C) rest 10 minutes D) warm-up throwing E) 100% (25 throws)	**Step 16**	A) 20 fastballs (100%)* B) 15 fastballs (100%) C) 5 off-speed pitches D) 5 pickoff throws to 1st E) 20 fastballs (100%) F) 5 off-speed pitches* G) 20 fastballs (100%) H) 5 off-speed pitches*

Table 1. (continued)			
Javelin Interval Throwing Program (Steve Lemke, BS, e-mail communication, November 13, 2013)		*Baseball Interval Throwing Program*[14]	
Step 18	A) warm-up throwing B) 100% (25 throws) C) rest 10 minutes D) warm-up throwing E) 100% (25 throws) F) rest 10 minutes G) warm-up throwing H) 100% (25 throws)	**Step 17**	A) 15 fastballs (100%) B) 5 off-speed pitches* C) 15 fastballs (100%) D) 3 pickoff throws to 1st * E) 20 fastballs (100%) F) 5 off-speed pitches* G) 15 fastballs (100%) H) 3 pickoff throws to 2nd * I) 15 fastballs (100%) J) 5 off-speed pitches*
- Steps 19 through 24 are performed with a 600 gram javelin.		**Step 18**	A) active rest B) repeat step 14
Step 19	A) warm-up throwing B) 50% (25 throws) C) rest 10 minutes D) warm-up throwing E) 50% (25 throws)	**Step 19**	A) 20 fastballs (100%) B) 5 off-speed pitches* C) 20 fastballs (100%) D) 3 pickoff throws to 1st * E) 20 fastballs (100%) F) 3 pickoff throws to 2nd * G) 15 fastballs (100%) H) 5 off-speed pitches* I) 15 fastballs (100%) J) 5 off-speed pitches*
Step 20	A) warm-up throwing B) 50% (25 throws) C) rest 10 minutes D) warm-up throwing E) 50% (25 throws) F) rest 10 minutes G) warm-up throwing H) 50% (25 throws)	**Step 20**	A) batting practice B) 110-120 pitches C) field bunts and comebacks
Step 21	A) warm-up throwing B) 75% (25 throws) C) rest 10 minutes D) warm-up throwing E) 75% (25 throws)	**Step 21**	A) simulated game - 10 minutes warm-up of 50-80 pitches with gradually increasing velocity - 5-8 inning for starters, 3-5 innings for relievers, 2-3 innings for closers - 15-20 pitches per inning, including 10-15 fastballs - 9 minutes rest between innings

Table 1. (continued)

Javelin Interval Throwing Program (Steve Lemke, BS, e-mail communication, November 13, 2013)		*Baseball Interval Throwing Program*[14]
Step 22	A) warm-up throwing B) 75% (25 throws) C) rest 10 minutes D) warm-up throwing E) 75% (25 throws) F) rest 10 minutes G) warm-up throwing H) 75% (25 throws)	*Rest 9 minutes after these sets. †Begin steps in this phase with warm-up toss to 120 feet. All fastballs are from level ground after a crow hop. Finish steps in this phase with 25 long tosses to 160 feet. ‡Begin all steps in this phase with warm-up toss to 120 feet. Finish steps in this phase with 25 long tosses to 160 feet. Instructions: A) Baseline/preseason - To establish a base for training and conditioning, begin with step 4 and advance one step daily following soreness rules. B) Nonthrowing arm injury - After medical clearance, begin step 4 and advance one step daily following soreness rules. C) Throwing arm – bruise or bone involvement - After medical clearance, begin with step 1 and advance program as soreness rules allow throwing every other day. D) Throwing arm – tendon/ligament injury (mild) - After medical clearance, begin with step 1 and advance program to step 7 throwing every other day as soreness rules allow. - Throw every third day on steps 8-12 as soreness rules allow. - Return to throwing every other day as soreness rules allow for steps 13-21. E) Throwing arm – tendon/ligament injury (moderate, severe, or post-op) - After medical clearance, begin throwing at step 1. - For steps 1-7, advance no more than 1

Table 1. (continued)		
Javelin Interval Throwing Program (Steve Lemke, BS, e-mail communication, November 13, 2013)		*Baseball Interval Throwing Program*[14]
		- step every 3 days with 2 days of active rest (warm-up and long tosses) following each workout. - Steps 8-12 advance no more than 1 step every 3 days with 2 days active rest (see step 14) following each workout. - Steps 13-16 advance no more than 1 step every other day with 1 day active rest (see step 14) between steps. Advance steps 17-21 daily as soreness rules allow.

Appendix F

"Thrower's Ten" Program[28]

Designed to target the major muscle groups necessary for throwing. The program's goal is to be a well-organized and concise exercise program for thrower's. This program can be utilized and specified to increase power, strength, and endurance.

- 1A: PNF D2 diagonal extension pattern
- 1B: PNF D2 diagonal flexion pattern
- 2A: external rotation of shoulder with UE in zero degrees of abduction
- 2B: internal rotation of shoulder with UE in zero degrees of abduction
- 2C: (optional) external rotation of shoulder with UE in 90 degrees of abduction
- 2D: (optional) internal rotation of shoulder with UE in 90 degrees of abduction
- 3: shoulder abduction from 0 to 90 degrees
- 4: shoulder abduction in scapular plane from 0 to 90 degrees
- 5: sidelying external rotation
- 6A: prone horizontal abduction with UE in neutral
- 6B: prone horizontal abduction with UE in full ER and 100 degrees of abduction
- 6C: prone rowing
- 6D: prone rowing into ER
- 7: press-ups
- 8: push-ups
- 9A: bicep curls
- 9B: overhead tricep extension
- 10A: wrist extension

- 10B: wrist flexion
- 10C: forearm supination
- 10D: forearm pronation

Appendix G

Rehabilitation Protocol following UCL Reconstructive Surgery

Unlike baseball players who undergo reconstructive surgery, javelin throwers do not have an interval throwing program that is prescribed post-operatively to prevent re-injury. Therefore, researchers, Dines et al., created a program that focused on core and lower extremity strengthening to assist the injured upper extremity support the weight of the javelin. Also, the javelin athletes were required to undergo an extended healing time of eight months compared to the baseball athletes healing time of four months prior to throwing a javelin.[5,22]

In his research, Azar explained the rehabilitation program utilized after UCL reconstructive surgery which consists of four phases. Phase one begins the day of surgery and continues for the first three weeks. The elbow is placed in an immobilizer at 90 degrees of flexion for the first week to promote wound healing. Therefore for this week, rehabilitation focuses on wrist and hand range of motion and grasping activities as well as submaximal isometric strengthening of the shoulder and arm musculature. By the second post-operative week, a range of motion brace is utilized to allow 30-100 degrees of elbow flexion. This range of motion is then increased by the third week to 15-110 degrees of elbow flexion and by 5 degrees of extension and 10 degrees of flexion each subsequent week. The goal is the have the patient at full range of motion by post-operative week six. The brace is removed by week eight.[22]

The second phase of treatment begins during post-operative week 4 and continues through week 8. This phase consist of initiating a progressive isotonic resistive exercise program focusing on the rotator cuff muscles, as well as the muscles that cross the elbow and wrist. The athlete will begin by using one pound of resistance and progress each week by adding one pound.[22]

Phase three begins during post-operative week 9 and progresses to week 12. Sport-specific rehabilitation is initiated using isotonic strengthening exercises which focus on the rotator cuff muscles, the external rotators of the shoulder, the elbow and wrist musculature, and the pronator and supinators of the forearm. Proprioceptive neuromuscular facilitation and dynamic stabilization exercises are utilized for the shoulder and elbow. Also during this phase, the athlete is able return to plyometric training using the 2-hand drills of the chest pass, soccer throw, and side throw.[22]

The final phase of rehabilitation begins during week 14 and extends through week 26. The interval throwing program is initiated during this phase, beginning at 45 feet and progressing to 180 feet. The athlete will begin by throwing every other day and progress if they are free of pain. If the athlete is experiencing pain while throwing, they are instructed to regress one step, either in distance or number of throws.[22]