# Return to Play Throwing Programs

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**KEYWORDS**

• Return to throw • Return to play • Ulnar collateral ligament • Baseball • Overhead athlete

**KEY POINTS**

- Before beginning a throwing program, an athlete should be pain-free, have no motion arc deficits in abduction, minimal scapular dyskinesis, have completed strength training, and completed plyometric training.
- Baseball players, specifically pitchers, have differing range of motion profiles when comparing nondominant and dominant arms, which should be considered during rehabilitation.
- We outline a throwing program for fielders and pitchers that should be completed with the inclusion of a radar gun.

## INTRODUCTION AND BACKGROUND

Upper extremity injuries are common in baseball, accounting for approximately 51% of major league baseball (MLB) injuries, with an average annual cost of US$423,267,634 when players are designated to the injured list.[1,2] In recent years, we have seen a considerable rise in upper extremity injuries at all levels, from adolescents to the professional level, which has led to a subsequent increase in surgical management.[2–4] Return to play/throw rates vary significantly based on the pathology treated. Ulnar collateral ligament (UCL) reconstruction return to play rates range from 75% to 85% overall with a 63% return to same level in MLB players.[5–7] Superior labrum anterior to posterior repair has an overall return rate of 63% to 80%, with a 52.3% return to same level of play for pitchers.[8,9] Rotator cuff repair has a return rate of 38% to 49.9% for same level of play in all levels of baseball players and further

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to 33.3% for MLB players.[10–12] Shoulder instability has the lowest return rate, ranging from 10% to 19%.[13–15]

To improve return to play rates, rehabilitation protocols have been an important subject of research at all levels of competition. However, this has been complicated, first, by a lack of consensus on the definition of return to play and, second, by differing rehabilitation protocols. Although a formal standardized definition has not been adopted, return to play most commonly refers to an athlete returning to competition in a game or competitive play with some studies investigating elite athletes further specifying this as a return to same level of sport.[16] Additionally, a systematic review of rehabilitation protocols for UCL reconstruction revealed a wide variability of protocols, milestones, and timing of milestones considered vital during rehabilitation.[17–20] Standardized evidence-based protocols are vital to prevent reinjury given that return to play rates decrease substantially to as low as 0% to 33% for revision surgery depending on pathology.[21–23] In this review, we outline the criteria for engagement in a return to throw program and emphasize key milestones while presenting a structured throwing program based on data-driven rehabilitation programs to optimize player outcomes and return to play.

## PREPARING TO THROW

Prior to beginning a return to throw program after shoulder or elbow surgery, it is crucial to achieve specific milestones to prevent reinjury or exacerbation of pain that can lead to revision surgery. The criteria that we suggest should be met before initiation of a throwing program are lack of baseline pain, no rotational motion arc deficits in abduction, no scapular dyskinesis, completion of strength training, and completed plyometric training. One recent systematic review of return to throw in UCL reconstruction revealed similar criteria, also focusing on full range of motion (ROM), no pain, and completion of Advanced Throwers Ten and plyometric exercises.[20] Our outlined criteria can serve as guidelines that should be met before initiating a return to throw program to minimize the risk of reinjury.

### *Pain Free*

The athlete should be pain-free before initiating a return to throw program. Specifically, the athlete should have no swelling or inflammation of the joint and have no or very minimal pain at baseline. Mild pain may be acceptable (1–3/10 on a visual analog scale) when throwing and is commonly reported in the general population of uninjured pitches throwing less than the maximum pitches per day.[24] Pain after UCL reconstruction has been linked to higher rates of revision surgery.[22,25] Pain and fatigue lead to changes in pitching mechanics, particularly changes in knee flexion and increased hip to shoulder separation, leading to increased shoulder and elbow torques that increase the risk for reinjury.[24,26] Pain at baseline and pain greater than 3 out of 10 during throwing should prompt a pause of a throwing program. These players should be re-evaluated with further examination prior to initiation of a return to play program.

### *Range of Motion and No Motion Arc Deficits in Abduction*

Restoration of ROM to preoperative values and focus on total arc of motion are critical to prevent high torque on the shoulder and elbow during throwing. It is important to note that overhead athletes, and particularly pitchers, have different ROM profiles when comparing the dominant to the nondominant arm. Pitchers have decreases in dominant elbow extension (7.9°), elbow flexion (5.5°), and total flexion-extension arc (13.3°) when compared to the nondominant arm.[27,28] When looking at pitchers'

passive dominant shoulder ROM, they demonstrate on average 132° of external rotation (ER) at 90°, 52° of internal rotation (IR), and 102° of mean ER at 45° of abduction.[29] These values can be used as a baseline when examining either ROM deficits or excesses. A shoulder flexion deficit greater than 5° is a significant risk factor for elbow injury, and the risk of elbow injury increases by 7% for each degree of ER deficit and 9% for each degree of decreased shoulder flexion.[28] The loss of shoulder rotational ROM and increased elbow flexion can increase shoulder and elbow torque and risk for reinjury.[26] However, too much shoulder ER can also predispose players to injuries, and therefore, a balance must be struck.[30] Prioritizing postoperative matching of preoperative ROM rather than emphasizing end range stretching should be the focus during rehabilitation, which has been shown to improve outcomes during rehabilitation.[31]

Previously, much of the focus on ROM was on glenohumeral internal rotation deficits (GIRDs); however, recent literature suggests that the focus should instead be shifted to rotational motion (total arc of motion).[32] Certainly baseball pitching prior to skeletal maturity does contribute to an increased humeral retrotorsion, which is then reflected in an increased external and decreased internal rotation, without a change in total rotational arc. It has been shown that a decreased total arc of motion is significantly associated with IR deficits and, therefore, represents the underlying cause of GIRDs.[33] Additionally, decreased total arc of motion is associated with decreased shoulder strength.[33] Furthermore, a decrease in rotator cuff stiffness is associated with acute ROM gains as opposed to glenohumeral joint mobility or humeral torsion.[34] Baseball players with shoulder pain show a significant decrease in total arc of shoulder motion, along with IR compared to pain-free players.[35] ROM exercises should, therefore, focus on restoring total arc of motion rather than solely IR deficits, which will ultimately lead to improved strength and decreased rotator cuff stiffness that lead to decreased pain and risk of reinjury.

### *Scapular Evaluation*

Another important aspect of a rehabilitation program is assessing the scapular mechanics of the overhead athlete, paying particular attention to scapular dyskinesis. The scapula plays an integral part in throwing mechanics. Scapular protraction and anterior tilt can increase loads and alter throwing motions leading to decreased performance and increased injury risk.[36] Similarly to ROM profiles, healthy throwing athletes have significantly increased upward rotation, IR, and retraction of the scapula during humeral elevation compared to the general population.[37] Rehabilitation protocols with regards to scapular mechanics have recommended a focus on serratus anterior muscle function to prevent impingement, while others focus mainly on assessing dyskinesis as this has long been associated with throwing-related injuries.[38–40] Assessing for scapular dyskinesis entails examining for winging in the medial or inferior border, which may indicate abnormal protraction, anterior tilt, and/or internal rotation. Recent literature has shown that scapular dyskinesis may not be an isolated risk factor for shoulder injuries; however, patients with dyskinesis still had a 43% increased risk of shoulder pain.[41,42] We, therefore, choose to focus on rehabilitation of dyskinesis in the process of return to play to avoid exacerbating the injury or inciting shoulder pain, which could then, in turn, lead to further kinetic chain alterations and abnormal throwing mechanics.

### *Strength: Hip/Core and Upper Extremity*

Hip and core strength are essential to a successful rehabilitation program due to their large contribution to the kinetic chain that generates the energy necessary for

throwing.[43] Furthermore, as pitch counts increase, core and leg muscles fatigue leading to breakdowns in the kinetic chain, altering throwing mechanics, and potentially resulting in injury.[24] Hip abduction strength deficits and lumbopelvic control of the drive leg are also related to increased movement of the lower extremity that can lead to altered kinematics increasing the shoulder and elbow valgus torque.[44,45] Hip and core strength can be assessed with a single leg squat and forward lunge or a crossed toe-touch.[46] Signs of imbalance or hip deviations during these exercises indicate that further strengthening is necessary before moving to a throwing program.

Upper extremity strength is also an important element to rehabilitation, particularly shoulder ER. ER deficits have previously been shown to be a risk factor for throwing-related injuries.[47,48] The dominant arm and nondominant arm have different strength profiles, and ER can be improved particularly with prone rowing into ER.[49,50]

### *Plyometrics and Throwers Ten*

Plyometrics are another aspect of rehabilitation that has gained popularity in all levels of baseball.[51] Plyometrics utilize the stretch-shortening muscular cycle to develop power and improve strength and is thought to not have negative effects on muscle given it showed no significant rises in creatinine kinase or lactate dehydrogenase.[52,53] The exercises are widely published and have shown improved throwing velocity in programs greater than 7 weeks, as well as improved grip strength, side step, and standing long jump.[52,54] Plyometrics can be combined with the widely published Throwers Ten exercises and Advanced Throwers Ten exercises (**Figs. 1–14**).[55] These exercises are

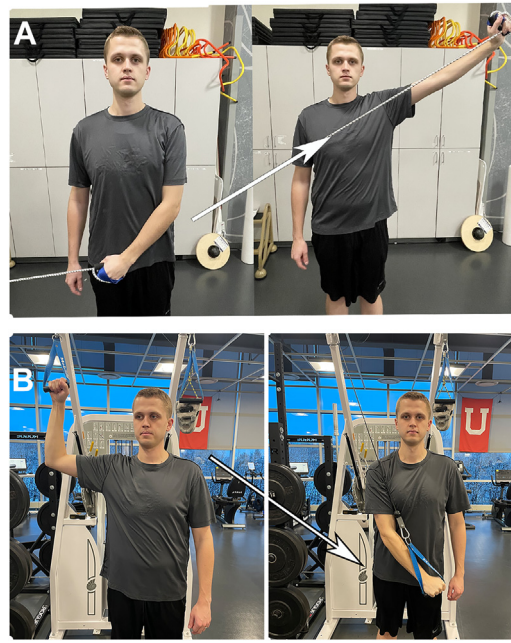


**Fig. 1.** (*A*) Diagonal flexion: Gripping tubing handle in hand of involved arm, begin with arm out from the side and palm facing backward. After turning palm forward, proceed to flex. (*B*) Diagonal Extension: Involved hand will grip tubing handle overhead and out to the side. Pull tubing down and across your body to the opposite side of leg. During the motion, lead with your thumb and elbow and bring arm up and over involved shoulder. Turn palm down and reverse to take arm to starting position.

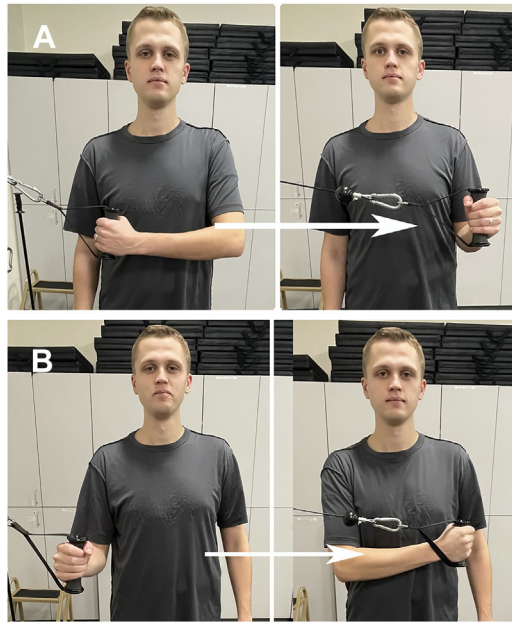


**Fig. 2.** (*A*) External rotation at 0° abduction: Stand with involved elbow fixed at side, elbow at 90° and involved arm across front of body. Grip tubing handle while the other end of tubing is fixed. Pull out arm, keeping elbow at side. Return tubing slowly and controlled. (*B*) Internal rotation at 0° abduction: Standing with elbow at side fixed at 90° and shoulder rotated out. Grip tubing handle while other end of tubing is fixed. Pull arm across body keeping elbow at side. Return tubing slowly and controlled.

an important bridge between rehabilitation and return to throw as they utilize dynamic stabilization, neuromuscular control, and rotator cuff facilitation.[56] The Throwers Ten in particular has shown improved torque and angular impulse on the dominant and nondominant arm by 10% to 14%, while also demonstrating an increase in throwing velocity.[57,58] These exercises function as a safe strengthening program that allows for an improved transition to a throwing program.

## THROWING PROGRAM

### *Overview*

After completion of the return to throw criteria, a player is deemed ready to participate in a throwing program. Completion of the earlier rehabilitation and strengthening process typically depends on nonoperative versus operative treatment, which can range from 6 to 8 weeks but could take up to about 6 to 8 months.[20,59] There has not been a widely accepted standardized throwing program published, and milestones vary based on the protocol, trainer, or institution. In a systematic analysis of throwing programs, Griffith and colleagues found that, on an average, the first flat ground throw is 4.9 months after UCL reconstruction, the first mound throw is 9.4 months, first live game is 10 months, and return to same level of play is 17.4 months.[59] Notably, return to live batting was at an average of 6.9 months.[59] It is important to note that the timing of achievement of these milestones varied widely and did not correlate with return to play.[59]

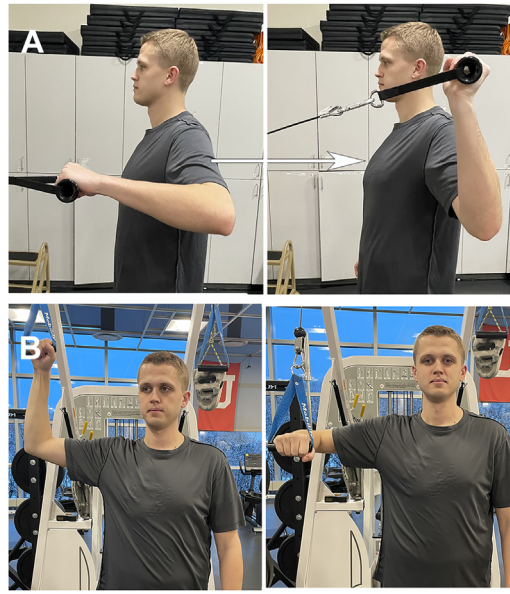


**Fig. 3.** (*A*) External rotation at 90° abduction: Stand with shoulder abducted 90°. Grip tubing handle while the other end is fixed straight ahead, slightly lower than the shoulder. Keeping shoulder abducted, rotate shoulder back keeping elbow at 90°. Return tubing and hand to start position. (*B*) Internal rotation at 90° abduction: Stand with shoulder abducted to 90°, externally rotated 90°, and elbow bent to 90°. Keeping shoulder abducted, rotate shoulder forward, keeping elbow bent at 90°. Return tubing and hand to start position.

A return to throw program is outlined in Fig. 15. The throwing program takes time: approximately 4 weeks for fielders and 10 weeks for pitchers. During this time, the athlete alternates between hitting and throwing days. Throwing days consist of throws on a flat field with marked distances at 45, 60, 90, 120, and 150 feet. Throwing begins at 45 feet and will increase incrementally over the course of 4 weeks until reaching 180 feet. When increasing throwing distance, all throws should be on an "arc" instead of a

**Fig. 4.** Shoulder abduction to 90°: Stand with arm at side, elbow straight, and palm against side. Raise arm to the side, palm down, until arm reaches 90° (shoulder level).

**Fig. 5.** Scaption and external rotation: Stand with elbow straight and thumb up. Raise arm to shoulder level at 30° angle in front of body. Do not go above shoulder height. Hold 2 seconds and lower slowly.

"line" to decrease elbow valgus stress. At 4 weeks, fielders who have progressed through the program without experiencing setbacks in ROM, pain, or strength can return to competitive play. Pitchers, however, continue the throwing program and begin an effort-based program beginning at week 5. During this time, the athlete should alternate pitching days, rest days, and long toss days. This continues for 5 more weeks until an anticipated return to play after 11 weeks of the structured throwing program.

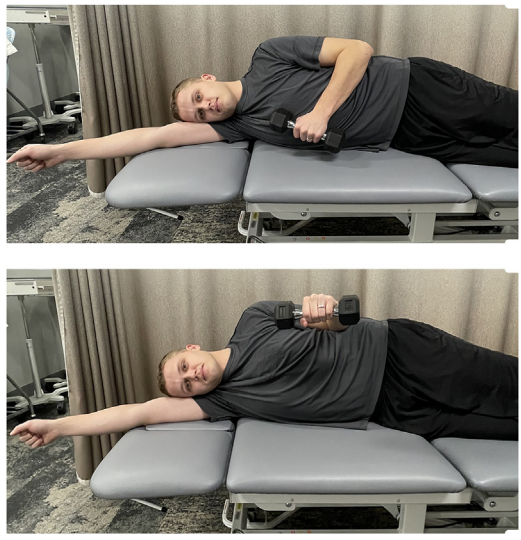

**Fig. 6.** Side lying external rotation: Lie on uninvolved side, with involved arm at side of body and elbow bent to 90°. Keeping the elbow of the involved arm fixed to side, raise arm. Hold seconds and lower slowly.


**Fig. 7.** (*A*) Prone horizontal abduction (Neutral): Lie on table, face down, with involved arm hanging straight to the floor, and palm facing down. Raise arm out to the side, parallel to the floor. Hold 2 seconds and lower slowly. (*B*) Prone horizontal abduction (Full ER, 100° abduction [ABD]): Lie on table face down, with involved arm hanging straight to the floor, and thumb rotated up (hitchhiker). Raise arm out to the side in front of shoulder, parallel to the floor.

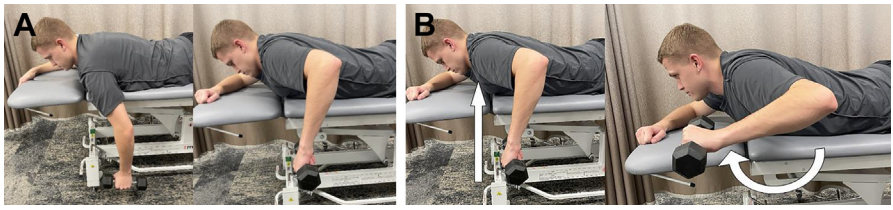


**Fig. 8.** (*A*) Prone rowing: Lying on your stomach with your involved arm hanging over the side of the table, dumbbell in hand and elbow straight. Slowly raise arm, bending elbow, and bring dumbbell as high as possible. (*B*) Prone rowing into external rotation: Lying on your stomach, slowly raise arm, bending elbow, up to the level of the table. Pause one second. Then rotate shoulder upward until dumbbell is even with the table, keeping elbow at 90°.

**Fig. 9.** Press-ups: Seated on a chair or table, place both hands firmly on the sides of the chair or table, palm down and fingers pointed outward. Hands should be placed equal with shoulders. Slowly push downward through the hands to elevate your body. Hold the elevated position for 2 seconds and lower body slowly.

**Fig. 10.** Push-ups: Start in the down position with arms in a comfortable position. Place hands no more than shoulder width apart. Push up as high as possible, rolling shoulders forward after elbows are straight. Start with a push-up into wall. Gradually progress to tabletop and eventually to floor as tolerable.

**Fig. 11.** Elbow extension (abduction): Raise involved arm overhead. Provide support at elbow from uninvolved hand. Straighten arm overhead. Hold 2 seconds and lower slowly.

Crow hopping has been shown to increase torque on the medial elbow when compared to standing throws at distances up to 90 feet.[60] After 90 feet, elbow stress seems to be roughly equivalent between standing and crow hop throwing technique.[60] Therefore, during the initial phases of throwing, crow hopping should be withheld until reaching distances of greater than 90 feet.

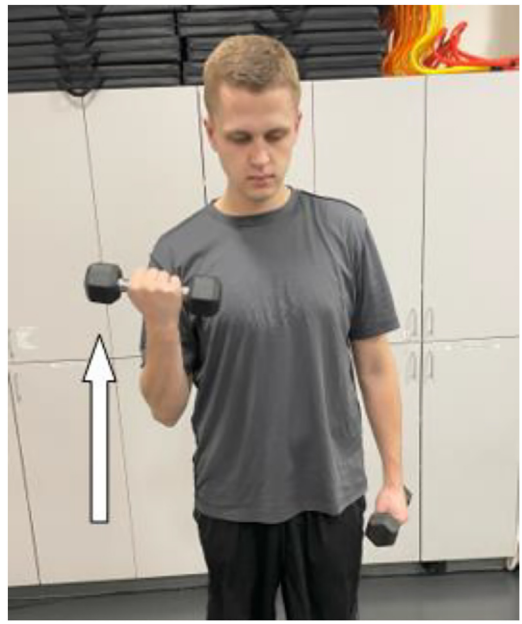

**Fig. 12.** Elbow flexion: Standing with arm against side and palm facing inward, bend elbow upward turning palm up as you progress. Hold 2 seconds and lower slowly.

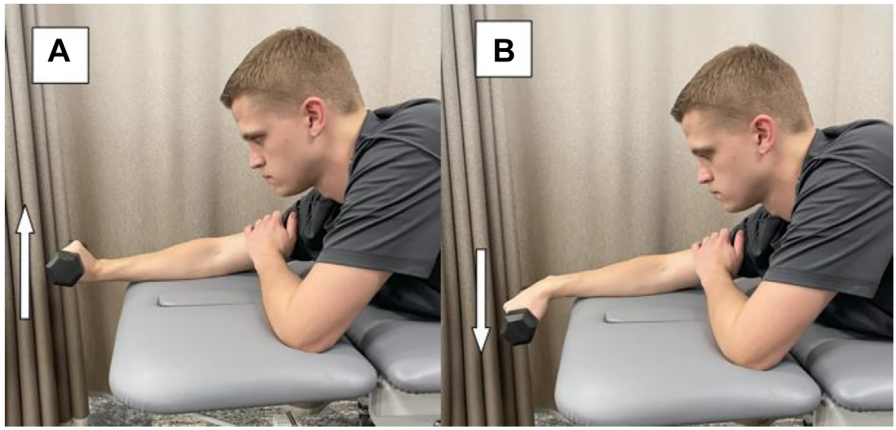


**Fig. 13.** (*A*) Wrist extension: Supporting the forearm and with palm facing downward, raise weight in hand as far as possible. Hold 2 seconds and lower slowly. (*B*) Wrist flexion: Supporting the forearm and with palm facing upward, lower a weight in hand as far as possible and then curl it up as high as possible. Hold for 2 seconds and lower slowly.

### *Long Toss*

Long toss is a commonplace warm up routine for throwers and is central to rehabilitation protocols. However, it must be noted that long toss produces a significant amount of torque on the elbow.[61] Long tossing on flat ground at significant distances greater than 150 feet can produce levels of torque and kinematics that are in excess of pitching.[61] During a rehabilitation protocol, it is important to long toss under controlled settings only on flat ground, with marked distances, and with throws kept on an arcing trajectory instead of on a "line" to control the torque placed on the elbow. Maximum

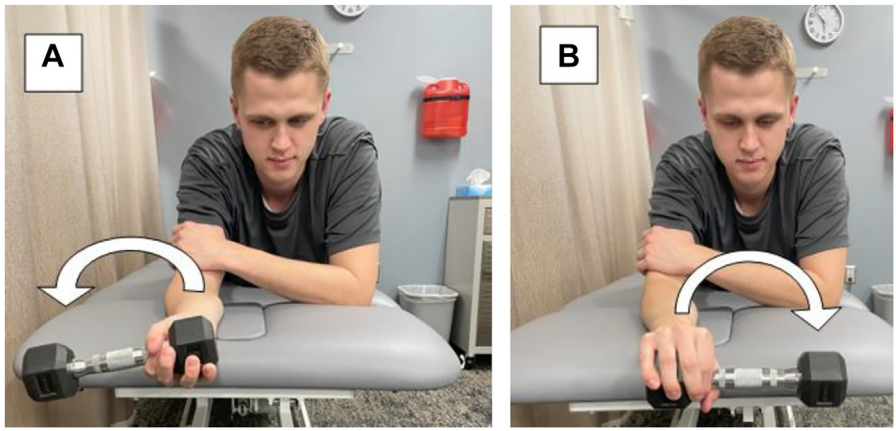


**Fig. 14.** (*A*) Supination: Forearm supported on table with wrist in neutral position. Using a weight or hammer, roll wrist taking palm up. Hold for a 2 count and return to starting position. (*B*) Pronation: Forearm should be supported on a table with wrist in neutral position. Using a weight or hammer, roll wrist taking palm down. Hold for a 2 count and return to starting position.

| | Week | Sun | Mon | Tue | Wed | Thur | Fri | Sat |
|---|---|---|---|---|---|---|---|---|
| Fielders | 1 | Hitting | 45'x50 | Hitting | 45'x75 | Hitting | 60'x50 | Hitting |
| | 2 | 60'x75 | Hitting | 90'x50 | Hitting | 90'x75 | Hitting | 120'x50 |
| | 3 | Hitting | 120'x75 | Hitting | 150'x50 | Hitting | 150'x75 | Hitting |
| | 4 | 180'x50 | Hitting | 180'x75 | Hitting | 180'x50 | Hitting | RTP |

| | Week | Sun | Mon | Tue | Wed | Thur | Fri | Sat |
|---|---|---|---|---|---|---|---|---|
| Pitchers | 5 | 50%x15 | Rest | Long Toss | 50%x30 | Rest | Long Toss | 50%x45 |
| | 6 | Rest | Long Toss | 50%x60 | Rest | Long Toss | 50%x70 | Rest |
| | 7 | Long Toss | 50%x45+ 75%x30 | Rest | Long Toss | 50%x30+ 75%x45 | Rest | Long Toss |
| | 8 | 50%x10+ 75%x65 | Rest | Long Toss | 75%x60 +BPx15 | Rest | Long Toss | 75%x45 +BPx45 |
| | 9 | Rest | Long Toss | 75%x(30+15) +BPx60 | Rest | Long Toss | 75%(30+30) +BPx30 | Rest |
| | 10 | Long Toss | 75%x30 +BPx90 | Rest | Long Toss | Simulated Game | Rest | Long Toss |
| | 11 | RTP | | | | | | |

**Fig. 15.** Proposed throwing program. In the first 4 weeks, the throwing program is distance based, with the first number corresponding to the distance and the second number corresponding to the number of throws (ie, 45′ × 50). Throws at this stage are done on flat ground. Week 5 marks the beginning of the effort-based program. Pitches during this time are done from the mound and long toss days are done on flat ground. The highlighted cells are throwing days where the first number indicates the percent effort, and the second number is the number of throws (50% × 15). BP, batting practice; RTP, return to pitching.

distance in long toss may vary based on the patients' level of play but should be approached only in a stepwise manner according to the protocol outlines in **Fig. 15**. Consequences of long tossing at too long of a distance may include pain and breakdowns in throwing mechanics.

### *Inclusion of Radar Gun*

When progressing to the effort portion of the throwing program (week 5), it can be helpful to incorporate a radar gun. Players are unable to reliably match decreases in physical effort with a proportional decrease in velocity and/or torque.[62–64] Melugin and colleagues reported that for every 25% decrease in perceived effort, elbow varus torque only decreased 7% and velocity only decreased 11%.[62] Fiegen and colleagues demonstrated similar results from mound throws and found that at 75% effort throws, elbow stress was still 81% of full effort throw and ball velocity was 90%.[63] Furthermore, they reported that at 50% effort, elbow stress was still high at 75% and ball velocity was 85% of maximum effort.[63] Lizzio and colleagues found that when pitchers were told to throw a perceived decrease in velocity, they achieved a more proportional decrease in elbow torque than by asking them to throw at decreased perceived effort.[64] Because of this, a radar gun should be included so that pitchers have a metric (velocity) to which they can match a decrease in effort to control torque on the elbow.

### *Strict Pitch Count Monitoring*

Once an athlete has completed a throwing program, it is particularly important to monitor pitch counts to prevent reinjury. Pitch counts have been adopted by youth leagues and outlined in the Pitch Smart guidelines.[65] There is no standardized pitch

count guidelines for MLB players, and the limit is largely dependent on stamina and relief versus starting pitcher status. Relief pitchers throw on average 30 pitches in a game whereas starting pitchers usually do not exceed more than 100 pitches.[66,67] MLB coaching staffs should routinely monitor pitch counts and stay within recommended limits especially in the early return to throwing period. In youth pitchers, pitch count limits have been shown to decrease elbow pain and prevent loss of elbow flexion.[68] Importantly, in-game pitch counts do not typically account for the substantial volume of pitching that occurs during warm-ups on the field and in the bullpen ("hidden pitches").[69] Particularly after completion of a throwing program, pitch counts in the bullpen and during warm-up should be monitored as exceeding pitch counts in youth increases the risk of requiring UCL reconstruction in the future.[70]

## CLINICS PEARLS AND PITFALLS

| Pearls | Pitfalls |
|---|---|
| Be patient | Skipping steps, particularly in not meeting the criteria necessary to begin a return to throw program, can greatly increase the chance of reinjury and poor outcomes, particularly if revision surgery is required as a result |
| Throw with a friend, parent, or therapist | Throwing with the team can influence an athlete to throw at higher effort and distances than indicated for their point in rehabilitation. This is especially important in youth players |
| Use a radar gun | The implementation of a radar gun is helpful to guide effort-based portion of the throwing program |
| It is okay if an athlete "takes a step back" | Many athletes will experience setbacks during rehabilitation including drops in strength, ROM, or increased pain. This should be normalized and used as an indication that the throwing program or rehabilitation program should be extended and tailored to the athletes' symptoms |

## SUMMARY

Injuries in overhead throwers are common, and there are limited data on return to throw programs in the literature. This article outlines the criteria that baseball players should meet before initiating throwing and further describes an evidenced-based throwing program that can be utilized to aid in the rehabilitation of overhead athletes and optimize chances of returning to same level of throwing. These guidelines may be used for rehabilitation after injury is treated operatively or nonoperatively.

## DISCLOSURE

A.Z. Da Silva and J.W. Connelly: These authors have nothing to disclose. P.N. Chalmers is a paid consultant for Depuy-Mitek, Exactech, DJ Orthopedics, and Smith and Nephew; received intellectual property royalties from Depuy, Exactech, and Responsive Arthroscopy; receives publishing royalties from the Journal of Shoulder and Elbow Surgery, and has stock in TitinKM Biomedical.

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