10/27/2025

BASEBALL REHAB NETWORK
Ulnar Collateral Ligament Injury Rehab Guidelines

1. Introduction

An estimated 90-97% of all players who undergo UCL reconstruction or repair are able to return to play (11, 30, 104, 201), suggesting that recovery from UCL surgery is nearly guaranteed. However, most definitions of "return to play" (RTP) only require a pitcher to throw a single pitch in a game, without considering whether they can throw at or above their pre-injury velocity or return to the same level of competition as before the injury (201).

Using RTP (as defined above) as the barometer of surgery success is highly misleading because players who undergo UCL surgery view success as binary. They are either able to return to (or exceed) their prior performance, or they are not. When evaluating surgical success based on this criteria, the success rates for UCL surgery are considerably lower. A 2021 study published in the *Orthopedic Journal of Sports Medicine* examined the outcomes of MLB pitchers who underwent ulnar collateral ligament reconstruction (UCLR) from 2015-2019 and had thrown at least 100 pitches in the year before surgery. The study found that 37% of pitchers never returned to throw a single pitch at the MLB level, and 43% did not reach the 100-pitch threshold in two years following surgery (162).

If this finding is not worrisome enough, **the findings of a Dr. Chris Ahmad led study presented at the September 2024 American Shoulder and Elbow Surgeons Annual Meeting (234) should serve as an immediate call to action for every clinician and musculoskeletal rehabilitation specialist**. Dr. Ahmad's team evaluated return to performance using advanced analytics and pitch tracking outcomes in the seasons following Tommy John surgery for 54 MLB pitchers who underwent either UCL reconstruction or repair from November 2017 to November 2023. Their findings: by season 2 after surgery, only 12% of all pitchers in the study had returned to their pre-injury level of performance based on pitch count, fastball velocity, vertical movement, and other factors used across MLB to determine the effectiveness of a pitcher. By season 3, the percentage of pitchers to return to prior performance had only increased to 28%.

In simpler terms, according to the findings of Dr. Ahmad and his team, **based on the analytics employed across the MLB, over 70% of MLB pitchers who had UCL reconstruction or repair from 2017 to 2023 failed to return to prior performance within the 3 years following their surgery** (234).

Recent surgical advancements may have improved the odds of a player being able to return to (or exceed) their prior performance (RT/EPP) following surgery, but there have been minimal published advancements in the postoperative rehabilitation after surgery. We believe RT/EPP success rates from any UCL injury can be substantially improved through the adoption of the Rehabilitation Guidelines presented in this document.

Assuming both a proper diagnosis and intervention, we contend that a pitcher's inability to RT/EPP following a UCL injury can often be traced back to a suboptimal rehab program, either due to poor programming and/or poor execution.

Our Rehabilitation Guidelines assume:

1) The diagnosis was correct,
2) Any surgical or biologic intervention was appropriate for the injury and performed capably, and
3) The player complied with all program expectations.

Why are these Rehab Guidelines needed

According to Christopher Camp, MD, Glenn Fleisig, PhD, Joshua Dines, MD, David Dines, MD, David Altchek, MD, and Brittany Dowling, MS, "the advancement of injured or recovering athletes through a return to throw program (abbreviated throughout the document as RTT or RTTP) is largely based on conventional wisdom rather than evidence-based data on workload progression (6)."

1) <u>Tremendous variance</u>: In a 2019 article (186), Ahmad, MD, et.al., examined 30 rehab protocols – 22 from different orthopedic programs and 8 published in scientific journals – and found wide variance in when players began RTT programs. Additionally, the authors found that fewer than 20% of the 30 protocols they reviewed incorporated any specific grip strengthening programming, an especially surprising finding given that strengthening the FCU and FDS is well-established in the literature as the most effective way to prevent UCL tears by enhancing the dynamic stabilization these muscle-tendon units (MTUs) provide to the medial elbow (2, 5, 11, 18, 43, 64, 95).

2) <u>Insufficient RTP criteria</u>: Nearly every publicly available UCL injury rehab protocol lacks any objective RTP criteria, and the few that do contain criteria that often result in players being cleared to RTP despite being unprepared to do so from a neuromuscular perspective. In a 2021 study (199), clinicians from the University of Southern California examined the RTP criteria following UCL reconstruction or repair across 84 rehab protocols. Their conclusion: "no study in our review gave specific range of motion (ROM) or strength measurement guidelines for returning to play, and none defined "normal" ROM or strength in relation to the preinjury measurements on the operated upper extremity or contralateral upper extremity. This review highlights the need for evidence-based and validated return to sport criteria."

   Surprisingly, 70 of the 84 rehab protocols reviewed contained no RTP criteria, and only 1 contained RTP criteria that was in any way dependent upon muscle strength in the shoulder and forearm, albeit with a glaring omission. This widely used protocol has no absolute strength requirements. It only requires that a player's shoulder and forearm strength on the surgically repaired limb be 100-115% of the unaffected limb. As a result, players following this protocol, which much of the industry views as the "gold standard," can be cleared to RTP despite being weak, as long as they are equally weak on both limbs. This shortcoming may partially explain why in a study reviewing the outcomes of all MLB pitchers who had UCLR from 1999-2011, 57% returned to the Injured List due to subsequent injuries to their throwing arm (56).

3) The need for customization: Most rehabilitation protocols use similar pre-RTT therapeutic activities and exercises, and they tend to follow standardized RTT timelines regardless of the athlete's age, competition level, or the specific demands their healing soft tissue will face upon returning to prior performance levels. Without individualized planning or objective criteria for RTT/RTP, athletes often progress through rehab unaware that they have not developed sufficient strength or neuromuscular control in the forearm musculature optimally positioned to protect the UCL. As a result, they may experience setbacks or plateaus when increasing their throwing intensity, frequency, or volume.

Our Rehabilitation Guidelines, a collaborative effort from experts in orthopedic surgery, sports medicine, physical therapy, bio-mechanics, and high level performance, are designed to address these shortcomings. When it comes to the rehabilitation of any potentially career ending UCL injury, thankfully, we now have the technology and a sufficient body of literature to take a more evidence-based approach. Based on the latest peer-reviewed research and the expertise of our team in having treated hundreds of athletes with UCL injuries, our Guidelines contain what we believe to be "best practice" for the vast majority of rehabilitation conditions for a thrower's UCL injury.

We understand there is nuance and art involved in the rehabilitation of any athlete; therefore, rather than prescribing a discrete rehab program for each injury and treatment, we offer suggested phase progressions from intervention to return to competition. While we provide the objective criteria we believe should be met for the athlete to safely transition between each phase, we allow for flexibility based on how an athlete progresses and what a practitioner observes.

In our Guidelines, we also offer a comprehensive RTT program, designed to take the rehabbing athlete from their initial throws all the way to full game readiness and beyond.

Our RTT program, both structured and adaptable, ensures a progressive and individualized approach to recovery, while standing apart from traditional programs through:

1) A Refined Approach to Workload Management: Our program relies upon the widely accepted Acute to Chronic Workload Ratio (ACWR) model, but redefines its application by utilizing throwing values that more accurately reflect the number of throws required at submaximal velocities to cause tissue adaptation to withstand the velocity, volume, and frequency levels that initially caused the injury.
2) Purposeful Throwing Progressions: Rather than focusing on throwing volume without a specific goal or direction, our RTT program prioritizes high-intensity and low-intensity throwing days to maximize tissue adaptation while allowing for adequate recovery between high-effort sessions.
3) A True Return to Performance, Not Just Rehab: Many throwing programs leave athletes short of true game readiness, creating a gap between rehabilitation and competition. Our RTT program guides athletes through live at-bats, workload volumes and intensities, and a

pitcher's full pitch arsenal that mirror real game conditions, ensuring a seamless transition back to competition.

4) Data-Driven Progression: The program integrates objective feedback through metrics such as forearm MTU strength, velocity and arm speed (if users have access to an inertial measurement unit sleeve), allowing for precise monitoring and management of each athlete's progression.

While comprehensive, our RTT program is designed for flexibility, allowing for customization based on individual needs. By emphasizing progressive overload and incorporating cutting-edge high-performance research, we aim to prepare rehabbing throwers better than ever for a successful return to competition.

We welcome your feedback and suggestions.

Primary Authors:

Per Gunnar Brolinson, D.O., Vice President for Research, Professor of Family and Sports Medicine Edward Via College of Osteopathic Medicine (*pbrolins@vt.vcom.edu*)

Matthew Fury, M.D., Orthopaedic Surgeon – Baton Rouge Orthopaedic Clinic / Team Physician for LSU Athletics (*mfury16@gmail.com*)

Adam Moreau, CSCS, FlexPro Grip: Co-founder and President, Baseball Division (*amoreau@flexprogrip*)

Daryl Moreau, FlexPro Grip: Co-founder and CEO (*dmoreau@flexprogrip.com*)

Dylan Newcomer, PT, DPT, CSCS, Driveline Baseball physical therapist / Owner of Athletic Potential Performance Physical Therapy (*dylan.newcomer@athleticpotentialpt.com*)

Contributors:

Emily Ferree, PT, DPT, SCS, CMTPT

Josh Hejka, professional pitcher, Driveline Baseball research & development

Jeff Leatherman, MS, PT, DPT

Dan Mahoney, owner Evolved Pitching, former Cleveland Guardians Rehab Pitching Coach

Chris Martin, CSCS (Louisiana State University Baseball Strength and Conditioning Coach, former Houston Astros MiLB Strength & Conditioning Coordinator)

Casey Mulholland, Kinetic Pro Performance

Nolan Rappe, PT, DPT, CSCS, FRCms, Premier Pitching Performance

Ryan Yoshida, PT, DPT, CSCS, founder Armored Heat

2. Overview:

At a minimum, the goal of the rehabbing pitcher is to return to prior performance (RTPP), defined as the ability throughout the season following rehabilitation to replicate pre-injury pitch arsenal, velocity, command, volume, and frequency.

To achieve this goal, two objectives must be met:

1) Physiologic – The structures responsible for protecting the UCL must be trained to provide greater support than they were able to provide pre-injury, which by definition was inadequate. Additionally, other physical components should be evaluated and addressed if found inadequate, including overall conditioning, range of motion, global strength and output, as well as shoulder-specific strength and rate of force development (RFD).
2) Neurologic – The nervous system of the athlete must be retrained to properly activate, coordinate, and control movement throughout the kinetic chain, with an emphasis on the kinematic sequencing of the muscles in the throwing arm.

If neurologic adaptation outpaces physiologic adaptation during the rehabilitation process, a concern for setback or injury rises.

Our Rehabilitation Guidelines are separated into two macro phases (Pre-Return to Throw, and Return to Throw to Return to Play):

1) <u>Phase 1: Pre-Return to Throw</u> – The focus of Phase 1 is on building tissue tolerance to the peak stress the elbow must endure when the athlete returns to play, while addressing other non-elbow deficiencies that may result in increased stress being placed on the elbow. In the latter stages of Phase 1, low intensity drills/movements are recommended to gradually reintroduce valgus loading to the elbow to prepare the player for the neurological demands they will face when RTT begins.

   Thoughts about several non-elbow related deficiencies:

   a) Balance – In a 2013 study involving 60 baseball players (30 with a UCL tear vs 30 controls), those with UCL tears were found to have decreased balance in both their drive and plant legs as compared to healthy players when performing a Y balance test. The authors cited that impaired control at the trunk and lower extremities may disrupt the effective transfer of energy from the lower body and trunk to the upper extremity, and in so doing, alter the position of the shoulder and elbow throughout the throwing motion in a way that could result in increased stress being placed across the shoulder and elbow (39).

      While the results of this study were not linked to injury causation, we believe it prudent to correct any balance deficiencies. That said, given that the pitching motion is dynamic throughout the entire delivery, we see little value in having a rehabbing athlete perform traditional balance exercises that focus more on mastering the specific skill of executing a balancing task than true physical improvement (e.g. one leg balances on a half ball).

Rather, when balance deficits exist, we advocate building single-leg and core strength through robust multi-directional training and balance perturbation exercises that may incorporate proprioceptive, visual, and vestibular challenges to gradually expose athletes to a wide variety of movement patterns.

b) Internal Rotation Strength – The rotator cuff, and specifically internal rotation (IR) strength, has been found to play a role in controlling the stress placed across the medial elbow as pitchers accelerate into maximal external rotation (MER) and torque on the medial elbow peaks (89, 206). A 2022 study involving 86 high school and collegiate athletes (43 in the UCLR group and 43 in the healthy group) found that when the UCLR group was cleared to RTT, there was no difference in the ER strength in the throwing shoulders of the UCLR group vs the healthy group, but the IR strength in the throwing shoulders of the UCLR group was 8.5% less than the healthy group. In a separate study involving high school and college pitchers, the researchers found that IR strength did not increase after a season of throwing (and in many instances decreased). As a result, the study's authors recommended that athletes rehabbing from a UCL injury engage in an IR strengthening program as throwing alone cannot be relied upon to increase a player's IR strength (204). We concur and believe any IR strength deficits should be corrected before a player is cleared to RTT/RTP to reduce the amount of torque that would otherwise be placed on the elbow.

c) External Rotation Strength – While ER strength has been found to play a major role in absorbing the deceleration forces on the shoulder, its role in offloading torque on the shoulder or elbow at MER is negligible (206). Additionally, a 2019 study on 87 college pitchers found that stress on the medial elbow was 50% lower during deceleration (when the muscles in the shoulder which control ER are most active) than at MER (135). Therefore, from the standpoint of protecting the UCL, training ER strength is not nearly as important as correcting any IR strength deficits. Regardless, we believe Phase 1 is a perfect time to correct any ER strength deficits as doing so can be extremely beneficial to overall shoulder health, and there is no negative impact on elbow health in doing so.

Regardless of the measurement technology at your disposal, as a guide, we believe that when testing in a supine position at 90 degrees of abduction and 0 degrees of external rotation, an athlete's ER and IR strength should be at least 20% of their bodyweight, with no greater than a 15% ER to IR strength imbalance.

d) Shoulder and Hip Range of Motion – Before intervening when an athlete presents with shoulder or hip ROM deficiencies, we believe it is essential to carefully consider the surrounding context and proceed with caution.

For shoulders, it's crucial to distinguish between true Glenohumeral Internal Rotation

Deficit (GIRD) versus total arc of motion losses, and the contribution of humeral retroversion should be investigated.

When it comes to hips, there are numerous anatomical variations that can significantly impact ROM. Factors such as dysplasia and acetabular version, femoral anteversion or retroversion, and femoroacetabular impingement can result in athletes having hips that may seem "suboptimal" according to textbook standards, yet the athlete is able to perform exceptionally well despite these hard anatomical limitations. In some cases, a shoulder or hip ROM deficiency may be caused by a soft tissue limitation which can be addressed, whereas other times it's just a normal variation in anatomy that will not improve regardless of intervention; in fact, it may be exacerbated.

e) Spine mobility – Cervical, thoracic, and lumbar spine mobility plays an important role in creating adequate separation in the throw as reduced spine mobility requires compensatory motions potentially resulting in increased torque being placed on the shoulder and elbow. This likely explains why limited spine ROM has been found to be associated with an increased risk of injury. In a 2020 study involving 49 college pitchers across an entire season, 10 pitchers (20.4%) sustained a shoulder or elbow injury (7 involving the elbow). Specifically, pitchers who had less than 39 degrees of mobility on their dominant side in a Cervical Flexion-Rotation Test were found to have a 9 times greater risk of shoulder or elbow injury (229).

f) Core – Regardless of how it is measured, it is quite common to see players rehabbing from a UCL injury who have weak core strength. As with balance deficits, many believe that a weak core may disrupt the effective transfer of energy from the lower body and trunk to the upper extremity, altering the position of the shoulder and elbow throughout the throwing motion possibly resulting in increased stress being placed across the shoulder and elbow (39). To our knowledge, there has never been a study that has linked weak core strength to an increased risk of elbow injury. Nevertheless, there is no good reason to avoid improving an athlete's overall core strength throughout the rehabilitative process. When doing so, we believe the primary focus should be on building bilateral rotational core strength, as well as the ability to create and withstand high levels of force in all directions.

A word of caution – Players who experience a UCL injury often present with any number of deficits: a combination of asymmetrical hip or shoulder ROM; a weak core; poor lower extremity strength, balance or flexibility; scapular dyskinesia; weak rotator cuff strength; and limited thoracic mobility or shoulder ER or IR. Of course, any such deficiencies should be addressed. However, whether the result of a single pitch or the cumulative microtrauma of near failure tensile stress over a season or career, a UCL tears when the valgus forces generated by a pitch or throw exceed the tensile strength of the UCL (8, 33). Consequently, **a player's ability to RT/EPP and maintain it following a UCL injury will depend upon reducing the amount of torque the UCL was routinely being subjected to prior to the injury. In most instances, that burden will fall principally on a few key MTUs in the forearm**.

2) <u>Phase 2: Return to Throw to Return to Play</u> – Focused on neurologic progression**,** including kinetic sequencing, movement quality, and throwing mechanics, Phase 2 is designed to help the pitcher re-establish pitch mix, command, and velocity after developing the soft tissue capacity in the elbow during Phase 1 to tolerate the peak stresses of game-level throwing. The physiologic emphasis in Phase 2 shifts toward building soft tissue endurance to support increased pitch counts and enhance post-throw recovery.

A few thoughts about mechanics

The throwing motion has been described as "a fluid, continuous movement that starts with the lower extremities and core, which provides a base of support and helps generate kinetic energy that translates through the throwing arm, eventually culminating with the ball release from the hands and fingers. An efficient and effective throwing motion requires optimized anatomy, physiology, and mechanics in all of the segments of the kinetic chain (206)." It has been estimated that a 20% decrease in kinetic energy delivered from the hip and trunk to the arm requires a 34% increase in the rotational velocity of the shoulder to impart the same amount of force to the hand (207). Any increase in the rotational velocity of the shoulder will increase arm speed, resulting in increased torque on the elbow. Ideally, pitchers should strive to create as much kinetic energy through the hip and trunk to reduce the torque placed on the shoulder and elbow, as any deficits or "breaks" in the kinetic chain can lead to injury or impaired throwing performance (206).

While it is beyond the scope of our Rehabilitation Guidelines to make any specific recommendations regarding altering a pitcher's mechanics, we would be remiss in not raising two points:

1) the throwing mechanics employed by a pitcher pre-injury may have played a role in causing the injury, and
2) altering the pitcher's mechanics could reduce future injury risk if the pitcher currently employs throwing mechanics that place an excessive amount of torque on the medial elbow.

Various studies have identified that the following patho-mechanics result in more torque being placed on the elbow:

1) Decreased balance on the drive and plant legs on Y test (39)
2) Trunk rotation before front foot contact (14)
3) Shoulder abduction angles greater than 109° at front foot contact (15)
4) Elevated elbow extension angle at MER (15)
5) Excessive contralateral trunk tilt (42)
6) A more lateral / side-arm release point (225)

Given these findings, well-intentioned clinicians and coaches often seek to alter a pitcher's mechanics or arm slot in hopes of preventing a UCL tear. Unfortunately, **chasing torque reduction on the elbow/UCL through improved mechanics has not appeared to have any impact on reducing the rate of UCL tears** considering that:

1) The “flawed” mechanics that a pitcher employs often contribute heavily to their success.
2) A pitcher’s mechanics can be so neurologically engrained that the pitcher is either unwilling or unable to make the types of mechanical changes necessary to reduce torque on their elbow.
3) Those deemed to have “good” mechanics also frequently tear their UCL (Walker Buehler, Shohei Ohtani, Jacob deGrom, Clayton Kershaw, Yu Darvish, Hunter Greene, Justin Verlander, Corbin Burnes, etc.)
4) What constitutes “good” mechanics is highly subjective. No study has shown a direct relationship between injury and what many consider “poor” mechanics such as dropping the elbow, the inverted W, and/or opening the front side too soon (43). This is consistent with a 2009 study involving 169 youth pitchers which found no statistically meaningful correlation between pitchers aged 14-18 who employed “proper” mechanics and elbow valgus torque (EVT).
5) If “good” mechanics alone were capable of preventing UCL tears, the 38% of all active MLB pitchers with presumably some of the best pitching coaches in the world would not have undergone UCLR (232), and half of all asymptomatic pitchers would not have partial UCL tears that might eventually require surgery (44).

For these reasons, we caution against altering a pitcher’s throwing mechanics in hopes of reducing the amount of torque being placed on the medial elbow without the involvement of a skilled pitching coach.

A) Phase 1: Physiology provides the foundation for rehab success

Elbow valgus torque (EVT) is defined as a bending moment about the elbow joint that causes an increase in compressive force on the lateral structures and an increase in tensile force on the medial side. When throwing a baseball, considerable valgus torque is placed on the elbow (14).

Although the cause of each UCL tear is multifactorial, decades of research by baseball’s leading experts have identified a common underlying factor in all cases. UCL tears occur when the valgus torque applied to a pitcher’s elbow at maximum external rotation (the point of greatest EVT in the throwing motion) exceeds the combined counteracting varus torque contributions of three key structures: the UCL, the radio-capitellar (RC) joint, and the MTUs spanning the medial side of the elbow (6, 89).

Understanding the magnitude of this torque and how it will be counter-balanced provides a road map for rehabilitation and an indication of what objective criteria should be met for a player to be cleared both to RTT and RTP.

While considerable variance exists between players depending upon throwing mechanics and their anthropometrics, the amount of peak valgus torque in Newton meters (Nm) placed on a pitcher’s elbow at maximum external rotation (MER) is roughly equivalent to a pitcher’s velocity in mph (63). Pitchers who throw fastballs at roughly 90-100 mph likely place between 90-115 Nm of torque on the medial side of their elbows (89, 142, 143).

For a pitcher generating 90–115 Nm of torque on the medial elbow to prevent a UCL tear, the three structures that work together to absorb this load are estimated to contribute as follows:

1) UCL – The average tensile limit – and by extension, the varus torque contribution ceiling – of the native UCL is 34 to 45 Nm (80, 95, 99, 242), and roughly 10% less in a fully mature tendon graft / surgically reconstructed ligament (99, 200). While the native UCL has been found to strengthen over a lifetime of throwing (86), there is no evidence to suggest that anything can be done throughout the course of rehabilitation to materially increase the tensile load limit of any tendon grafted for UCLR.

2) RC Joint – The magnitude of varus torque contribution from the RC joint depends on the amount of bony compression force and the magnitude of the externally applied torque. At 90° of elbow flexion – approximately the position of the elbow at MER – RC joint compression with an intact UCL has been shown to equal about 33% of peak torque, or roughly 30–40 Nm during a 90–100 mph pitch (78). While the RC joint can withstand greater compressive force, it can only do so if the soft tissue on the medial side of the elbow (i.e., the UCL and/or the MTUs that dynamically stabilize the elbow) is lax or torn.

3) Medial elbow MTUs – Given the limited capacity of the UCL and RC joint to resist valgus torque, the MTUs that dynamically stabilize the medial elbow must generate a minimum of approximately 1/3rd the amount of elbow varus torque (roughly 26–32 Nm) at MER to prevent UCL loading from exceeding its tensile limit during a 90–100 mph pitch.

Most published rehabilitation protocols are in agreement on the ROM required in the elbow to handle the demands of throwing. However, given that **roughly 40-70% of all professional pitchers fail to RT/EPP following surgery** (162, 233), meeting ROM criteria alone has proved inadequate to ensure players are able to successfully RT/EPP (162). Since the varus torque constraints of the UCL and RC joint are relatively fixed, for a player to have an opportunity to RT/EPP following a UCL injury/surgery, the "primary focus (throughout rehabilitation) should be directed on strengthening the musculature surrounding the UCL (5) to repeatedly handle the valgus torque throwing will impose on the medial elbow. Otherwise if "the muscles about the forearm fatigue, the ligamentous and bony structures undergo a greater load, which can ultimately cause ligamentous failure of the medial UCL (95)."

Specifically, **the primary goal during Phase 1 is to increase the capacity of the medial elbow to withstand greater valgus torque than its pre-injury limits**. Because the torque on the medial elbow will be primarily tied to throwing velocity (89, 142, 143), before being cleared to RTT/RTP, rehab should prepare the player to meet objective strength, power, and endurance criteria matched to a pitcher's pre-injury throwing velocity in the MTUs that dynamically stabilize the medial elbow.

As it relates to the reconstructed ligament, two overarching objectives should supersede all other considerations throughout rehabilitation:

1) Protect the anchors and tissue-suture interface. Depending on the individual's healing process and the surgical technique used, it may take several weeks to a few months for

the anchor sites and tissue-suture interface to fully heal and become secure. Until receiving clearance from the surgeon to proceed, avoid placing any valgus load onto the UCL.

2) Allow time for ligamentization (in the case of UCLR). Over roughly 24 months following UCLR, and possibly even longer, the tendon graft used to replace the torn UCL transforms into a new ligament in 3 biological phases: inflammation, proliferation, and remodeling.

3) While a primary goal of rehabilitation is to reduce the amount of stress throwing places on the UCL by increasing the strength/stiffness of the MTUs that dynamically stabilize the medial elbow, the pace at which a grafted tendon transforms into a ligament is dictated by biological timelines that cannot be significantly accelerated.

   An injured UCL treated conservatively can be expected to go through similar phases in the healing process, but at a quicker pace (128).

   a) In the Inflammatory Phase (0-6 weeks), the tendon graft undergoes a period of inflammation and necrosis of some cells, followed by an influx of cells that help in the healing process. While cell necrosis is more likely to occur at the graft harvesting site, it is possible that it can occur at the graft fixation site, weakening the graft and temporarily making it more vulnerable to injury. Because fibroblasts are disorganized, randomly arranged, and metabolically active, it is still essential to load the soft tissue affected by the surgery to trigger cell adaptation.
   b) In the Early Remodeling / Cell Proliferation Phase (6 weeks to 3 months), the graft is populated with new cells that release growth factors. Additionally, there is an increase in the production of extracellular matrix components like collagen. The tissue formed initially appears as disorganized scar tissue.
   c) In the Remodeling / Maturation Phase (3 – 24 months), the collagen fibers within the graft start to align more closely with the direction of stress, resembling the native ligament's structure. Although significant improvement occurs by 12 months, maturation can continue up to 2 years before the graft fully adapts and functions like the native UCL. Until fully mature, the remodeled ligament tissue is morphologically and biomechanically inferior to normal, native ligament tissue.

As for the forearm flexors, the primary rehab goal should be to increase the capacity of the MTUs best positioned to dynamically stabilize and protect the UCL. These structures should ultimately provide more varus support than they did prior to the injury, as the previous levels were, by definition, insufficient to prevent the UCL damage. Concurrently, during the mid to late stages of Phase 1, valgus load should be gradually reintroduced to the repaired ligament. This begins with pre-throw activities to help the soft tissue adapt to the stress it will face at the start of RTT, and culminates in the peak demands of RTP.

The literature has identified that the FDS and FCU are the 2 primary MTUs best positioned to provide medial elbow valgus support to the proximal and mid-belly of the UCL by means of direct muscle action with vectors optimally positioned to resist valgus torque (103, 5, 11, 18, 43, 64, 95). Although rarely studied, we believe the literature supports that a third MTU, the FDP, can play a vital role in protecting against distal tears (2). The origin, insertion, and function of each are identified in Figures 1 and 2.

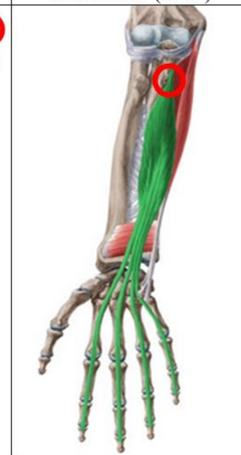
Flexor Digitorum Superficialis (FDS)	Flexor Digitorum Profundus (FDP)	Flexor Carpi Ulnaris (FCU)
		
Controls flexion of MCP & PIP joints	Controls flexion of DIP joint	Controls ulnar deviation (along with ECU)

Figure 1 (Illustration rights through Kenhub)

Muscle	Origin	Insertion	Primary function	Role in protecting UCL
Flexor Digitorum Superficialis (FDS)	1) Medial epicondyle 2) Ulnar ridge	Middle phalanges 2-5	Flex metacarpal and proximal finger joints	Primary UCL dynamic stabilizer by means of direct muscle action with vectors optimally positioned to resist valgus torque (103)
Flexor Digitorum Profundus (FDP)	Ulna overlaying distal insertion of UCL	Distal phalanges 2-5	Flex distal finger joints	Protect distal UCL attachment via overlay of origin (2)
Flexor Carpi Ulnaris (FCU)	1) Medial epicondyle 2) Posterior olecranon	Pisiform	Ulnar deviation of wrist	Primary UCL dynamic stabilizer by means of direct muscle action with vectors optimally positioned to resist valgus torque (103)

Figure 2

The mechanisms by which these key MTUs work to stabilize the UCL and the implications for the rehabilitative process are as follows:

1) Muscles and tendons act as functional stabilizers to reduce strain placed on ligaments due to their stiffness (96).
2) In general, as muscles fatigue, they become 16-21% less stiff (148).
3) A stiffer tendon experiences less strain at a given load and resists a greater external load prior to failure (164). It is the stiffness of a MTU that reduces strain on a ligament, in this case the UCL.
4) If the FDS, FCU and/or FDP fatigue, their stiffness decreases, which in turn increases strain on the UCL and subjects it to forces that can cause a tear (43, 103).
5) Strain on the UCL is often accompanied by an increase in gapping of the medial elbow joint space (159), and with it, up to a 600% greater risk of UCL injury (149). To reduce the risk of a UCL tear, the most effective intervention would enhance

stiffness and minimize fatigue in the FCU, FDS, and FDP, thereby limiting joint gapping.

6) Strength must be trained to increase MTU stiffness / Young's modulus (103, 148).
7) Tendons are highly responsive to changes in mechanical load and can become stiffer and stronger with sustained increases in loading (164).
8) High-intensity resistance training protocols (≥70% of a one rep maximum voluntary contraction or MVC), regardless of contraction mode (i.e., concentric, isometric, eccentric), produce large increases in tendon stiffness and Young's modulus (164).
9) Gains in MTU stiffness / Young's modulus move linearly with, but trail, strength gains. Regardless of contraction mode, it will take 12 weeks of strength training at ≥70% MVC to elicit the greatest changes in MTU stiffness (77). An 8-week training program performed 3x per week at ≥70% MVC has been shown to increase maximum voluntary contraction by 28%, with only mild increases (12%) in tendon stiffness and Young's modulus. However, when continued for 12 weeks, tendon stiffness can be expected to increase by over 50% (132).
10) Unlike stiffness, training induced reductions in MTU fatigue are primarily influenced by neurological adaptations, not strength gains (100). This allows for increases in muscle endurance independent of increases in maximum strength to be effectively trained in 4 weeks.
11) The MVC force produced by any finger in a multi-finger task is on average 32% less than the MVC force produced by that same finger in a single finger task (146). Thus, any multi-finger training will likely result in each individual finger being trained at less than the 70% MVC threshold found to elicit the greatest changes in MTU stiffness (77). To optimally increase MTU in each finger, each should be trained individually at ≥70% of its 1 rep MVC.
12) A concomitant forearm flexor injury occurs in roughly 50% of all UCL injuries (172, 181), and 90% of all injuries to the flexor pronator mass involve the FDS. Further, whenever the FDS is injured along with the UCL, the injury is nearly always to the deep layer of the muscle which controls the index and little finger, as opposed to the superficial layer, which controls the middle and ring fingers (172). Consequently, if a concomitant flexor injury occurred, training that isolates the index and little should be performed.

Phase 1 considerations

After a UCL injury or surgery, prolonged immobilization can have harmful effects, including synovial adhesions, reduced collagen production, and disorganized collagen development. Therefore, while immobilization may be crucial to protect the ligament from valgus stress during early rehabilitation, it's equally important to minimize how long the elbow joint is restricted.

Once elbow ROM is restored, the primary goal is to rebuild and improve strength. After strength is re-established, the focus progresses to regaining power and explosiveness, and finally, endurance. Although rest may temporarily reduce discomfort, soft tissue heals best when exposed to appropriate loading. Periods of reduced loading can lead to decreased tissue stiffness and strength while promoting scar tissue formation, ultimately weakening the tissue and hindering full recovery.

To counteract this, controlled activity should be reintroduced early in the process, incorporating properly dosed, repetitive loading to enhance tissue mass and strength, ultimately promoting a shift toward normalized collagen levels (128, 182).

Once swelling clears and ROM is restored, the rehabbing athlete should begin general physical preparation (GPP) weight room work before progressing into a global strength accumulation phase aimed at achieving 90%+ of an estimated 1 RM in the athlete's pre-injury primary/base movements.

If you have access to the technology, we recommend the use of blood flow restriction (BFR) training during the early stages of Phase 1 rehabilitation following UCL surgery, BFR training has been found to offer significant advantages by enabling meaningful muscular adaptations at very low loads (20–30% of 1RM), thus minimizing joint stress. By partially restricting venous outflow while maintaining arterial inflow, BFR creates a hypoxic, metabolite-rich environment that mimics the effects of high-load training. This promotes fast-twitch fiber recruitment, stimulates anabolic pathways (like mTOR and IGF-1), and enhances muscle protein synthesis and hormonal responses critical for recovery and hypertrophy. According to a May 2025 study on occlusion thresholds (257), the optimal load for BFR lies below 30% of 1RM—where vascular perfusion is still partially intact—allowing BFR to significantly amplify metabolic stress. Loads above 40% 1RM naturally occlude blood flow through muscle contraction alone, rendering additional BFR ineffective. Therefore, BFR at 20–30% 1RM is ideal during post-surgical recovery, offering a joint-friendly, low-load alternative that preserves and builds muscle strength while reducing risk to healing structures.

"Long Holds" to facilitate collagen crosslinking in the MTUs that stabilize the UCL

As you look at our rehab exercise recommendations (Exhibits 1, 2, and 3), while most are conventional, one that you may wonder about is a FlexPro Grip (FPG) exercise titled "Long Holds." Athletes rehabbing with FlexPro Grip have derived great benefit from this targeted exercise and loading style, influenced heavily by tendon and ligament expert Keith Baar, PhD. Baar's research suggests:

1) 30 second isometric exercises that target a functional, yet injured tendon cause the muscle to contract without changing length and the healthy part of a tendon to relax after roughly 15 seconds. This then loads the strained or scarred part of the tendon to stimulate cells to organize collagen crosslinks along the line of force.
2) The amplitude of the load is not important for stimulating collagen production, only the direction of force.
3) It only takes 5 to 10 minutes of activity to stimulate a tendon or ligament, after which it becomes refractory for at least 6 hours, making exercise beyond 10 minutes of no benefit to tendon health.

Avoiding setbacks

We find players often experience setbacks or plateaus in the rehab process when beginning a RTT program if they have not restored pre-injury global and local strength (global: presses, pullups, squats, rows, etc. / local: forearm, rotator cuff, peri-scapula, etc.); corrected any lower extremity imbalance; and been sufficiently exposed to maximal effort stimuli on both ends of the force-velocity curve (heavy/slow, light/fast). Prior to RTT, restoring maximal strength in the upper and lower body (pressing, pulling, squatting, hinging, and rotational movements) and the muscles in the forearm that are best positioned to protect the UCL allows the athlete to reduce lifting intensity when the primary focus of rehab shifts to throwing. As intensity scales, a maintenance approach to lifting/training is all that is needed prevent a decline in weightroom progress. Adding the stress of throwing while increasing lifting intensity can cause excessive fatigue and require early shutdowns or deload periods.

In our Rehabilitation Guidelines (Exhibits 1, 2, 3), we provide recommendations on the objective criteria that we believe should be met before the athlete is allowed to both RTT and RTP.

Using cross-education to avoid atrophy in the early stages of rehab
Over 4 weeks of disuse or neglect, muscle mass can decrease by roughly 10%, and strength by 20% (227). Cross-education training of the contralateral limb can mitigate this loss in the injured limb (220).

In validating the efficacy of cross-education, two studies using isometric training reported contralateral extremity strength gains of 16% and 17%, respectively. The prior included 16 subjects who trained forearm extension for 3 weeks and another with the latter monitored 26 subjects who trained forearm flexion for 8 weeks (153). A third study involving 13 subjects who trained elbow flexion for 4 weeks resulted in a 28% average increase in the trained limb and a 19% increase in the untrained limb (158).

These studies mirror the results of a 4 week internal study performed in 2021 with FlexPro Grip involving 30 MiLB pitchers who experienced an average 23% increase in their one rep max (1RM) finger flexion strength in their trained limb and a 17% increase in the untrained limb.

Based on these findings, we strongly recommend that injured players begin strength training with the FlexPro Grip device on their uninjured arm as soon as possible, even before surgery, if feasible. This training should continue until they are able to safely load their repaired tissue at 50% of the 1RM strength needed to protect the UCL when throwing at their pre-injury maximum velocity.

B. Phase 2: Neurology is king

The RTT process following UCLR or repair surgery represents one of the most critical and delicate phases in a pitcher's rehabilitation journey. Beyond the fundamental goal of restoring throwing capacity, the RTT program must ensure safe, progressive exposure of healing tissue to throwing-specific stresses while re-establishing neuromuscular efficiency. Two primary objectives guide this phase:

1) Retraining and refining throwing mechanics across the pitch arsenal to optimize movement patterns and muscle recruitment, and
2) Progressively loading the UCL and surrounding MTUs to restore tissue capacity sufficient for the demands of competition.

To achieve the second objective, the RTT program must carefully regulate throwing intensity, volume, and frequency. These 3 variables must be managed within a “Goldilocks zone” to incite positive adaptations without precipitating re-injury.

In the absence of definitive empirical evidence favoring one regulatory method over another, clinicians must draw on physiological principles, applied research, and clinical experience. Among the four possibilities – distance, rate of perceived exertion (RPE), velocity, and arm speed – we believe a clear hierarchy of effectiveness emerges when scrutinized through the lens of progressive loading and injury prevention models. Below, we review these four approaches used to regulate throwing volume and intensity in RTT programs, highlighting both their strengths and limitations.

RPE-Based Regulation

An RPE-based program offers practical advantages, as it requires no specialized technology and can be conducted indoors within limited space – athletes can throw into a wall or net if necessary. However, research has demonstrated that most athletes struggle to accurately align their perceived exertion with actual changes in velocity and arm speed. This disconnect makes RPE-based programs unreliable in ensuring the UCL and its supporting musculature is exposed to progressive, yet controlled loading. For instance, a pivotal study involving 60 high school and collegiate athletes found that when instructed to throw at 75% and 50% of their RPE, participants still generated EVT values respectively averaging 93% and 87% of the EVT observed at 100% RPE (223). This discrepancy between perceived effort and actual joint loading increases the risk of applying excessive stress to healing soft tissue during rehabilitation. In short, RPE-based programs are unreliable and pose an elevated re-injury risk.

Distance-Based Regulation

For athletes with access to a field and no limiting seasonal or climatic restrictions – but lacking technology such as a radar gun or an IMU sleeve – a distance-based RTT program may offer slight advantages over RPE-based approaches. However, this benefit is limited, as throws made from the same distance can result in significant variation in EVT depending on the throw’s velocity and arm speed. Conversely, similar EVT levels can be produced across a wide range of distances (106). Notably, a 2019 study by Ben Hansen et.al. analyzed 627,925 anonymized long toss throws using the MotusTHROW IMU sleeve (now known as the Driveline PULSE) and concluded that "long toss at moderately long distances can be both therapeutic by producing lower elbow torques, or can increase injury risk by producing higher elbow torques (249).” These findings underscore the variability and potential inherent risk in distance-based programs when not paired with more precise monitoring tools.

Velocity-Based Regulation

With the use of a radar gun, velocity-based RTT programs provide a more reliable framework for scaling elbow torque when compared to RPE or distance-based protocols. Numerous studies have demonstrated a strong correlation between throwing velocity and EVT (89, 142, 143), supporting the use of velocity as a more accurate proxy for managing stress on the UCL and surrounding musculature if more sophisticated monitoring tools are unavailable. However, keep in mind that outlier cases do exist in which the relationship between velocity and torque weakens, introducing potential variability in specific individuals (209).

Arm Speed-Based Regulation
Using arm speed measured by an IMU sleeve as a foundation for an RTT program is based on the premise that arm speed correlates with elbow stress (253). IMU sleeves like the MotusTHROW / Driveline PULSE use proprietary algorithms that combine arm speed with other motion data (such as linear acceleration, shoulder rotation, and elbow angle) to approximate EVT. Since EVT cannot be directly measured outside a lab, arm speed becomes a practical proxy. However, even though higher arm speed is generally associated with higher EVT torque, the relationship is not linear or perfectly predictive, and the relationship between arm speed and elbow torque varies by individual (254). While IMU accuracy falls short compared to gold-standard motion capture equipment at measuring EVT, studies have shown moderate to strong correlations between arm speed and EVT when measured using IMUs, making them one of the best tools available outside a lab setting, especially when combined with objective velocity data. Of note, many experienced rehab professionals using IMU devices have noted that the correlation between velocity and arm speed significantly weakens above 700-800 rpm.

Which approach is best?
Given the strengths and limitations of each method, we believe the most effective RTT programs combine IMU sleeve data with radar gun-measured velocity, overseen by a skilled professional who can use this information to regularly adjust throwing volume and intensity to progressively overload tissue and prevent sudden workload spikes.

For players without access to an IMU sleeve and expert guidance, velocity tracking remains the next-best control mechanism, incorporating:

1) A radar gun – a Pocket Radar works – to regulate throwing intensity, and
2) Daily workload monitoring of session intensity and volume.

However, regardless of the methodology employed to regulate the RTT program, throwing adaptations alone are insufficient to maintain MTU strength gained throughout Phase 1. It is imperative that training on FlexPro Grip continues. Throughout Phase 2, we strongly advise close monitoring of strength benchmarks matched to peak throwing velocity to ensure rehabbing players maintain adequate strength to prevent the UCL and key flexor MTUs from being exposed to excessive torque.

Using an ACWR Model to Guide RTT After UCL Surgery
A key component of any effective RTT program following UCL surgery is workload management – the progressive reintroduction of stress to the throwing arm, in this case the elbow, without exceeding the athlete's tissue capacity for recovery and adaptation. Regardless of the metrics employed (distance, RPE, volume, torque, etc.), every RTT program fundamentally aims to scale intensity, volume, and frequency in a safe, deliberate manner. Over the past five years, Gabbett's Acute-Chronic Workload Ratio (ACWR) has emerged as a valuable tool for guiding this process, especially in the context of monitoring elbow stress in pitchers or throwers of any kind.

Gabbett's model proposes a training-stress balance based on two competing factors: chronic workload, a marker of "fitness," and acute workload, a marker of "fatigue." In most ACWR models, chronic workload is measured over the most recent 28 days of an activity, while acute workload is typically measured over the most recent 7 or 9 days (216). The difference between the positive function of fitness and the negative function of fatigue provides either a positive training-stress balance (i.e., chronic workload is above the acute workload) or a negative training-stress balance (i.e., acute workload is above the chronic workload) (219). Numerous studies, including Gabbett's foundational work in rugby and cricket, have demonstrated a "U-shaped" relationship between workload and injury risk, with ACWR values between 0.7–1.3 associated with the lowest injury rates (217).

This insight directly translates to RTT protocols: athletes exposed to sudden spikes in acute workload before building sufficient chronic workload (which Gabbett considered a proxy for tissue capacity / resilience) face dramatically increased injury risk. In applying the principles of Gabbett's ACWR model to baseball, the underlying premise is that chronic workload is a measure of general throwing fitness, and acute workload is a measure of throwing fatigue. If players increase throwing volume or intensity too quickly within the "acute" period (Driveline PULSE uses a 9 day acute period, whereas most other programs use 7 days), they risk exceeding an ACWR of 1.3, potentially inducing fatigue. As fatigue increases, the varus torque contribution of the muscle-tendon units capable of protecting the UCL could drop, thereby increasing the probability of injury to the UCL. One study involving baseball players found that players with an ACWR >1.27 were 14.9 times more likely to experience an injury (211).

In baseball, the ACWR has been adapted using IMU-based tools like Driveline PULSE, which estimate EVT adjusted for player size to quantify throwing workload. This allows athletes and practitioners alike to monitor daily throwing stress, manage volume and vary throwing intensity, closely mirroring strategies grounded in established strength and conditioning principles that support tissue adaptation and recovery.

In Gabbett's research involving elite rugby players, workload was defined as the absolute total distance covered as measured by GPS during all field training sessions and matches (216). To determine throwing workload for baseball, ACWR models using IMU devices assign a value to each throw based on the estimated amount of EVT normalized by the athlete's height and weight. The value of each throw is then summed to arrive at a total workload measurement for a day.

While the ACWR framework is sound in principle, a significant limitation lies in the lack of scientific consensus on how many submaximal-effort throws at various intensities equate to the stress of a single max-effort throw.

Driveline's PULSE system, widely regarded as the gold standard among baseball IMU sensors, assign workload values to each throw based on a NASA-derived exponential bone-loading model. For example, PULSE assigns a workload of 0.2114 to a throw generating 50 Nm of EVT, and 0.5177 to a throw generating 100 Nm of EVT.

Given the well-established correlation between throwing velocity and EVT – with multiple studies showing that a 90 mph throw typically produces 90–100 Nm of torque (89, 142, 143, 247, 248) – this model implies that roughly 2.45 throws at 50 Nm (about 50 mph) equal one throw at 100 Nm (about 100 mph) in workload.

However, when we queried 50 pitchers, none felt that 3 throws at 50% of max velocity would come close to being as stressful as a single full-intensity throw. As such, we believe PULSE overvalues low-effort throws, particularly those below 70% of max velocity where arm speed is used as a proxy for stress. This, in turn, inflates the perceived workload of submaximal throws, leading to distorted acute workload scores and ACWR calculations.

An additional shortcoming is PULSE does not normalize throw values relative to an individual pitcher's maximum velocity, which can mask meaningful risk differences. For example, a 75 mph throw is far more stressful for a pitcher whose maximum velocity is 78 mph, than for one who can reach 100 mph. Yet, if both pitchers generate the same arm speed, and share similar height and weight, PULSE may assign them nearly identical workload values for that 75 mph throw.

This is a major flaw, as most UCL injuries occur at or near an athlete's maximum effort, not during submaximal exertion. As a result, assigning inflated workload values to low-effort throws can distort risk assessment by either unnecessarily limiting a pitcher's progression or creating a false sense of safety.

We highlight these shortcomings not to diminish the usefulness of IMU sleeves like PULSE in RTT programs, but to emphasize the need for expert interpretation. When using IMU sleeves to guide a throwing program, it's essential to work with someone who understands the limitations of the data, particularly the uncertainty around how many submaximal throws truly match the stress of one maximal effort throw.

In short, while ACWR is valid in theory, its use with the PULSE system (or any other IMU sensor/sleeve) requires cautious interpretation and clinical oversight to avoid misinformed training decisions.

Limitations of an ACWR model to shape a RTT program

Taking all of this into consideration, even if EVT could be precisely measured to guide throwing volume and intensity, and a RTT program kept the athlete within Gabbett's "safe" 0.7–1.3 ACWR, UCL protection still would not be guaranteed. Soft tissue capacity is not just a function of throwing exposure, but also by strength. An athlete might progress through a throwing program while staying inside the "safe" ACWR range, yet still rupture the UCL if the MTUs meant to support it haven't developed enough strength to offset the torque experienced during high-velocity throwing.

Despite the known limitations of Gabbett's ACWR model and PULSE's ability to measure EVT, we believe Gabbett's ACWR model remains an essential framework for structuring workload progression during RTT for one simple reason. When paired with objective strength diagnostics (e.g., FlexPro Grip targets for UCL-protective MTUs) and individualized progression thresholds, ACWR enables a data-informed, adaptive approach to throwing load management far superior to any alternative.

The ACWR model can serve as a useful framework for managing stress and pacing recovery during a RTT program, but it shouldn't be treated as a rigid rule. Like any model, it's only as effective as the context in which it's applied. Interpreting ACWR values in isolation overlooks critical factors such as the athlete's current strength, neuromuscular readiness, and the relative intensity of each throw based on their individual peak velocity. A well-designed RTT plan uses ACWR to inform decisions, not dictate them.

Blending ACWR Throwing Progression with MTU Training

Minimizing the risk of re-injury or setbacks during a player's return to competition requires a combination of structured throwing days – each with clearly defined intensity levels regulated within a safe ACWR range – and focused training of the MTUs that support the throwing arm. Muscular strength and endurance provide the foundation, while the throwing program builds the specific tissue tolerance needed for competition.

In our experience, players who meet or exceed FlexPro Grip strength, power, and endurance benchmarks associated with their peak throwing velocity are able to maintain a higher ACWR throughout their RTT without issue, enabling them to advance more quickly through rehab. In contrast, those who fall short of these strength benchmarks are more prone to setbacks, performance plateaus, or reinjury and require a slower RTT on-ramp.

Given these findings, we recommend closely monitoring the rehabbing player's ACWR throughout the RTT process and making adjustments based on strength levels in the MTUs optimally positioned to protect the UCL. (See Exhibits 1, 2, and 3 for FlexPro Grip's recommended Strength, Power, and Endurance training schedule and requirements matched to a player's peak throwing velocity to be cleared to RTT/RTP when rehabbing from a UCLR, UCL repair, or rest/PRP from a UCL injury.)

MTU Training Considerations in the RTT Program

Muscles, tendons, and ligaments adapt according to the principle of specificity – they respond to the type, intensity, and volume of stress placed on them. To prepare the arm for the demands of high-velocity throwing during return-to-throw (RTT) programs, we believe decades of strength and conditioning research support alternating between high and low/moderate intensity throwing days.

In 2024, a study (238) examined how the elasticity of two muscle-tendon units (MTUs) – the flexor digitorum superficialis (FDS) and flexor digitorum profundus (FDP) – responds to the stress of throwing. These MTUs are key to dynamically stabilizing the elbow against the valgus forces generated during high-effort throws. Researchers measured their elasticity before, immediately after (0 hours), and 24 hours after a session of 100 max-effort pitches.

Results showed that FDP elasticity increased by 77% immediately after throwing but returned close to baseline (9% above) within 24 hours, suggesting near-full recovery. In contrast, FDS elasticity rose by 86% immediately post-throwing and remained elevated at 72% above baseline 24 hours later – indicating it had not fully recovered and remained in a fatigued or overstretched state, lacking the optimal stiffness needed to safely absorb valgus stress.

This may help explain why forearm flexor injuries occur in approximately 50% of UCL tears (172, 181) and why 90% of flexor-pronator mass injuries involve the FDS.

At a minimum, these findings support the conclusion that RTT programs should not include consecutive high-intensity throwing days. As an added precaution, we also recommend avoiding moderate-intensity throwing the day after a high-intensity session. This conservative approach is reflected in the RTT schedules shown in Exhibit 5.

The goal of high days is to combine meaningful intensity and volume to progressively stress the MTUs and the UCL. This promotes the tissue adaptation needed to withstand the torque and neuromuscular demands of returning to, or surpassing, pre-injury throwing velocity.

In contrast, light days are designed to support recovery through increased blood flow, reduced muscle soreness, and improved flexibility and range of motion without triggering additional tissue stress or adaptation. Moderate days are designed to add throwing volume to the overall RTT program.

Submaximal throwing promotes muscle endurance by encouraging capillary growth and improving oxygen delivery, especially in the shoulder and forearm. However, this primarily activates type I (slow-twitch) and type IIa (fast oxidative) muscle fibers, which are more fatigue-resistant but do not contribute meaningfully to maximum force output. In contrast, high-velocity throwing recruits type IIx (fast glycolytic) fibers essential for explosive movement and high-level performance.

Longstanding S&C literature has shown that loading MTUs at intensities below 70% of a 1RM produce little to no strength or tissue adaptation. In the context of throwing, there is currently no evidence demonstrating that forearm MTUs or the UCL adapt meaningfully to submaximal throwing. Therefore, we find no scientific basis to support that throwing below 70% of a player's max velocity contributes to preparedness for high-intensity competition. As such, to optimize the RTT program we believe:

1) Light days should not exceed 65% of a player's pre-injury max velocity,
2) Moderate days should be programmed no more than once a week and not exceed 75% of a player's pre-injury max velocity, and
3) High days should include as many throws as possible – within the program's structure – above 70%, with an ideal target of greater than 85% of max velocity.

Utilizing such a model enables tissue to recover and adapt between sessions, while ensuring the neuromuscular and connective tissue systems are sufficiently challenged to handle the rigors of competition-level throwing.

Additional Thoughts About Programming Throwing Intensity in a RTT Program

In the RTT schedules we offer in Exhibit 5 and displayed in the chart below, we assign a considerably lower value to throws made at sub max velocities in comparison to the PULSE throw valuation scale. We believe our Baseball Rehab Network (BRN) valuation scale more closely represents the number of throws required at sub max velocities to equal the stress of a max effort throw. Our rationale:

1) EVT has been found to increase disproportionately with throwing intensity (243).
2) A 2023 meta-analysis of 77 studies on submaximal lifting found that individuals had to perform significantly more repetitions at various percentages of their 1RM to match the effect of a single 1RM lift than the PULSE model estimates for submaximal throws matching the effect of max-effort throws. Although lifting isn't directly comparable to throwing, we believe the repetition volumes reported in this S&C research offer a more reliable foundation than relying solely on a single NASA bone density study.
3) We surveyed 50 pitchers and all felt the values we with the Baseball Rehab Network employ more closely matched their perceptions as to the amount of throws they would need to make at 50% and 75% of their max velo to equal the stress of 1 throw made at their max velo.

The chart below reveals the relative value assigned across 10 throwing zones in both the PULSE model and in our BRN model.

Throwing Zones	**Z1**	**Z2**	**Z3**	**Z4**	**Z5**	**Z6**	**Z7**	**Z8**	**Z9**	**Z10**
Percent of max velo	50%	56%	61%	67%	72%	78%	83%	89%	94%	100%
PULSE value per throw	0.06	0.07	0.09	0.12	0.15	0.19	0.22	0.26	0.31	0.35
# required to = 1 max velo throw	5.8	5.0	3.9	2.9	2.3	1.8	1.6	1.3	1.1	1.0
BRN value per throw	0.02	0.03	0.03	0.04	0.06	0.07	0.09	0.12	0.18	0.35
# required to = 1 max velo throw	15.0	12.8	10.5	8.3	6.0	5.0	4.0	3.0	2.0	1.0

Should deload weeks be programmed into a Return-to-Throw Program?

Deloading is defined as "a period of reduced training stress designed to mitigate physiological and psychological fatigue, promote recovery, and enhance preparedness for subsequent training (212)." This concept originates from traditional strength and conditioning paradigms and is commonly applied in resistance training, endurance, and RTT programs.

In strength and hypertrophy programs, periodized training cycles are often separated by pre-planned deload weeks every 4–8 weeks to encourage recovery and adaptation. However, there is limited evidence to suggest that pre-planned, periodized training is superior to non-periodized training (212).

Furthermore, to date, all peer-reviewed research involving periodized training and deloading has focused on strength, hypertrophy, and endurance, not on return-to-throw protocols.

While many RTT programs incorporate scheduled deload weeks, there is no published research demonstrating that pre-programmed deload weeks improve outcomes in RTT programs or should be considered best practice.

In fact, recent research challenges the assumed value of "deloads" in general. A 2024 study involving 39 participants examined strength outcomes over a 9-week resistance training program. One group trained continuously, while the other took a 1-week deload break midway through. The continuous training group achieved greater gains in both isometric and dynamic strength, leading the authors to speculate that mid-program deloading may hinder muscular endurance adaptations due to its negative impact on strength development (214).

In RTT programs, the practice of scheduling deloads may be an estimation of when an athlete might encounter systemic fatigue or tissue overload. But no two athletes are the same, and every rehab is different, making it more likely that scheduling deload periods in a RTT program are a concession to historical limitations in measuring fatigue, particularly in the muscle-tendon units (MTUs) responsible for protecting the UCL. In short, deloads have been used not because of individualized data, but because there was no better way to monitor readiness or tissue stress.

FlexPro Grip changes this calculus. Rather than relying on generalized deload schedules, FlexPro Grip allows RTT programs to quantify fatigue in the forearm MTUs that support the UCL. This enables a progressive, individualized, and clinically controlled overload program that minimizes overtraining, manages fatigue, and reduces injury risk without any guesswork.

To be clear, we are not suggesting that deload periods have no place in an RTT program, but they should never be pre-programmed and should only be used when an athlete experiences:

1. Abnormal or increasing soreness/fatigue, either locally (shoulder/elbow) or systemically (via force plate data or indirect field tests like broad jumps, vertical jumps, medicine ball throws, timed sprints, etc.),
2. An inability to make prescribed velocity progressions,
3. Declining forearm MTU strength, power, or endurance (as measured via FlexPro Grip), and/or
4. Decreased shoulder strength or range of motion, typically measured with dynamometry.

Closing thoughts

Most rehabilitation failures occur late in the RTT process as players near their pre-injury max velocity and increase their throwing frequency, volume, and pitch mix. The combination of making more throws, more frequently, at higher intensities across a full pitch arsenal can cause the MTUs that dynamically stabilize the UCL to fatigue (156), leaving the UCL unprotected and subjected to torque that can cause it to tear (43). For this reason, as throwing becomes the primary focus of rehabilitation, it is crucial to maintain the strength developed during Phase 1. If the MTUs supporting the UCL weaken due to detraining, they may become unable to handle the torque generated during throwing, increasing the risk of UCL failure.

Once the necessary strength and endurance in the UCL's supporting MTUs have been established, the RTT program should progressively introduce higher levels of velocity and EVT. This progression must be carefully managed to approach, but never exceed, the adaptation rate of the most vulnerable tissues (i.e., the UCL and its supporting MTUs). The primary goal is to manage workload effectively, ensuring that as throwing velocity, frequency, and volume increases, tissue tolerance and overall throwing fitness is developed in tandem.

This is where art and science intersect. Muscles, tendons, and ligaments adapt to whatever stress is placed upon them. Each tissue type responds to stress at a cellular level at different but fairly predictable rates. Since each player's baseline tissue strength and endurance varies, it is impossible to predict precisely how long it will take for their UCL and supporting MTUs to develop the necessary capacity to withstand the increasing stress of throwing as intensity and volume progresses.

A perfectly on-ramped throwing program will still result in rehab failure if the strength, power, and endurance in the MTUs optimally positioned to protect the UCL have not been increased to a level that prevents torque on the UCL from reaching its break point. Likewise, a solely strength-centric program will also fail if it is not paired with a well-designed RTT program that adequately conditions the soft tissue to the demands imposed across the entire system when throwing across an entire competitive season.

We believe the best practice guidelines for the rehab of a UCL injury are as follows:

1) As soon as rehab begins, identify the strength, power, and endurance requirements of the MTUs best positioned to protect the UCL based on the player's pre-injury max velocity.
2) Have the athlete train to meet these criteria before beginning a RTT program and receiving clearance to return to play.

3) While building volume and throwing frequency during the RTT program, progressively expose the athlete to higher levels of intensity and EVT, while staying under an ACWR that aligns with their strength, power, and endurance in the MTUs optimally positioned to protect the UCL.
4) As volume, throwing frequency, and velocity increase during the RTT program, regularly assess the strength, power, and endurance of the muscle-tendon units (MTUs) that dynamically stabilize the medial elbow to ensure they can continue to generate enough varus torque to protect the UCL from excessive stress that could lead to re-injury.

We firmly believe that **the most effective approach to RTT programming after UCL surgery combines IMU sleeve data with radar gun-measured velocity, all overseen by a knowledgeable professional who can continuously adjust throwing volume and intensity based on this information.**

If you'd like help connecting with professionals experienced in integrating these technologies into RTT programs, we're happy to assist. Just reach out to info@flexprogrip.com or call 504-526-4747.

That said, we understand that not everyone has access to expert guidance throughout the RTT process. For those in this situation, Exhibit 5 contains three velocity based RTT programs that offer a strong, practical alternative. Each program differs in throwing volume, frequency, and velocity based on the athlete's strength, power, and endurance in the MTUs that dynamically stabilize the elbow. If you follow the FPG training program recommended in Exhibit 1 for UCL reconstruction or Exhibit 2 for UCL repair, you will notice that at week 25 for UCL reconstruction and week 18 for a UCL repair, we recommend performing various tests on FlexPro Grip.

Based on the results of FPG's Strength, Power, and Endurance tests, we recommend you follow either our Level 1, 2, or 3 RTT program. In our experience, most players will likely not acquire sufficient strength, power, and endurance in their forearm musculature to safely begin an RTT program until week 25 following a UCL reconstruction and week 18 following a UCL repair, but for those players who achieve FPG's training targets earlier, it is fine to begin the RTT program earlier.

Should you (or the rehabbing player) fail to meet any of the strength, power, and endurance percentage targets prescribed below or if you are returning from a UCL sprain or flexor strain treated conservatively with rest or PRP, contact FPG if you would like our recommendations on a RTT program.)

RTT Programs Based on FPG Strength, Power, Endurance Test Results

	Level 1	Level 2	Level 3
FPG test results (UCLR at 25 weeks / UCL repair at 18 weeks) a) Strength: % of 1RM Target Force using FPG's Rapid Flexion Test b) Power: Force at 176 ms using FPG's Power % of 1RM Target protocol c) Endurance: Average force using FPG's Endurance % of 1RM Target protocol	 70-80% 50-60% 50-55%	 80-95% 60-75% 55-65%	 > 95% > 75% > 65%
Average Acute to Chronic Workload Ratio	1.11	1.13	1.15
Average weekly workload increase (%)	8%	9%	10%
Weeks to RTP and throw 1 inning from onset of RTT	34	30	27
Weeks to RTP and throw 2 innings from onset of RTT	35	31	28
Weeks to RTP and throw 3 innings from onset of RTT	37	34	30
Weeks to RTP and throw 1 inning from UCLR / UCL Repair	59/52	55/48	52/45
Weeks to RTP and throw 2 innings from UCLR / UCL Repair	60/53	56/49	53/46
Weeks to RTP and throw 3 innings from UCLR / UCL Repair	62/55	59/52	55/48

A few comments regarding the Exhibit 5 velocity based RTT programs

1) Each RTT program calls for a player to be ramped up to make roughly 85, 105, and 125 Zone 10 throws, respectively, to throw 1, 2, and 3 in game innings. These throw volumes are consistent with a 2018 study performed at the University of Florida which found that the average amount of in game pitches thrown by a pitcher, excluding all pre-bullpen throws, represented 58% of all throws made (251).

   On the surface, requiring players to make 85, 105, and 125 Zone 10 throws, respectively, during a RTT program to be cleared to throw 1, 2, and 3 in game innings may seem excessive, but recognize these throw volumes represent all Zone 10 throws a player would likely make if called upon to throw 1, 2, or 3 in game innings. The chart below shows a likely breakdown.

	Z10 Throws	Z10 Throws	Z10 Throws
Long toss	25	25	25
Post long toss pull downs	5	5	5
Bullpen	25	25	25
Pre-game mound	8	8	8
1st Inning	20	20	20
Pre-inning mound		5	5
2nd Inning		20	20
Pre-inning mound			5
3rd Inning			20
Total	83	108	133

2) We stop programming throwing volume once we reach 125 Zone 10 throws, which we estimate to be the upper number of Zone 10 throws necessary to throw 3 full innings.

Please reach out if you would like our assistance programming throwing volumes to prepare to throw more than 3 innings.

3) Each RTT program prepares the pitcher as a starter who will be called upon to throw at max velocity only once a week upon his return. Please reach out if you would like our assistance programming throwing volumes if you are returning as a reliever who will be required to throw to prepare to throw at max velocity 2-3 times per week.

Exhibit 1 contains the objective criteria we believe players should meet to begin a RTT program and RTP, along with FlexPro Grip's weekly training protocol recommendations incorporating Strength, Power, Endurance, and Long Holds for rehabilitation from a UCL Reconstruction. All protocols scale over time based on a player's pre-injury peak throwing velocity.

Exhibit 2 contains the objective criteria we believe players should meet to begin a RTT program and RTP, along with FlexPro Grip's weekly training protocol recommendations incorporating Strength, Power, Endurance, and Long Holds for rehabilitation from a UCL Repair / Hybrid procedure. All protocols scale over time based on a player's pre-injury peak throwing velocity.

Exhibit 3 contains the objective criteria we believe players should meet to begin a RTT program and RTP, along with FlexPro Grip's weekly training protocol recommendations incorporating Strength, Power, Endurance, and Long Holds for rehabilitation from rest or PRP for a UCL injury. All protocols scale over time based on a player's pre-injury peak throwing velocity.

Exhibit 4 contains a 10 Phase Overview of Rehabilitation from UCLR that details the primary objective, emphasis, goals and recommended criteria to meet to progress to the next phase. (Please reach out for our recommendations on how to modify this Phase Overview if you are rehabilitating from a UCL injury treated by a UCL repair, PRP, or rest, or a flexor injury.)

Exhibit 5 contains 3 levels of our recommended RTT program, detailing daily throwing volume, intensity, and frequency based on velocity, arm speed, and/or distance. These parameters are aligned with objective strength, power, and endurance benchmarks measured using FlexPro Grip.

Exhibit 6 contains a one page summary of one page summary of these guidelines.

While we believe **the gold standard for RTT programming is a velocity-based approach supported by an IMU device capable of measuring EVT, all overseen by a knowledgeable professional who can continuously adjust throwing volume and intensity based on this information** we recognize that not everyone has access to this technology. For those without it, the

If you would like help developing a personalized RTT or Strength & Conditioning program – either for yourself or an athlete you work with – feel free to reach out to us at info@flexprogrip.com or call us at

504-526-4747. We'd be happy to connect you with one of the many highly trained professionals we've collaborated with over the years.

Daryl Moreau, Co-founder and CEO
FlexPro Grip
dmoreau@flexprogrip.com

References

2. UCL Injuries in the Throwing Athlete. Jeremy R. Bruce, MD, James R. Andrews, MD. The American Academy of Orthopaedic Surgeons. 2014.

5. Qualitative and Quantitative Analyses of the Dynamic and Static Stabilizers of the Medial Elbow: An Anatomic Study. Salvatore J. Frangiamore, MD, Gilbert Moatshe, MD, Bradley M. Kruckeberg, BA, David M. Civitarese, BS, Kyle J. Muckenhirn, BA, Jorge Chahla, MD, PhD, Alex W. Brady, MSc, Mark E. Cinque, BS, Morten Lykke Oleson, MD, Matthew T. Provencher, MD, Thomas R. Hackett, MD, and Robert F. LaPrade, MD, PhD. 2017.

6. The Relationship of Throwing Arm Mechanics and Elbow Varus Torque Within-Subject Variation for Professional Baseball Pitchers Across 82,000 Throws. Christopher L. Camp, MD, Travis G. Tubbs, MS, Glenn S. Fleisig, PhD, Joshua S. Dines, MD, David M. Dines, MD, David W. Altchek, MD, and Brittany Dowling, MS. Investigation performed at Motus Global, Rockville Centre, New York, USA. 2017.

8. Analysis of Pitching Velocity in Major League Baseball Players Before and After UCLR. Jimmy J. Jiang, MD, and J. Martin Leland, MD. University of Chicago Medical Center 2014.

11. Elbow UCL injuries in athletes: Can we improve our outcomes? Lauren H Redler, Ryan M Degen, Lucas S McDonald, David W Altchek, Joshua S Dines. World J Orthop 2016 April 18; 7(4): 229-243.

14. Correlation of Throwing Mechanics With Elbow Valgus Load in Adult Baseball Pitchers. Arnel L. Aguinaldo, MA, ATC, and Henry Chambers, MD. From the Center for Human Performance and Motion Analysis Laboratory, Rady Children's Hospital, San Diego, California. 2009.

15. Relationship between throwing mechanics and elbow valgus in professional baseball pitchers. Sherry L. Werner, PhD, Tricia A. Murray, Richard J. Hawkins, MD, FRCS, and Thomas J. Gill, MD, 2002.

18. Functional Anatomy of the Flexor Pronator Muscle Group in relation to the MCL of the Elbow. Davidson, MD, Pink PT, Perry MD, Jobe MD. 1995.

30. Treatment of Partial UCL Tears in the Elbow With Platelet-Rich Plasma. Podesta, MD, Crow, MD, Volkmer, MD, Bert, MD, and Yocum, MD. Kerlan-Jobe Orthopaedic Clinic, Los Angeles, California. 2013.

33. Optimal management of UCL injury in baseball pitchers. Elizabeth Hibberd, J Rodney Brown, Joseph T Hoffer, Department of Health Science, The University of Alabama, Tuscaloosa, AL, USA; Department of Intercollegiate Athletics, The University of Alabama, Tuscaloosa, AL, USA. 2015.

39. Baseball Players Diagnosed With UCL Tears Demonstrate Decreased Balance Compared to Healthy Controls. J. Craig Garrison, Pt, PhD, ATC, Amanda Arnold, Pt, DPT, Michael J. Macko, Pt, DPT, John E. Conway, MD. 2013.

42. Biomechanical Estimation of Elbow Valgus Loading in Throwing Athletes as a Means to Reduce Injury Risk. Ryan L. Crotin, PhD, CSCS, Sarah A. Zinamon, BS, John D. Kelly IV, MD, Josh R. Baxter, PhD. 2016.

43. Panel discusses elbow UCL injury in throwing athletes: Orthopedics Today, March 2015 Roundtable Participants.

44. MRI Predictors of Failure in Non-operative Management of UCL Injuries in Professional Baseball Pitchers: Article in The Orthopaedic Journal of Sports Medicine. July 2016. Frangiamore, MD, T. Sean Lynch, MD, Vaughn, MD, Soloff, MS, Forney, MD, Styron, MD, and Schickendantz, MD.

46. Risk of Serious Injury for Young Baseball Pitchers A 10-Year Prospective Study. Glenn S. Fleisig, PhD, James R. Andrews, MD, Gary R. Cutter, PhD, Adam Weber, BS, Jeremy Loftice, BS, Chris McMichael, MPH, Nina Hassell, MPH, and Stephen Lyman, PhD. Investigation performed at the American Sports Medicine Institute, Birmingham, Alabama. 2011.

56. Performance, Return to Competition, and Reinjury After Tommy John Surgery in Major League Baseball Pitchers A Review of 147 Cases. Article in The American Journal of Sports Medicine · April 2014.

63. Fastball Velocity and Elbow-Varus Torque in Professional Baseball Pitchers. Jonathan Slowik, PhD; Kyle T. Aune, MPH; Alek Z. Diffendaffer, MS; E. Lyle Cain, MD; Jeffrey R. Dugas, MD; Glenn S. Fleisig, PhD. 2019.

64. Dynamic Contributions of the Flexor-Pronator Mass to Elbow Valgus Stability. Maxwell C. Park and Christopher S. Ahmad. J. Bone Joint Surg. Am. 86:2268-2274, 2004.

77. Human tendon adaptation in response to mechanical loading: a systematic review and meta-analysis of exercise intervention studies on healthy adults. Sebastian Bohm, Falk Mersmann and Adamantios Arampatzis, Bohm et.al. Sports Medicine - Open (2015) 1:7.

78. Articular and ligamentous contributions to the stability of the elbow joint. Morrey, Kai-Nan, Mayo clinic. The American Journal of Sports Medicine. Volume 11. Number 5. 1983.

80. Reconstruction of the Medial UCL of the Elbow Biomechanical Comparison of a Novel Anatomic Technique to the Docking Technique. Christopher L. Camp, MD, Christopher Bernard, BS, Bill Benavitz, BBA, John Konicek, BS, David W. Altchek, MD, and Joshua S. Dines, MD. 2019.

86. Stress Sonography of the UCL of the Elbow in Professional Baseball Pitchers: A 10-Year Study. Michael G. Ciccotti, MD, Alfred Atanda Jr, MD, Levon N. Nazarian, MD, Christopher C. Dodson, MD, Laurens Holmes, MD, and Steven B. Cohen, MD. Am J Sports Med. 2014 March ; 42(3): 544–551.

89. Computing muscle, ligament, and osseous contributions to the elbow varus moment during baseball pitching. James H. Buffi, Katie Werner, Tom Kepple, Wendy M. Murray. Ann Biomed Eng. 2015 February.

95. Effects of flexor-pronator muscle loading on valgus stability of the elbow with an intact, stretched, and resected medial UCL. John H. Udall, MD, Michael J. Fitzpatrick, MD, Michelle H. McGarry, MS, Thu-Ba Leba, MD, Thay Q. Lee, PhD. Journal of Shoulder Elbow Surg. 2009.

96. Effect of Increased Quadriceps Tensile Stiffness on Peak Anterior Cruciate Ligament During a Simulated Pivot Landing. David B. Lipps, PhD, Youkeun K. Oh, PhD, James A. Ashton-Miller, PhD, and Edward M. Wojtys, M.D. Orthop Res. 2014 March ; 32(3): 423–430.

99. Biomechanical evaluation of a new UCL reconstruction technique with interference screw fixation. Ahmad CS, Lee TQ, ElAttrache NS. Am J Sports Med. 2003 May-Jun;31(3):332-7.

100. Changes in Strength, Endurance, and Fatigue During a Resistance-Training Program for the Triceps Brachii Muscle. Journal of Athletic Training 2013. Jelena Z. Popadic Gacesa, MD, PhD; Aleksandar V. Klasnja, MD, MSc; Nikola G. Grujic, MD, PhD.

103. Muscle contribution to elbow joint valgus stability. J of Shoulder and Elbow Surg 2007. Fang Lin, DSc, Navjot Kohli, MD, Sam Perlmutter, BS, Dohyung Lim, PhD, Gordon W. Nuber, MD, and Mohsen Makhsous, PhD.

104. AOSSM 2017 Annual Meeting. Epidemiology of UCL Reconstruction in Major and Minor League Baseball Pitchers: Comprehensive Report on 1,313 Cases. Christopher L. Camp, MD, Stan Conte, PT, John D'Angelo, Stephen Fealy, MD.

106. Biomechanical Comparison of Baseball Pitching and Long-Toss: Implications for Training and Rehabilitation. Fleisig, Wilk, Andrews MD. May 2011. Vol 41. #5. Journal of Orthopaedic & Sports Physical Therapy.

128. Ligament Injury and Healing: A Review of Current Clinical Diagnostics and Therapeutics. R.A. Hauser MD, E.E. Dolan, H.J. Phillips, A.C. Newlin, R.E. Moore and B.A. Woldin. The Open Rehabilitation Journal, 2013.

132. Time course changes in muscle and tendon properties during strength training and detraining. Kubo et.al. Journal of Strength and Conditioning Research 2010.

135. Deceleration phase moments: a potential cause for elbow injury in college pitchers. Solomite, PhD, Garibay MS, Nissen, MD. Orthopaedic Jrnal of Sports Medicine. 2019.

142. The influence of mound height on baseball movement and pitching biomechanics. Alek Z. Diffendaffer, Jonathan S. Slowik, Nicholas J. Lo, Monika Drogosz, Glenn S. Fleisig. Journal of Science and Medicine in Sport 22, 2019.

143. The influence of baseball pitching distance on pitching biomechanics, pitch velocity, and ball movement. Alek Z. Diffendaffer, Jonathan S. Slowik, Karen Hart, James R. Andrews, Jeffrey R. Dugas, E. Lyle Cain Jr., Glenn S. Fleisig. Journal of Science and Medicine in Sport 23, 2020.

146. Coordinated force production in multi-finger tasks: finger interaction and neural network modeling. Vladimir M. Zatsiorsky, Zong-Ming Li, Mark L. Latash. Biological Cybernetics. 1998.

148. Changes in joint, muscle, and tendon stiffness following repeated hopping exercise. Keitaro Kubo & Toshihiro Ikebukuro. Department of Life Science, The University of Tokyo, Meguro, Tokyo, Japan. Physiological Reports. August 2019.

149. Using SUS to Understand the Risk of UCL Injury Among Professional Baseball Pitchers Based on Ligament Morphology and Dynamic Abnormalities. Shanley PhD, Smith MD, Mayer MD, Bailey PhD, Thigpen PhD, Tokish MD, Kissenberth MD, and Noonan MD. The Orthopaedic Journal of Sports Medicine. 2018.

153. Cross-education of muscular strength following unilateral resistance training: a meta-analysis. A. Manca. Dragone. Dvir. Deriu. Eur J Appl Physiology. 2017.

156. Ulnar Collateral Ligament Laxity After Repetitive Pitching Associated Factors in High School Baseball Pitchers. Hiroshi Hattori, PT, PhD, CSCS, Kiyokazu Akasaka, PT, PhD, Takahiro Otsudo, PT, PhD, Toby Hall, PT, PhD, Katsunobu Sakaguchi MD, PhD, and Yomei Tachibana, MD, PhD. Investigation performed at Saitama Medical University, Saitama, Japan. The American Journal of Sports Medicine April 8, 2021.

158. Strength Training of One Limb Increases Corticomotor Excitability Projecting to the Contralateral Homologous Limb. Dawson J. Kidgell, Mark A. Stokes, and Alan J. Pearce. Motor Control, 2011, 15, 247-266.

159. Elasticity of the Flexor Carpi Ulnaris Muscle After an Increased Number of Pitches Correlates With Increased Medial Elbow Joint Space Suppression Akira Saito, Yusuke Namiki, and Kyoji Okada. Journal of Strength and Conditioning Research 00(00)/1–8. 2021 National Strength and Conditioning Association. July 2021.

162. Return to Performance After UCLR in MLB Pitchers: A Case-Control Assessment of Advanced Analytics, Velocity, Spin Rates, and Pitch Movement. Fury MD, Oh MD, Linderman MS, Wright-Chisem MD, Scarborough PhD, and Berkson MD. 2021. Orthopedic Journal of Sports Medicine.

164. Mechanical, Material and Morphological Adaptations of Healthy Lower Limb Tendons to Mechanical Loading: A Systematic Review and Meta-Analysis. Stephanie L. Lazarczuk, Nirav

Maniar, David A. Opar, Steven J. Duhig, Anthony Shield, Rod S. Barrett, Matthew N. Bourne. Sports Medicine. April 2022.

172. Sites of flexor-pronator muscle injury and relationship between ulnar collateral ligament injury and flexor-pronator muscle injury in baseball players: a retrospective cohort study. Journal of Shoulder and Elbow Surgery. Volume 31, p 1588-1594. Masahiro Ikezu, MS, PT, Shintarou Kudo, PhD, PT, Mutsuaki Edama, PhD, PT, JSPO-AT , Mizuho Ueda, MD, Takanori Kubo, MD, Masazumi Hirata, PhD, MD, Makoto Watanuki, PhD, MD, Hiroki Takeuchi, MS, PT, Jumpei Kaneiwa, MS, PT, Yasuhiko Iizuka, RT, Hidetoshi Hayashi, PhD, MD. August 2022.

181. Forearm flexor injury is associated with medial ulnar collateral ligament injury in throwing athletes Jason L. Zaremski MD, CAQSM, FACSM, FAAPM | Marissa Pazik MS, LAT, ATC, CSCS | Cooper W. Dean MD | Niran Vijayaraghavan BS | Nicholas P. Fethiere | Kevin W. Farmer MD | Mary Beth Horodyski EdD, LAT, ATC, FNATA. American Academy of Physical Medicine and Rehab. March 2021.

182. Minimizing Injury and Maximizing Return to Play: Lessons from Engineered Ligaments. Keith Baar. 2017. Sports Med (2017).

186. Rehabilitation Variability After Elbow UCLR. Harry M. Lightsey, MD, David P. Trofa, MD, Julian J. Sonnenfeld, MD, Hasani W. Swindell, MD, Eric C. Makhni, MD, MBA, and Christopher S. Ahmad, MD. The Orthopaedic Journal of Sports Medicine, 2019.

199. Return-to-Sport Criteria After Upper Extremity Surgery in Athletes—A Scoping Review, Part 2 Ulnar Collateral Ligament of the Elbow Procedures. Rebecca Griffith, MD, Ioanna K. Bolia, MD, MS, PhD, Nickolas Fretes, MD, Iain R. Murray, MD, John Meyer, DPT, OCS, Alexander E. Weber, MD, Seth C. Gamradt, MD, and Frank A. Petrigliano, MD. The Orthopaedic Journal of Sports Medicine, 9(8), 2021.

200. Biomechanical comparison of UCLR with single-tunnel proximal suspensory fixation versus modified docking technique. Matthew L. Vopat, MD, Bradley W. Fossum, BA, Justin Hollenbeck, MS, Justin R. Brown, MD, Richard L. Vopat, MD, Kathrin Kaeppler, MD, David L. Bernholt, MD, Charles A. Su, MD, PhD, Thomas R. Hackett, MD, Randall W. Viola, MD.

201. Pain Is the Most Frequently Cited Reason Athletes Fail to Return to Sport After UCL Surgery: A Systematic Review and Meta-analysis. Amir Fathi, BS, Aryan Haratian, BA, Joshua Treloar MD, Ioanna K. Bolia, MD, MS, PhD, Laith K. Hasan, BBA, Alexander E. Weber, MD, and Frank A. Petriglian MD. The Orthopaedic Journal of Sports Medicine. August 2022.

204. Differences in Shoulder Internal Rotation Strength Between Baseball Players With Ulnar Collateral Ligament Reconstruction and Healthy Controls. Sean M. Kennedy, PT, DPT, SCS, CSCS, Philip Sheedy, PT, DPT, SCS, CSCS, Brooks Klein, PT, DPT, SCS, Mason F. Gist, PT, DPT, OCS, Joseph P. Hannon, PhD, PT, DPT, SCS, John E. Conway, MD, Kalyssa Creed, MS, CCRP, and J. Craig Garrison, PhD, PT, SCS, ATC. The Orthopaedic Journal of Sports Medicine, 10 (1), 2022.

206. The Kinetic Chain Revisited: New Concepts on Throwing Mechanics and Injury Samuel K. Chu, MD, Prakash Jayabalan, MD, PhD, W. Ben Kibler, MD, Joel Press, MD. 2016 by the American Academy of Physical Medicine and Rehabilitation.

207. The Kinetic Chain in Overhand Pitching: Its Potential Role for Performance Enhancement and Injury Prevention Shane T. Seroyer, MD, Shane J. Nho, MD, Bernard R. Bach, MD, Charles A. Bush-Joseph, MD, Gregory P. Nicholson, MD, and Anthony A. Romeo, MD vol. 2, no. 2 Sports Health.

209. Variability in Baseball Throwing Metrics During a Structured Long-Toss Program: Does One Size Fit All or Should Programs Be Individualized? Nels D. Leafblad, MD, Dirk R. Larson, MS, Glenn S. Fleisig, PhD, Stan Conte, DPT, ATC, Stephen A. Fealy, MD, Joshua S. Dines, MD, John D'Angelo, BS, and Christopher L. Camp, MD. vol. 11. no. 6 Sports Health. 2019.

211. Relationship between workload and throwing injury in varsity baseball players. Sameer Mehta. Physical Therapy in Sport 40 (2019).

212. Integrating Deloading into Strength and Physique Sports Training Programmes: An International Delphi Consensus Approach. Bell et.al. Sports Medicine - Lee Bell , Ben William Strafford, Max Coleman, Patroklos Androulakis Korakakis and David Nolan. Sports Medicine.

214. Gaining more from doing less? The effects of a one-week deload period during supervised resistance training on muscular adaptations Max Coleman, Ryan Burke, Francesca Augustin, Alec Piñero, Jaime Maldonado, James P. Fisher, Michael Israetel, Patroklos Andr. PeerJ. 2024.

216. The acute:chronic workload ratio predicts injury: high chronic workload may decrease injury risk in elite rugby league players. Billy T Hulin, Tim J Gabbett, Daniel W Lawson, Peter Caputi, John A Sampson. Br J Sports Med 2015.

217. Chronic Workload, Subjective Arm Health, and Throwing Injury in High School Baseball Players: 3-Year Retrospective Pilot Study. Sameer Mehta, PT, DPT, Sisi Tang, BS, Chamith Rajapakse, PhD, Scott Juzwak, PT, DPT, and Brittany Dowling, MS vol. 14. Sports Health. 2021.

219. Spikes in acute workload are associated with increased injury risk in elite cricket fast bowlers Billy T Hulin, Tim J Gabbett, Peter Blanch, Paul Chapman, David Bailey, John W Orchard. BJSM on October 20, 2014.

220. The Cross-Education Phenomenon: Brain and Beyond. Ashlee M. Hendy and Séverine Lamon. Frontiers in Physiology. May 10, 2017

223. Baseball Pitchers' Perceived Effort Does Not Match Actual Measured Effort During a Structured Long-Toss Throwing Program . Heath P Melugin , Dirk R Larson , Glenn S Fleisig , Stan Conte , Stephen A Fealy , Joshua S Dines , John D'Angelo , Christopher L Camp. Am J Sports Med . 2019 Jul;47(8):1949-1954.

225. A Number of Modifiable and Nonmodifiable Factors Increase the Risk for UCL Injury in Baseball Players: A Systematic Review. Joshua R. Labott, M.D., Devin P. Leland, M.D., Sara E. Till,

M.S., Adam Diamond, D.P.T., Christian Hintz, D.P.T., Joshua S. Dines, M.D., and Christopher L. Camp, M.D. Arthroscopy: The Journal of Arthroscopic and Related Surgery, Vol 39, No 8 (August), 2023: pp 1938-1949.

227. Single-leg disuse decreases skeletal muscle strength, size, and power in uninjured adults: A systematic review and meta-analysis. Nicholas Preobrazenski, Joel Seigel, Sandra Halliday, Ian Janssen & Chris McGlory, Journal of Cachexia, Sarcopenia and Muscle 2023; 14: 684–696. March 7, 2023 in Wiley Online Library DOI: 10.1002/jcsm.13201.

229. Preseason Neck Mobility Is Associated With Throwing-Related Shoulder and Elbow Injuries, Pain, and Disability in College Baseball Pitchers. Laurie Lee Devaney, PhD, MScPT, ATC, Craig R. Denegar, PhD, PT, ATC, Charles A. Thigpen, PhD, PT, ATC, Adam S. Lepley, PhD, ATC, Cory Edgar, MD, PhD, and Lindsay J. DiStefano, PhD, ATC. Investigation performed at the University of Connecticut, Storrs, Connecticut, USA.

232. John Rogele Tommy John list injury site. https://docs.google.com/spreadsheets/d/1gQujXQQGOVNaiuwSN680Hq-FDVsCwvN-3AazykOBON0/edit?gid=0#gid=0

233. The effect of baseball grips on the hardness of the flexor digitorum superficialis. Oshima, Shimao, Hiroyuki. J Sports Med Phys Fitness. 2024 Jun 18.

234. How advanced pitching analytics may redefine TJ surgery success. Chris Ahmad. Presented at American Elbow and Shoulder Surgeons Annual Meeting 10/16/24.

242. Is Ulnar Collateral Ligament Strength Proportional to Height and Weight? David P. Beason, MS, Ricardo E. Colberg, MD, Brandon K. Kimbrel, MD, Marcus A. Rothermich, MD, Jonathan S. Slowik, PhD, and Glenn S. Fleisig PhD. Investigation performed at American Sports Medicine Institute, Birmingham, Alabama, USA. Am J Sports Med. 2023 Mar;51(3):779-785.

243. Changes in Elbow Stress and Ball Velocity During Reduced Effort Pitching: A Marker-Based Motion Capture Analysis. Anthony P Fiegen , Stuart P Nezlek, Stacy R Loushin , Dan Christoffer , Martijn Verhoeven , Kenton R Kaufman, Christopher L Camp M.D. Am J Sports Med. 2023 Mar;51(3):779-785.

247. PULSE Throw. How to Measure and Track Throwing Intensity and Volume Using PULSE. https://www.scribd.com/document/610269750/PULSE-Measure-and-Track-Throwing-Intensity-and-Volume

248. Using PULSE to define throwing workload. April 23, 2020. https://www.drivelinebaseball.com/2020/04/what-is-throwing-workload/?srsltid=AfmBOoqr2ou2RBAt6EakcfeFWYZ3q8vePXUeYohqAE0kxcf6Vcy6EQNY

249. Modeling Elbow Valgus Torque From Throwing Distance With 627,925 Baseball Throws By Competition Level. Ben Hansen, Brittany Dowling, Will Carroll Motus Global, Rockville Centre, NY. Motus. 4/22/2019.

251. Unaccounted Workload Factor Game-Day Pitch Counts in High School Baseball . Pitchers—An Observational Study. Jason L. Zaremski, MD, Giorgio Zeppieri Jr, Deborah L. Jones, PT, Brady L. Tripp, PhD, ATC, Michelle Bruner, ATC, Heather K. Vincent, PhD, and MaryBeth Horodyski, ATC, LAT. The Orthopaedic Journal of Sports Medicine, 6/4/2018.

253. Exploring wearable sensors as an alternative to marker-based motion capture in the pitching delivery Kyle J. Boddy, Joseph A. Marsh, Alex Caravan, Kyle E. Lindley, John O. Scheffey and Michael E. O'Connell. PeerJ. 2019.

254. The Relationship of Throwing Arm Mechanics and Elbow Varus Torque: Within-subject Variation for Professional Baseball Pitchers Across 81,999 Throws. Joshua S. Dines, MD, Travis Tubbs, MS, Glenn S. Fleisig, PhD, David M. Dines, MD, David W. Altchek, MD, Brittany Dowling, MS, Christopher L. Camp, MD. AOSSM 2017 Annual Meeting.

257. A Critical Occluding Tension Phase Transition Occurs Between 30% and 40% 1RM in Dynamic Knee Extension Exercise. Matthew D. Fliss, Max J. Abercrombie, Katrin G. Denson, Lucas Wiens, Justin M. Losciale, Allyson M. Schweitzer, Ian F. Coccimiglio, Thomas R. Tripp, Jamie F. Burr, Martin J. MacInnis, Cameron J. Mitchell. Scandinavian Journal of Medicine & Science in Sports, 2025; 35:e70082

FlexPro Grip Protocols, Targets and RTT/RTP clearance criteria for UCLR Rehab **Exhibit 1** 10/23/25

WEEK	% of 1RM Target Cycle (1)	Long Hold % of 1RM Target Cycle (2)	Rehab Strength Cycle (1)	Strength Cycle (1)	Power % of 1RM Target Cycle (3)	Endurance % of 1RM Target Cycle (4)	Strength Cycle Uninjured Arm (5)
1							X
2	10%						X
3	10%						X
4	15%	10%					X
5	20%	10%					X
6	20%	10%					X
7	25%	10%					X
8	30%	10%					X
9	30%	20%					X
10	35%	20%					X
Rapid Flexion Test - GOAL			60% of 1RM targets				
Rapid Flexion Test - MINIMUM			45% of 1RM targets				
11	(40%)*	20%	X*				
12	(45%)*	20%	X*				
13	(50%)*	20%	X*				
14	(55%)*	20%	X*				
Rapid Flexion Test - GOAL			70% of 1RM targets				
Rapid Flexion Test - MINIMUM			55% of 1RM targets				
15	(60%)*	10%	X*		20%		
16		10%		X	20%		
17		10%		X	30%	20%	
18		10%		X	30%	20%	
19		10%		X	40%	30%	
20		10%		X	40%	30%	
21		10%		X	50%	40%	
22		10%		X	50%	40%	
23		10%		X	60%	50%	
24		10%		X	60%	50%	
25		10%		X	70%	60%	
RTT clearance - GOAL (Rapid Flexion Test)			90% of 1RM targets		70%	60%	
RTT clearance - MINIMUM (Rapid Flexion T.)			70% of 1RM targets		50%	50%	
26		10%		X			
27		10%			70%		
28		10%				60%	
29		10%		X			
30		10%			80%		
31		10%				60%	
32		10%		X			
33		10%			80%		
34		10%				70%	
35		10%		X			
36		10%			90%		
37		10%				70%	
38		10%		X			
39		10%			90%		
40		10%				80%	
41		10%		X			
42		10%			100%		
43		10%				80%	
44		10%		X			
45		10%			100%		
46		10%				90%	
RTP clearance - GOAL (Rapid Flexion Test)			100% of 1RM targets		90%	90%	
RTP clearance - MINIMUM (Rapid Flexion T.)			85% of 1RM targets		70%	70%	

** Continue to peform % of 1RM Target Cycle at the assigned percentages if >55% of all 1RM targets after week 10 on Rapid Flexion Test. If <55% after week 10, discontinue % of 1RM Target Cycle and perform Rehab Strength Cycle instead.*

1) Prior to RTT, train 3x per week with 1 day of rest between each session.
   When RTT, train 3x per week but never on same day of high intensity throwing before you throw.
2) Prior to RTT, train 3-4x per week. Can do on same day as other training but separate by at least 6 hours.
   When RTT, do Long Hold training post-throw.
3) Prior to RTT, train 2x per week immediately following % of 1RM Target or Strength Training "A" and "C" Days.
   When RTT, assuming 2 days of high intensity throwing (HIT), train 2x per week same day after HIT.
4) Prior to RTT, train 1x per week immediately following % of 1RM Target or Strength Training "B" Day.
   When RTT, assuming 2 days of high intensity throwing (HIT), train 2x per week same day after HIT.
5) To gain benefits of cross-education, begin Strength Training with the uninjured limb until week 10.

FlexPro Grip Protocols, Targets and RTT/RTP clearance criteria for UCL Repair					Exhibit 2		10/23/25
WEEK	**% of 1RM Target Cycle (1)**	**Long Hold % of 1RM Target Cycle (2)**	**Rehab Strength Cycle (1)**	**Strength Cycle (1)**	**Power % of 1RM Target Cycle (3)**	**Endurance % of 1RM Target Cycle (4)**	**Strength Cycle Uninjured Arm (5)**
1							X
2	10%	10%					X
3	10%	10%					X
4	15%	10%					X
5	20%	10%					X
6	25%	10%					X
7	30%	10%					X
8	30%	20%					X
9	35%	20%					X
10	40%	20%					
Rapid Flexion Test - GOAL			60% of 1RM targets				
Rapid Flexion Test - MINIMUM			45% of 1RM targets				
11	(45%)*	20%	X*	** Continue to peform % of 1RM Target Cycle at the assigned percentages if*			
12	(50%)*	10%	X*	*>55% of all 1RM targets after week 10 on Rapid Flexion Test.*			
13	(55%)*	10%	X*	*If <55% after week 10, discontinue % of 1RM Target Cycle and perform*			
14	(60%)*	10%	X*	*Rehab Strength Cycle instead.*			
Rapid Flexion Test - GOAL			70% of 1RM targets		*** If >70% of 1RM targets, okay to begin RTT.*		
Rapid Flexion Test - MINIMUM			55% of 1RM targets				
15		10%		X	20%		
16		10%		X	30%	20%	
17		10%		X	40%	30%	
18		10%		X	50%	40%	
RTT clearance - GOAL (Rapid Flexion Test)			90% of 1RM targets		60%	60%	
RTT clearance - MINIMUM (Rapid Flexion T.)			70% of 1RM targets		50%	50%	
19		10%		X			
20		10%			60%		
21		10%				50%	
22		10%		X			
23		10%			70%		
24		10%				60%	
25		10%		X			
26		10%			80%		
27		10%				70%	
28		10%		X			
29		10%			90%		
30		10%				80%	
RTP clearance - GOAL (Rapid Flexion Test)			100% of 1RM targets		90%	90%	
RTP clearance - MINIMUM (Rapid Flexion T.)			85% of 1RM targets		70%	70%	

1) Prior to RTT, train 3x per week with 1 day of rest between each session.
   When RTT, train 3x per week but never on same day of high intensity throwing before you throw.
2) Prior to RTT, train 3-4x per week. Can do on same day as other training but separate by at least 6 hours.
   When RTT, do Long Hold training post-throw.
3) Prior to RTT, train 2x per week immediately following % of 1RM Target or Strength Training "A" and "C" Days.
   When RTT, assuming 2 days of high intensity throwing (HIT), train 2x per week same day after HIT.
4) Prior to RTT, train 1x per week immediately following % of 1RM Target or Strength Training "B" Day.
   When RTT, assuming 2 days of high intensity throwing (HIT), train 2x per week same day after HIT.
5) To gain benefits of cross-education, begin Strength Training with the uninjured limb until week 10.

FlexPro Grip Protocols, Targets and RTT/RTP clearance criteria for UCL sprain or flexor strain treated with rest or PRP **Exhibit 3** 10/23/25

WEEK	% of 1RM Target Cycle (1)	Long Hold % of 1RM Target Cycle (2)	Rehab Strength Cycle (1)	Strength Cycle (1)	Power % of 1RM Target Cycle (3)	Endurance % of 1RM Target Cycle (4)	Strength Cycle Uninjured Arm (5)
1							X
2	10%	10%					X
3	20%	10%					X
4	25%	10%					X
5	30%	20%					X
6	35%	20%					X
7	40%	20%					X
8	45%	20%					X
9	(50%)*	10%	X*		20%	20%	
10	(55%)*	10%	X*		30%	30%	
11	(60%)*	10%	X*		40%	40%	
RTT clearance - GOAL (Rapid Flexion Test)			90% of 1RM targets		60%	50%	
RTT clearance - MINIMUM (Rapid Flexion T.)			70% of 1RM targets		50%	40%	
12		10%		X	50%		
13		10%		X		50%	
14		10%		X	60%		
16		10%		X		60%	
17		10%		X	70%		
18		10%		X		70%	
19		10%		X	80%		
20		10%		X		80%	
21		10%		X			
RTP clearance - GOAL (Rapid Flexion Test)			100% of 1RM targets		90%	90%	
RTP clearance - MINIMUM (Rapid Flexion T.)			85% of 1RM targets		70%	70%	

** Continue to perform % of 1RM Target Cycle at the assigned percentages if achieve all prescribed % targets during weeks 8-10. If fail to meet % of 1RM targets during any of these weeks, switch to Rehab Strength Cycle.*

1) Prior to RTT, train 3x per week with 1 day of rest between each session.
   When RTT, train 3x per week but never on same day of high intensity throwing before you throw.
2) Prior to RTT, train 3-4x per week. Can do on same day as other training but separate by at least 6 hours.
   When RTT, do Long Hold training post-throw.
3) Prior to RTT, train 2x per week immediately following % of 1RM Target or Strength Training "A" and "C" Days.
   When RTT, assuming 2 days of high intensity throwing (HIT), train 2x per week same day after HIT.
4) Prior to RTT, train 1x per week immediately following % of 1RM Target or Strength Training "B" Day.
   When RTT, assuming 2 days of high intensity throwing (HIT), train 2x per week same day after HIT.
5) To gain benefits of cross-education, begin Strength Training with the uninjured limb until week 8.

10/28/2025 **Exhibit 4**

BASEBALL REHAB NETWORK
Phase Overview for UCLR Rehab

PHASE	DESCRIPTION	WEEKS	PAGE
0	Immediate Post-Surgery	0-2	1
1	Early ROM and Protection	3-7	2
2	Early Strength and Valgus Loading Introduction	8-10	2-3
3	Strength Restoration and Moderate Valgus Loading	11-16	3
4	Maximal Strength and Power Training	17-26	3-4
5	Return to Throw (RTT) Introduction	27-30	4-5
6	Volume Accumulation	31-34	5
7	Mound Introduction	35-38	5-6
8	Velocity Progression on Mound	39-42	6-7
9	Velocity Progression and Pitch Design	43-46	7
10	Live At-Bats (Live AB) and Skill-Focused Training	47-50	8-9

Phase 0: Immediate Post-Surgery (Weeks 0-2)

Primary Objective:
Set the foundation for successful recovery by protecting the UCL and promoting healing through optimal recovery strategies. The athlete is typically in a fixed brace or splint and cannot get it wet or shower until stitches are removed around 10-14 days post-op.

Emphasis:
1) **Protection**: Avoid any movements that may stress the elbow, maintain the fixed brace/splint, and follow post-op guidelines strictly. Ensure the incision site stays dry.
2) **Nutrition**:
    a) **Protein**: Aim for 1.5-2.5 grams of protein per kilogram of body weight daily to support tissue repair.
    b) **Collagen Supplementation**: Take 10-15 grams daily 30-60 minutes before meals or therapy
    c) **Vitamin C**: 500 mg daily to aid in collagen synthesis. (Juven is one example of a supplement that combines both).
3) **Inflammation:** 2 schools of thought regarding managing the inflammatory response with no strong evidence to support either position.
    a) If seeking to enhance inflammatory response to kickstart the healing process, avoid:
        1. Omega-3 Fatty Acids
        2. Ibuprofen (Advil); use acetaminophen (Tylenol) instead as needed for pain
    b) If seeking to reduce inflammation, consider:
        1. Omega-3 Fatty Acids: 2-3 grams daily to reduce inflammation
        2. Anti-inflammatory Foods: Fatty fish, berries, turmeric, and ginger
        3. Ibuprofen (Advil) as needed for pain
4) **Hydration**: Aim for 2-3 liters of water per day. Use electrolyte supplements if necessary to maintain balance.

5) **Sleep**:
    a) Prioritize 8-10 hours of sleep per night. Good sleep hygiene – consistent schedule, cool room, minimize pre-bed screen time (if looking at screens, consider using blue light blocking glasses) – supports healing.
    b) Sleep positioning: Elevate the arm with pillows to reduce swelling and discomfort.
6) **Supplementation**: Vitamin D (1000-2000 IU), magnesium (300-500 mg), zinc (15-30 mg), and a high-quality multivitamin and greens powder.
    a) Avoid tobacco products as this compromises wound healing as well as microvascular changes that may affect the graft.

Goals:
1) Manage post-op pain and swelling.
2) Begin early recovery practices (nutrition, hydration, sleep).
3) Avoid any physical stress to the elbow.

Phase 1: Early ROM and Protection (Weeks 3-7)

Primary Objective:
Restore elbow range of motion (ROM) while protecting the UCL graft. Initiating formal PT around week 3, the focus is on gradual ROM restoration without forcing end ranges. Depending on the surgery type, final end ranges may take more time, particularly with hybrid procedures. Blood Flow Restriction (BFR) can be introduced as early as 5 weeks when performing training exercises at 15-30% of a 1RM to enhance muscle recruitment without overloading the tissues (see PHASE 2).

Emphasis:
1) **ROM Restoration**:
    a) Gentle ROM exercises as per physician protocol, aiming for 80-90% of full ROM by week 8.
    b) No forced end ranges, especially in flexion or extension – allow time for natural progression through active ROM. Avoid excess end-range pressure that can irritate the joint. Can utilize weighted plyoballs or small DBs (1-4 lbs), PNF techniques, or Grade II-III joint mobilizations to facilitate re-acquisition to end ranges.
2) **Early Strengthening**:
    a) Initiate FlexPro Grip Rehab % of Max exercises for the forearm flexors and pronators at 10-25% MVC, progressing slowly to prevent overloading. Long Hold exercise is initiated at 10%.
    b) Begin isometric strengthening for shoulder and scapular stability. As elbow extension improves, progress to isotonic variations.
    c) Begin training unaffected parts of the body.
        1. Build aerobic capacity upon clearance using a stationary bike or incline treadmill walk .
        2. Initiate GPP-style program for lower body and unaffected arm.
        3. Machines are a great option here.
3) **Avoidance of Valgus Loading**: No valgus loading of the elbow to protect the healing UCL.

Goals:

1) Achieve 80-90% of pre-injury ROM by week 8.
2) Gradually introduce flexor-pronator activation with light isometrics.
3) Maintain protection of the UCL from valgus stress.

Suggested FlexPro Grip criteria to meet to progress to next phase:

1) Minimally meet all "A", "B", and "C" Day Rehab 25% of Max protocol strength targets based on pre-injury peak throwing velocity without any pain.

Phase 2: Early Strength and Valgus Loading Introduction (Weeks 8-10)

Primary Objective:

Begin building strength with a focus on low-intensity, high-volume work while introducing light valgus loading.

Emphasis:

1) **BFR Training**:
   a) Incorporate BFR for pressing, pulling, biceps, triceps, shoulder movements (ER/IR, flexion/extension), and wrist movements (flexion/extension, radial/ulnar deviation, pronation/supination) 2-3 times per week when training at levels below 30% of a 1RM with each exercise receiving 60-90 reps and occlusion pressures from 40-60% as tolerated.
   b) BFR allows for increased muscle stimulus – promoting the hormonal benefits of strength training – with low load, protecting the UCL.
2) **Strength Training**:
   a) Continue FlexPro Grip progression, increasing load to 35% of 1RM Rehab target MVC, Long Holds progressed to 20%.
   b) Begin low-load, low-velocity valgus loading exercises such as submaximal, painless IR shoulder isometrics and isotonics with forearm activation to prepare the medial elbow tissues for future stress.
   c) Add progression of the rest of the S&C work.
   d) Increase intensity/focus of conditioning at least 1x/week, which usually begins once full ROM achieved. Players with a Gracilis graft will likely need more time before being cleared to run.
3) **ROM Maintenance**:
   a) Ensure full ROM is maintained or achieved, with no forced end-range stretching.

Goals:

1) Safely introduce valgus loading with low intensity.
2) Achieve 50% 1RM MVC in grip strength.
3) Maintain full, pain-free ROM.

Suggested FlexPro Grip criteria to meet to progress to next phase:

1) Minimally meet all "A", "B", and "C" Day Rehab 35% of Max protocol strength targets based on pre-injury peak throwing velocity without any pain.

Phase 3: Strength Restoration and Moderate Valgus Loading (Weeks 11-16)

Primary Objective:
Begin restoring 50-80% of pre-injury strength, with moderate valgus loading at low velocities. Start introducing low-amplitude ballistic movements and increasing overall strength.

Emphasis:

1) **Strength Training**:
   a) Begin restoring primary compound movement strength (presses, pulls, rows) to 50-80% of pre-injury levels.
   b) Focus on eccentric loading, especially in long-lever positions (anterior and posterior I/Y/T/A, ER/IR).
   c) Continue FPG % of submax progressions or switch to Rehab Strength training in week 11 while maintaining Long Holds at 20% of 1RM Rehab target. Introduce Power Rehab at 20% of 1RM Rehab target in week 15, with Long Holds pulled back to 10% of 1RM Rehab target. Consider beginning FPG Strength Training, which requires a 1RM of each exercise.
   d) The Strength Training Cycle – requiring a 1RM of each exercise – may be initiated at this time. Consult with your rehab professional or the FlexPro Grip team to determine whether you are better progressing in the Strength Training Cycle or continuing in the traditional Rehab % of Max protocol progressions.
2) **Valgus Loading**:
   a) Low-velocity, eccentric, moderate-to-heavy valgus loading: Emphasize slow-tempo eccentrics (3–5 s) through controlled layback end-range stress to keep improving maximal internal-rotation strength and motor control.
   b) Moderate-velocity, moderate-load extensive loading: Introduce higher-rep sets (10-15+) of dynamic drills into the layback position (e.g., band-accelerated rebounds, weighted ball drop catches, flywheel internal rotation) to re-educate the elbow to tolerate progressive valgus impulses and prepare for future high-speed tasks.
3) **Ballistic Movements**:
   a) Begin low-amplitude, low-velocity ballistic movements (bilateral progressing to unilateral – chest pass dribbles progressing to internal rotation dribbles), introducing light dynamic loading patterns.

Goals:

1) Restore 50-80% of pre-injury strength.
2) Safely increase valgus loading to moderate levels.
3) Begin ballistic movement training, emphasizing controlled progressions.

Suggested FlexPro Grip criteria to meet to progress to next phase:

1) Minimally achieve 55% of 1RM Rehab targets based on pre-injury peak throwing velocity on the exercises in Rapid Flexion Test

Phase 4: Maximal Strength and Power Training (Weeks 17-24)

Primary Objective:
Shift to normal maximal strength and power training. Ballistic movements are now progressed to high intent, and throwing pattern drills are introduced at higher intensities.

Many players will likely not acquire sufficient strength, power, and endurance in their forearm musculature to safely begin a return to throw (RTT) program until sometime between weeks 25-30 (Phase 5). However, for those players who achieve FPG's training targets earlier at some time during weeks 17-24, it is fine to introduce throwing during Phase 4 with a slow, controlled accumulation of volume and intensity, prioritizing comfort and mechanics over intensity.

Emphasis:

1) **Strength Training**:
    a) Focus on maximal strength with heavy weight (e.g., 3 sets in 3-5 rep range).
    b) Compound lifts should reach pre-injury levels.
    c) Ensure strength symmetry and endurance in grip and upper body.
    d) Complete 10 week FPG Strength Training Cycle requiring a 1RM of each exercise while initiating (and steadily increasing) submaximal Power Rehab and Endurance Rehab % of 1RM training to reintroduce ballistic firing of the finger flexors ranging from 20-70% pre-throw.
2) **Ballistic Training**:
    a) Ballistic movements are progressed to maximal intent, aiming to reintroduce the athlete to explosive efforts.
3) **Valgus Loading**:
    a) Transition to low-load, high-velocity valgus loading exercises (but no throwing a baseball) to simulate the forces experienced during throwing.

Goals:

1) Restore near-maximal strength (90-95+%) in all major lifts.
2) Introduce high-intent ballistic movements.
3) Safely tolerate high velocity valgus loading (but no throwing a baseball) in preparation for throwing.
4) A shoulder strength measure may be relevant here as another clearance criteria for throwing. It would begin being measured earlier in the process, and the exact numbers would depend on the method used to test. Please reach out if you would like our recommendations on measuring shoulder strength (info@flexprogrip.com).

Suggested FlexPro Grip criteria to meet to progress to next phase:

1) Minimally meet 70% of 1RM strength targets in Rapid Flexion Test, and 50% targets for Power % of 1RM and Endurance % of 1RM based on pre-injury peak throwing velocity without any pain.

Phase 5: Return to Throw (RTT) Introduction (Weeks 25-30)

Primary Objective:
Introduce throwing with a slow, controlled accumulation of volume and intensity, prioritizing comfort and mechanics over intensity.

Emphasis:

1) **Throwing Program**:
   a) Begin light throwing 3-4 days per week, starting with low volume and intensity.
   b) Focus on comfort, ensuring fluid mechanics and no pain with each throwing session.
   c) Progression scheme that prioritizes volume while only gradually scaling intensity so the athlete accumulates plenty low-stress reps to rebuild comfort, confidence and sharpen throwing mechanics.
   d) Peak throwing intensity in the range of 55-65% of pre-injury throwing velocity.
   e) Consider adding 7–16 oz overload balls to sessions as tolerated. The extra mass safely slows arm speed, cuts elbow torque, and unlocks deeper ROMs without max velocity – encouraging cleaner, non-pushy throwing mechanics. This is particularly useful for athletes who naturally throw hard and find difficulty in reducing intensity to sub 65% with clean throwing mechanics.
   f) Integrate targeted constraint drills – kneeling/half-kneeling throws, 'ten-toes' or pivot-pick stationary throws, and high-arc (> 45°) or preset-layback variations – to quiet the lower half, clean up sequencing, reinforce scapular retraction and forearm layback, and groove efficient, whip-like mechanics instead of "pushy" arm action.
2) **Strength Maintenance**:
   a) Continue strength and power training, focusing on maintaining and progressing strength at ≥ 80% intensity.
   b) FPG enters its three week cycle between maximal strength, power, and endurance training that continues to progress over the duration of the throwing program at a slow and steady rate. Ultimately, FPG device work sees a significant reduction in volume and enters a slow gain/maintenance period from here on out.
3) **Psychological Focus**:
   a) Help athletes regain trust in their arm. Encourage them to focus on the preparation of their arm for this task and recognize they are safe to throw. Being able to eliminate compensatory movements and feel confident in their ability to throw pain-free is critical before moving to the next phase.

Considerations for Progression:

1) Achieve 65% pre-injury velocity.
2) Safely build tolerance to early-stage throwing.
3) Achieve fluid, consistent mechanics, eliminating compensatory motions.

Suggested FlexPro Grip criteria to meet to progress to next phase:

1) Minimally meet 70% of 1RM strength targets in Rapid Flexion Test, 60% of Power % of 1RM targets and 50% Endurance % of 1RM targets based on pre-injury peak throwing velocity without any pain.

Phase 6: Volume Accumulation (Weeks 31-34)

Primary Objective:
Accumulate throwing volume while slowly increasing intensity. The primary focus remains on flat ground work with increased endurance and consistency.

Disclaimer: there is nothing inherently wrong about adding in some mound work during this phase if the rehabbing athlete's FPG test numbers exceed targets such that the athlete is able to progress to Zone 7 throwing (83% of pre-injury max velocity); though, there are multiple considerations to address before doing so. Throwing off the mound has been found to produce lower overall EVT than throwing on flat ground at the same velocity. However, throwing from the slope generally results in higher velocities and potentially increased stress that a rehabbing athlete may not be ready for at this time. Be mindful of the ability to govern intensity, as well as exposure to throwing demands during the introduction and inclusion of throwing from a mound. Self-governance here is key. If the athlete can stay within the session's velocity prescription, more mound throws are beneficial as they will result in less EVT than throws made at the same velocity on flat ground.

Emphasis:

1) **Throwing Program**:
    a) Increase throwing volume gradually, while intensity still progresses slowly.
    b) Continue working primarily on flat ground, focusing on mechanics, consistency, and endurance.
2) **Strength Maintenance**:
    a) Maintain strength and power work, ensuring all metrics stay at high levels to support throwing.
3) **Psychological Focus**:
    a) Athletes might feel frustrated by the slow progress. Emphasize that building consistency and endurance is key to long-term success. Reinforce that patience in this phase will lay a solid foundation for returning to higher intensity work.

Considerations for Progression:

1) Achieve 75-80% pre-injury velocity on flatground with subjective ease and zero discomfort.
2) Athlete adjusts to the increase in volume and intensity.
3) Maintain consistent mechanics during flat ground sessions.

Suggested FlexPro Grip criteria to meet to progress to next phase:

1) Minimally meet 75% of 1RM strength targets in Rapid Flexion Test, 65% of Power % of 1RM targets and 55% Endurance % of 1RM targets based on pre-injury peak throwing velocity without any pain.

Phase 7: Mound Introduction (Weeks 35-38)

Primary Objective:
Reach intensity levels where sub max effort mound throws feel natural. Transition the athlete to throwing on the slope by making 50% of all Zone 7 (83% of pre-injury max velocity) and above

throws from the mound.

Emphasis:

1) **Throwing Program**:
    a) Transition from flat ground to mound work.
    b) Begin with light, controlled mound throws, progressing volume as comfort increases.
2) **Strength Maintenance**:
    a) Continue strength and ballistic work to support throwing performance.
3) **Psychological Focus**:
    a) Athletes may feel pressure to ramp up quickly now that they're back on the mound. Encourage them to trust the slow, controlled build-up, which helps protect their arm and build confidence in their ability to perform without pain. The primary goal of being on the mound is relaxation and producing easy, subtle increases in velocity week over week.

Considerations for Progression:

1) Achieve 80-85% pre-injury velocity on the mound.
2) Smooth transition to mound throws without setbacks.
3) Maintain strength as mound intensity increases.

Suggested FlexPro Grip criteria to meet to progress to next phase:

1) Minimally meet 80% of 1RM strength targets in Rapid Flexion Test, 70% of Power % of 1RM targets and 60% Endurance % of 1RM targets based on pre-injury peak throwing velocity without any pain.

Phase 8: Velocity Progression on Mound (Weeks 39-42)

Primary Objective:

Make at least 50% of all Zone 7 (83% of pre-injury max velocity) and above throws from the mound, while also adding off speed pitches first into light catch play sessions, then from the slope. Doing so exposes the forearm muscles to different force vectors, which will help them adapt in coordination with the rest of the arm structures as intensity and volume increase. If this process starts too late, the athlete may already be throwing harder, with off speed pitches delivered at greater intensity than before, potentially leading to forearm fatigue that could have been prevented.

Emphasis:

1) **Throwing Program**:
    a) Adopt a mound-velocity progression plan: limit weekly gains to no more than 2–3 mph.
    b) For rapid progressors, consider imposing a fixed velocity ceiling for 1-3 weeks, then increase only the number of throws at that speed before nudging the ceiling higher – building throwing fitness and control at each intensity tier.
    c) Start integrating off speed pitches into light catch play sessions to build pitch variety. Thereafter, begin throwing off speed pitches from the slope.

2) **Strength Maintenance**:
    a) Ensure the athlete's strength continues to support increased throwing intensity.
3) **Psychological Focus**:
    a) Athletes may start focusing too much on velocity milestones. Remind them to prioritize easy production of velocity and smooth throwing mechanics rather than solely chasing velocity numbers and over exerting themselves to get there. This may come naturally for some, and others may feel totally out of sync with their body. Remind them that it's been a very long time since they've moved this fast and they may need some time and patience before accessing the easy and efficient patterns we are chasing.

Considerations for Progression:

1) Reach 80-90% of pre-injury velocity.
2) Comfortably integrate off speed pitches into the lower intensity throwing days.
3) As throwing intensity and volume increase, players may plateau or experience a slight setback. Based on objective testing and the subjective feedback of the athlete, adjust programming as needed.

Suggested FlexPro Grip criteria to meet to progress to next phase:

1) Minimally meet 85% of 1RM strength targets in Rapid Flexion Test, 70% of Power % of 1RM targets and 65% Endurance % of 1RM targets based on pre-injury peak throwing velocity without any pain.

Phase 9: Velocity Progression and Pitch Design (Weeks 43-46)

Primary Objective:

Continue progressing velocity, aiming to reach roughly 95% of pre-injury velocity. At this stage, off speed pitches are refined, and pitch design becomes a focal point. The athlete should begin to perform more game-like throwing sessions as they near their full performance levels.

Emphasis:

1) **Velocity Progression**:
    a) Continue velocity progression with the goal of reaching 95% of pre-injury velocity. Focus on consistent mechanics and smooth acceleration.
    b) Increase the intensity and frequency of mound work with undulating peak intensities, ensuring the athlete feels confident and comfortable with their ability to control their velocity.
2) **Pitch Design**:
    a) Begin focusing on refining pitch mechanics and design. Work on off speed pitches, spin rates, and other pitch characteristics to prepare for game situations. Integrate off speed pitches regularly into throwing sessions and on secondary, relatively submaximal mound days.
3) **Strength and Power Maintenance**:
    a) Maintain maximal strength and power training, ensuring that all physical metrics support the higher intensity throwing.
4) **Psychological Focus**:
    a) Athletes may become excited and impatient, pushing harder than necessary

to reach full velocity. Encourage them to stay disciplined and trust the structured progression, reminding them the closer they are to 100%, the more incremental they want their jumps to be. They have plenty of time to develop into their competitive velocity.

Considerations for Progression:

1) Achieve 95% of pre-injury velocity.
2) Successfully integrate and refine off speed pitches and pitch design on secondary mound days.
3) Maintain high-level strength and power to support throwing at increased velocities.

Suggested FlexPro Grip criteria to meet to progress to next phase:

1) Minimally meet 85% of 1RM strength targets in Rapid Flexion Test, 70% of Power % of 1RM targets and 70% Endurance % of 1RM targets based on pre-injury peak throwing velocity without any pain.

Phase 10: Live At-Bats (Live AB) and Skill-Focused Training (Weeks 47-58)

Primary Objective:

The final stage of the RTT program, focusing on the last 5% of velocity gains, live at-bat scenarios, and transitioning to skill-focused training. This is where the athlete prepares to fully return to competition, sharpening their competitive edge and ensuring they can handle the demands of their role.

Emphasis:

1) **Live AB Sessions**:
   a) Begin live at-bat sessions, where the athlete throws to hitters in game-like situations. This is crucial for simulating the pressure and intensity of real competition.
   b) Focus on maintaining pitch command, adjusting to different pitches, and fine-tuning velocity.
2) **Skill-Focused Training**:
   a) Shift towards a skill-centric approach, emphasizing pitch command, pitch sequences, and game strategy.
   b) Incorporate unanticipated, game-like scenarios to test and refine the athlete's ability to respond dynamically in competition.
3) **Velocity and Endurance**:
   a) Continue refining velocity with the goal of achieving 100% pre-injury or even improved velocity.
   b) Focus on endurance during high-intensity sessions to ensure the athlete can maintain performance across multiple innings or throws.
4) **Strength and Power Maintenance:**
   a) While the primary focus shifts to skill and game-readiness, maintain strength and power outputs with a slightly reduced volume. This supports the athlete's overall athleticism and stamina.
5) **Psychological Focus**:
   a) Athletes may feel intense pressure to "prove" themselves during live at-bats. Encourage them to focus on executing their process and staying

present in the moment, trusting that the final gains will come naturally.

Considerations for Progression:

1) Gain the final 5% of velocity, achieving or surpassing pre-injury levels.
2) Successfully complete Live AB sessions, demonstrating consistent performance and game-readiness.
3) Transition fully into skill-focused training, handling the demands of competition without setbacks.
4) Be physically prepared for full in-season demands.

10/27/2025 **Exhibit 6**

BASEBALL REHAB NETWORK GUIDELINES: A ONE PAGE SUMMARY

1) **Surgical Success Defined**
UCL surgery should be judged by a pitcher's ability to return to prior performance, not just return to play. When evaluated using MLB analytics, most pitchers do not return to their pre-injury performance levels.
2) **Flawed Clearance Criteria**
The most commonly used criteria for clearing an athlete to return to throw or competition – time since surgery, joint range of motion, and subjective feedback – fail to assess the most critical factor: whether the forearm flexors are sufficiently strong and stiff enough to protect the UCL from excessive torque. Before clearing a player to returning to competition, it's essential to determine whether the athlete has accumulated enough chronic training volume at competition-level intensity during the return-to-throw process.
3) **Mechanics Have Limits**
While improved biomechanical efficiency may reduce elbow torque, it is unlikely to be the most effective or accessible solution for preventing re-injury.
4) **Neurology vs. Physiology**
Neurological demand exceeding physiological readiness at any point in rehab will result in setback or injury.
5) **Tissue Adapts to Load, Not Rest**
Collagen crosslinking in injured soft tissue is stimulated by mechanical load, not by rest. Incorporating long-duration isometric holds early and consistently in the rehab process promotes collagen crosslinking and builds tissue resilience.
6) **Misvalued Throws in Acute-to-Chronic Workload Models**
The effectiveness of any ACW model depends upon how sub-maximal throws are valued. Most models overvalue these efforts, leading to underloading of the UCL during rehab.
7) **Avoid Gross Throwing Workload Fluctuations**
Use an ACW model that minimizes spikes and troughs to promote steady tissue adaptation.
8) **Return-to-throw Progression**
RTT progressions should be based on the capacity of the MTUs to protect the UCL from the torque imposed on the UCL from increasing velocity and volume.
9) **Velocity-Based Programming**
RTT programs must progressively load tissue to build resilience to throwing stress. Velocity and IMU based approaches are superior to those based on subjective RPE or throwing distance, as they better control for elbow valgus torque (EVT) and provide immediate, objective feedback, improving both precision and adherence to the prescribed workload.
10) **Submax Throwing Has Limits**
There's no evidence that submaximal throwing leads to meaningful adaptation of the UCL or forearm flexors. Use submax throws for recovery, not for building peak throwing capacity.
11) **Rethinking Deloads: Use Data, Not a Calendar**
Preplanned deloads are little more than educated guesses rooted in outdated limitations. Instead, RTT programs should be guided by objective fatigue measures, particularly in the forearm flexors that protect the UCL. A deload should only be considered when clear signs of fatigue or performance decline emerge, as evidenced by tracked data from radar guns, FlexPro Grip, force plates, ball-flight tracking, wearables, and other objective tools.
12) **Best Practice Guidelines**
    a) As soon as rehab begins, identify the strength, power, and endurance requirements of the MTUs best positioned to protect the UCL based on the player's pre-injury max velocity. FlexPro Grip is the only technology available to measure and train these capacities.
    b) Have the athlete train to meet these criteria before both beginning an RTT program and receiving clearance to return to play.
    c) Adopt an RTT program that uses velocity-based progressions (and an IMU if available) to progressively load tissue, minimize workload spikes, and objectively monitor forearm flexor capacity. to protect the UCL. Before clearing an athlete to return to competition, ensure they have accumulated sufficient chronic training volume at competition-level intensity throughout the RTT process.