28 Sport-Specific Rehabilitation After Ulnar Collateral Ligament Surgery

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Introduction

Injury to the ulnar collateral ligament (UCL) occurs secondary to repetitive and/or forceful valgus stress to the human elbow [1]. Initial reports of UCL rupture were published in 1946 by Waris [2] and mainly dealt with a population of 17 elite level javelin throwers. In their systematic review, Vitale and Ahmad [1] reported on 405 patients who underwent UCL reconstructions from studies with mean ages between 17.4 and 24.5 years. Ninety nine percent of these patients were males and the majority of these patients were throwing athletes. Nearly all of the studies reviewed in this paper were baseball players, but some populations did include tennis players, javelin throwers, softball players as well a more traumatic injuries in wrestling and football. For the purposes of this chapter, we discuss mainly sport-specific rehabilitation concepts for the throwing athlete that form by nearly all accounts the vast majority of cases seen in orthopedic and sports medicine settings [1]. This chapter is also meant to compliment the material we have provided in the preceding chapter with more specific rehabilitation principles for treating the overhead athlete following UCL injury.

Sport Specificity Concept

One of the basic tenants of any sports medicine rehabilitation program involves the concept of sport specificity training. Simply stated, this has typically referred to the incorporation of specific exercises and movement progressions that closely simulate the stressors and movement patterns that are encountered in the sport at initially controlled and submaximal levels along a progression continuum to allow athletes to return to their sport. Several recent articles have dealt with the concepts of return to sport [3, 4] and highlight and profile the specific steps undertaken during the often overlooked later stages of the rehabilitation program.

Two important factors should be discussed here before progressing into the specific rehabilitation parameters that will form the later part of this chapter. These are the most commonly considered characteristics/definitions of sport specific rehabilitation and also the less commonly discussed and possibly most important part of sport-specific rehabilitation [5]. The most commonly considered characteristic is that of sport simulation or preparation of the athlete for their activity by focusing on the specific musculature, joint positions, angular velocities, and ultimately simulation of the loads and forces encountered

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Fig. 28.1 90/90 internal rotation plyometric drill with rhythmic stabilization

in their particular sport during the rehabilitation process. An example would be the use of a 90° abducted medicine ball bounce drill that simulates the 90/90 position of arm cocking and early acceleration imparting controlled valgus loads to the medial aspect of the elbow (Fig. 28.1). This exercise specifically mimics the sport activity of throwing as well as replicates to some extent the valgus and extension loads on the elbow. This is a very important part of the process and one that is discussed more in this chapter.

The second and often less commonly discussed part of sport specificity actually focuses not specifically on simulation of the actual movement or skill activity but rather to focus on the musculature and movement patterns that emphasize the stabilizing and controlling aspects that are required for proper deceleration and neuromuscular control of the patients sport activity. An example of this would entail the use of an eccentric deceleration drill with the arm in the 90/90 position focusing on a catch of the ball thrown from behind the patient that results in an eccentric posterior rotator cuff activation and an actual backwards throw after deceleration (i.e., it does not simulate the actual throw used in baseball but rather the opposite of the typical throwing response to improve posterior rotator cuff activation) (Fig. 28.2). Through the use of this type of complimentary exercise, the rehabilitation specialist is actually addressing the need for stabilizing and muscular control and also providing in this case increased posterior rotator cuff activation and strengthening to a patient population that characteristically has imbalances in the external and internal shoulder rotation strength ratio [6–8]. Both parts of sport-specific rehabilitation will be discussed and are critically important parts of the comprehensive rehabilitation program following UCL reconstruction as well.

Kinetic Chain Rehabilitation

Steindler [9] defined the kinetic chain as a "combination of several successively arranged joints constituting a complex motor unit". In rehabilitation, we are completely aware that elbow rehabilitation cannot focus solely on the ulnohumeral articulation but must globally include segments both proximal and distal to the injured elbow [10, 11]. This complementary chapter to the one previous (Wilk et al. Chap. 27) provides greater detail on rehabilitation techniques for the entire upper extremity kinetic chain as well as some core and truly sport-specific exercises that can

Fig. 28.2 **a–c** 90/90 reverse toss plyometric drill for posterior rotator cuff strengthening

be included in the rehabilitation process for the patient following UCL reconstruction.

Proximal Upper Extremity Focus

To allow patients to return to full activity following UCL reconstruction requires rehabilitation of the entire upper extremity kinetic chain. Early in the rehabilitation process following UCL reconstruction, a proximal focus can be undertaken to improve scapular stabilization and proximal strength. The challenge for the clinician is to ensure that loads are minimized to protect the healing graft in the medial elbow. Careful attention to eliminate valgus loads to the elbow is followed; however, many proximal exercise progressions can be used to ensure early activation of the scapulothoracic and rotator cuff musculature without elbow loading. Exercises such as the dynamic isometric scapular retraction exercise using scapular strap (Fig. 28.3), manual scapular protraction, and retraction resistance provided by the therapist (Fig. 28.4) with direct scapular contacts which create scapular activation without elbow loading are recommended. Figure 28.5 shows a serratus punch exercise allowing for serratus anterior activation without elbow loading or movement [12]. Many exercises such as these can be used to facilitate muscular activation of the scapular muscles and can be applied early in the rehabilitation process to address the common finding of scapular dyskinesis in throwing athletes [13, 14]. An extended focus on this region during rehabilitation is an example of sport-specific rehabilitation necessitated by the common finding of scapular dyskinesis in the overhead athlete. Additional exercises outlined by Kibler and colleagues [15] including the robbery, low row, and lawn mower exercise are also important early inclusions in a kinetic chain rehabilitation program.

Fig. 28.3 Scapular retraction walk back isometrics with elastic resistance

Fig. 28.4 Manual scapular retraction provided by a physical therapist

Fig. 28.5 Serratus punch

Fig. 28.6 Horizontal abduction for posterior rotator cuff and scapular strengthening with resistance application proximal to the elbow

Exercise for the rotator cuff is also of critical importance. Research has identified modifications and alterations of the normal unilateral external/internal rotation strength ratios with decreased external rotation strength reported in several studies in elite level throwers [5, 6] and tennis players [16, 17]. Guidelines for inclusion of these exercises include minimization or elimination of elbow loading during early performance through the use of weight application proximal to the ulnohumeral joint. Exercises characterized by high levels of posterior rotator cuff activation include prone horizontal abduction (Fig. 28.6), prone extension [18, 19] in the early phase (weeks 1–6) with the addition of side-lying external rotation, and prone external rotation at 90° abduction are also recommended. Many references exist that cover shoulder rehabilitation with evidence-based exercise progression for the overhead athletes and can serve as a resource for program development following UCL reconstruction [20, 21].

Sport-specific exercise progressions that can commence in the later stages of rehabilitation (12 weeks) for the overhead athlete following UCL reconstruction with respect to the proximal segments of the upper extremity kinetic chain include isokinetic training of shoulder internal and external rotation (Fig. 28.7) simulating shoulder and elbow positions in the cocking and acceleration phases of the throwing [22] and serving position [23]. Additionally, the shoulder internal rotation portion of this training provided a controlled isokinetically resisted valgus load to the elbow while supported in 90° of elbow flexion in preparation for a return to throwing. To provide greater levels of co-contraction and neuromuscular control, Wilk et al. [24] have recommended advanced throwers ten exercises. One example extremely relevant for the proximal aspect of the upper extremity is the 90/90 external rotation exercise performed with elastic resistance (Fig. 28.8). This is a prime example of the integration of sport-specific positioning and movement patterns coupled with a kinetic chain focus to improve or normalize muscular strength ratios in the shoulder and scapular region of the overhead athlete.

Fig. 28.7 Isokinetic internal/external rotation training in 90° of abduction and 90° of elbow flexion

Core and Hip Stabilization of the Overhead Athlete

As mentioned earlier in this chapter, a global, whole body, kinetic chain focus to rehabilitation following UCL reconstruction is recommended

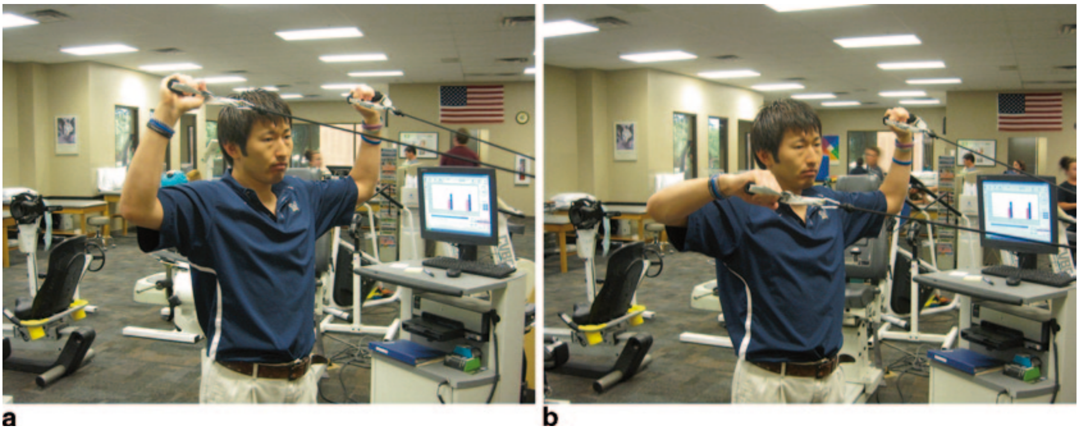

Fig. 28.8 90/90 sustained hold external rotation with elastic resistance. **a** Start position, bilateral shoulders hold contraction in 90° of external rotation while **b** R extremity does dynamic concentric and eccentric contractions of internal and external rotation. Exercise reverses when L shoulder does dynamic movements and R shoulder holds the contraction

[24]. Another key area in addition to early work on the posterior rotator cuff and scapular stabilizers is hip and core strengthening. While it is beyond the scope of this chapter to completely cover these important concepts, it must be emphasized and discussed in any chapter on sport-specific training and rehabilitation for the throwing athlete. The role of the core musculature has been eloquently documented in electromyography (EMG) research showing critically important sequential activation patterns during both the throwing [25], batting [26] as well as tennis serve [27] functional movement patterns. Early and continual focus on these muscle groups is of paramount importance as an adjunct to the more primary rehabilitation methods utilized during rehab following UCL reconstruction (Chap. 27, Wilk et al.).

Many athletes training for sport employ a wide array of sport-specific functional exercises to develop core muscles and enhance core stability. The "core" has been referred to as the lumbopelvic-hip complex, involving the deeper muscles, such as the internal oblique, transversus abdominis, transversospinalis (multifidus, rotatores, semispinalis), quadratus lumborum, and psoas major and minor, and the superficial muscles, such as the rectus abdominis, external oblique, erector spinae (iliocostalis, spinalis, longissimus), latissimus dorsi, gluteus maximus and medius, hamstrings, and rectus femoris [28–30]. We personally consider the core from the superior aspect of the scapula all the way down to pelvis including the proximal hamstrings and quads. This is especially true when training the posterior column of the spine and body. Core muscle development is believed to be important in many functional and athletic activities because core muscle recruitment should enhance core stability and help provide proximal stability to facilitate distal mobility. For optimal core stability, both the smaller deeper core muscles and the larger superficial core muscles must contract in sequence with appropriate timing and tension [31, 32]. Enhanced stability and neuromuscular control of the lumbopelvic-hip complex has been shown to decrease the risk of athletic injuries [33]. Core muscle weakness and deficits in neuromuscular trunk control can increase the injury risk to the trunk and extremities [33]. There are a variety of core exercises employed by athletes to enhance core stability [34–36]. Table 28.1 outlines the characteristic muscle activations during the performance of recommended core exercise progressions followed by a list of basic and core exercises that can be included in any sport-specific rehabilitation program for the throwing athlete. Figures 28.9, 28.10, 28.11, 28.12 and 28.13 display commonly used core exercises that have been studied with EMG demonstrating high activation levels of the core musculature and are recommended for inclusion

Table 28.1 Relative muscle recruitment of the trunk, upper extremity, and lower extremity musculature in swiss ball exercises versus traditional sit-up and crunch

	Upper and lower rectus abdominal muscles	External and internal oblique muscles	Upper extremity muscles	Low back muscles*	Lower extremity muscles
Greatest recruitment (>60% MVIC)*	Pike, rollout	Pike, knee-up, skier	Decline push-up, rollout	Pike, hip extension right	Hip extension left
Intermediate recruitment (31–60% MVIC)	Knee-up, skier, hip extension right, hip extension left, decline push-up, crunch, bent knee sit-up	Rollout, hip extension right, hip extension left, decline push-up, crunch, bent knee sit-up	Pike, knee-up, skier, hip extension right, hip extension left	Knee-up, skier, hip extension left, decline push-up, bent knee sit-up, rollout	Sitting march right, skier, knee-up, pike, bent knee sit-up
Least recruitment (0–30% MVIC)	Sitting march right	Sitting march right	Sitting march right, crunch, bent knee sit-up	Sitting march right, crunch	Crunch, rollout, hip extension right, decline push-up
Core training progression: basic to advanced					
I. Basic exercises and drills					
Supine straight leg bridges					
Supine bridge					
Supine abdominal bracing					
Planks (prone on elbows)					
Unilateral dumbbell hold					
Side lying plank					
II. Intermediate and advanced exercises and drills					
Stability ball rollout on elbows					
Supine bridge into hip abduction					
Russian twists					
Side plank with extremity lift (leg and arm alternating)					
Side plank with shoulder ER with dumbbell					
Unilateral stance on balance pad with elastic resisted abduction/flexion/extension kicks					

* *MVIC* Maximum Voluntary Isometric Contraction

Fig. 28.9 Starting position for the pike, knee-up, skier, decline push-up, hip extension right, and hip extension left

Fig. 28.10 Ending position for the pike

Fig. 28.11 Ending position for the skier

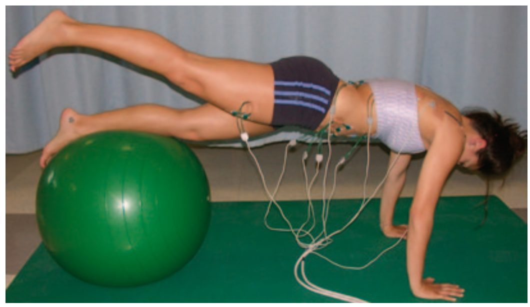

Fig. 28.12 Ending position for the hip extension

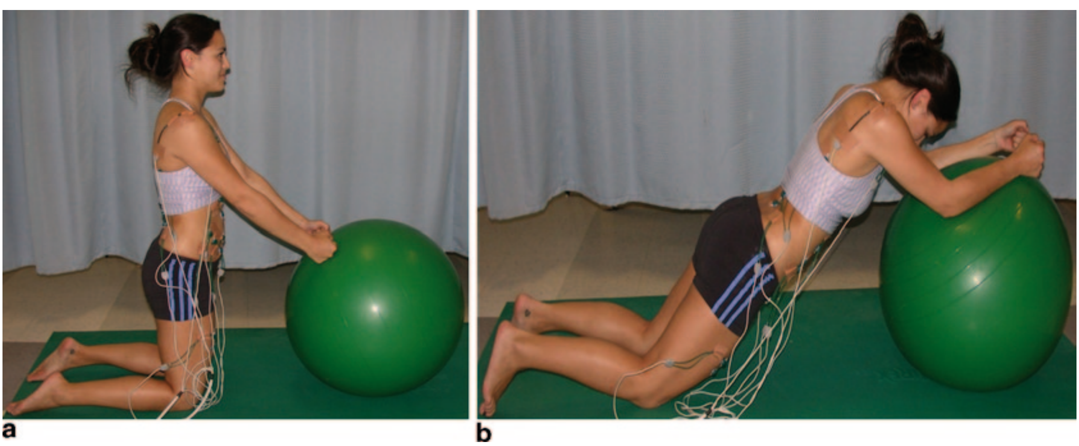

Fig. 28.13 Starting position for the roll-out **a**, ending position for the roll-out **b**

in the comprehensive rehabilitation programs for overhead athletes following UCL injury. Despite the injured or postoperative segment located in the elbow, these core exercises can form a critically important part of the overall program. Early considerations for these exercises include the use of supine exercise for core activation with no weight bearing or loading of the elbow or upper extremity segments. Progression to exercises with upper extremity weight bearing such as the plank progressions and Swiss ball pikes involve upper extremity loading and can be added in the intermediate and advanced stages of the rehab process to further challenge the core but also place gradually increasing levels of upper extremity loading through the ulnohumeral joint.

The inclusion of these exercises in a UCL rehabilitation program for the injured thrower ensures that attention and focus is generated to the additional segments of the body's kinetic chain.

Fig. 28.15 Isolated posterior shoulder stretch with 90° of elevation and scapular stabilization

Glenohumeral Joint Range of Motion

In addition to the attention focused on the elbow, wrist, and forearm for range of motion and mobilization following UCL reconstruction, it is recommended that evaluation and treatment of shoulder range of motion be performed. Use of a technique to measure glenohumeral joint internal and external rotation in the supine position with the scapula stabilized is of critical importance [37, 38] (Fig. 28.14). A "C" shaped stabilization method placing the thumb on the coracoid process and fingers posteriorly along the scapula provide optimal stabilization of the scapula to ensure accurate and reliable measurement of glenohumeral joint internal rotation [37]. Findings of reduced internal rotation range of motion and reduced total rotation range of motion (sum of internal and external rotation) compared to the contralateral uninjured extremity necessitate the use of stretches to improve internal rotation range of motion. Losses of as little as 12° of internal rotation and 5° of total rotation range of motion have been related to shoulder injury in professional baseball pitchers [39]. Additionally Dines et al. [40] have identified internal rotation deficits in professional baseball pitchers with the UCL injury. This important finding shows the importance between proximal shoulder range of motion and stress to the UCL.

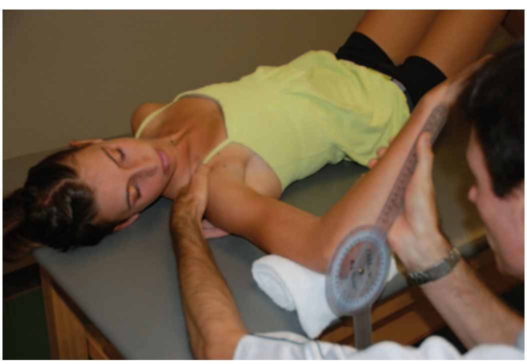

Fig. 28.14 Internal rotation range of motion measurement with scapular stabilization

Methods used and recommended to improve internal rotation range of motion include use of the sleeper stretch [41–43] and cross arm stretch [43, 44] as well as clinical methods performed by physical therapists and athletic trainers such as internal rotation positions with scapular stabilization at 90° of glenohumeral joint abduction (Fig. 28.15).

Functional Activity Progressions (Plyometrics)

One final area of progression to discuss prior to the actual return to sport programs is the use of functional activity progression based on sport-specific rehabilitation training principles. In these exercises, care is taken to simulate and prepare the athlete for the stresses and joint angular velocities that a return to their sport or functional activity will demand. These functional progressions take place after the return of proximal stabilization, and normalized range of motion relationships have been restored. Progression from initially no load (rapid motions) to the use of medicine balls to provide overload are followed.

Throwing Progressions Following UCL Reconstruction

The use of the 90° abducted glenohumeral position is important to simulate the throwing motion. Exercises initially geared at normalizing the external/internal rotator (ER/IR) muscular strength ratio and providing overload to the posterior rotator cuff and scapular musculature are pictured in Figs. 28.2 and 28.16 form a precursor to the internal-rotation-based exercises with valgus overload in Figs. 28.17. and 28.18. Carter et al. [45] have shown that these posterior rotator cuff exercises when coupled with elastic resistance training can provide improvements in concentric and eccentric internal and external rotation strength in addition to increasing throwing velocity. Additionally the use of the "towel drill" is recommended to provide simulation of throwing with a small distal load encountered at impact of the towel with the glove of the therapist (Fig. 28.19).

Fig. 28.16 90/90 ball drop prone plyometric

Fig. 28.17 Internal rotation plyo on plyo-back trampoline

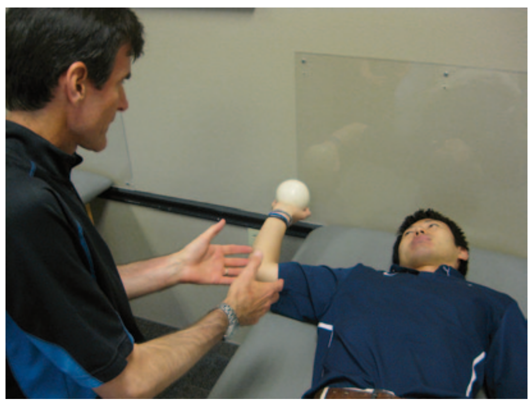

Fig. 28.18 Internal rotation plyo performed in supine position with medicine ball

Batting Progressions Following UCL Reconstruction

Less attention is often focused on the return to batting following UCL reconstruction. Typically, a progression from swinging without ball contact, to hitting off a tee, followed by soft toss, and then

Fig. 28.19 Towel drill: **a** start position, **b** acceleration with goal of snapping towel against glove held by therapist

finally facing a live pitcher in batting practice is recommended and followed [46]. Clinically, medicine balls can be used to load trunk rotation off a plyo back device in addition to simulating valgus loading with the shoulder in more neutral positions of elevation at the side (Fig. 28.20). Additional preparation for batting can be afforded by the use of either elastic or isoinertial devices such as the Impulse (Impulse Inc, Noonan Georgia) where rapid simulation of the batting sequence can be resisted (Fig. 28.21).

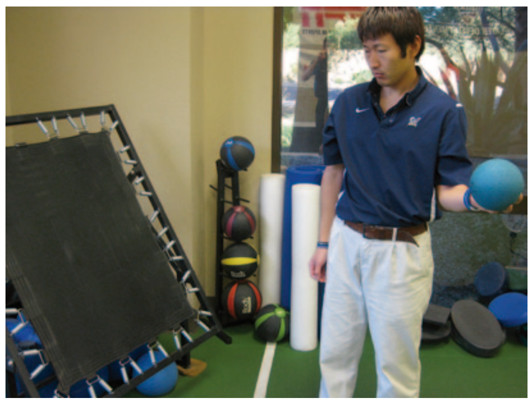

Fig. 28.20 Internal rotation plyometric (arm at side)

Golf Progression Following UCL Reconstruction

Large populations of golfers are not included in many reviews of athletes who suffer UCL injury [1]; however, the trail arm (right arm in a right-handed golfer) can be subjected to medially based loading during the acceleration and contact phases of the golf swing [47]. As such, patients returning to golf would benefit from many of the progressions listed earlier in the batting section. Additionally, the specific characteristics of the golf swing such as a straighter arm at impact compared to batting in baseball, etc., would necessitate the use of more sport-specific applications such as the golf plyometric (Fig. 28.22). Following a return to golf program, such as the one listed in Table 28.2, is recommended to ensure gradual loads are imparted to the medial aspect of the elbow during the return to sport phase of rehabilitation [48].

Fig. 28.21 Impulse batting simulation overload drill

a b

Fig. 28.22 a, b Golf plyo

Tennis Progression Following UCL Reconstruction

UCL injuries are reported in tennis players [1] with both similar valgus loads and elbow flexion positions inherent in the serve and overhand throwing motion [49], as well as unique loading characteristics on the elbow in the forehand and backhand groundstrokes [50]. Similar progressions are followed for serving in tennis players to the material presented in the 90° abducted position with the plyo balls for the throwing athlete. Additionally, to promote coactivation and muscular fatigue both proximally and distally, the statue of liberty exercise (Fig. 28.23) can be used with the oscillation afforded by the flex bar (Thera-band, Performance Health, Akron, OH) with overpressure in both the direction of external rotation (a) and internal rotation (b) to selectively load the medial and lateral aspects of the elbow and provide greater overload for the posterior rotator cuff. Additionally, the use of plyometric groundstroke simulations with alternating patterns of forehand and backhand to challenge foot work and lower extremity movement patterning is highly recommended (Fig. 28.24).

Use of an interval tennis program is also recommended with a more gradual introduction of the forehand groundstroke and greater initial use of the backhand and backhand volley due to smaller medially based loads on the elbow [50] as compared to forehands and forehand volleys. The interval tennis program displayed in Table 28.3 has been modified from other versions previously published [48, 51] for shoulder and nonligamentous injury of the elbow. In addition to the interval tennis program, careful introduction of loading is recommended and can easily be accomplished through the use of foam and low compression balls used in junior tennis player development programs (Fig. 28.25).

Emphasis on Proper Mechanics

One final area to discuss of importance in all sport-specific rehabilitation programs is the use of proper sport biomechanics. This most important element is often neglected in many rehabilitation programs and can lead to nonoptimal results and reinjury/reaggravation following an otherwise successful reconstruction of the UCL. To illustrate this concept and show the role of other body segments and their effect on the shoulder and elbow during the tennis serve the

Table 28.2 Interval golf program. (Adapted from Reinold MM et al. 2002)

	Day 1	Day 2	Day 3
Week 1	10 putts	15 putts	20 putts
	10 chips	15 chips	20 chips
	Rest	Rest	Rest
	15 chips	25 chips	20 putts
			20 chips/rest
			10 chips
			10 short irons
Week 2	20 chips	20 chips	15 short irons
	10 short irons	15 short irons	10 medium irons
	Rest	Rest	Rest
	10 short irons	10 short irons	20 short irons
		15 chips	15 chips
Week 3	15 short irons	15 short irons	15 short irons
	10 med irons/ Rest	10 med irons	10 med irons
	5 long irons	10 long irons/rest	10 long irons/rest
	15 short irons	10 short irons	10 short irons
	Rest	10 med irons	10 med irons
	20 chips	5 long irons	10 long irons
		5 woods (off tee)	10 woods (off tee)
Week 4	15 short irons	Play 9 holes	Play 9 holes
	10 med irons		
	10 long irons		
	10 drives (off tee)		
	Rest/repeat above		
Week 5	Play 9 holes	Play 9 holes	Play 18 holes

Key to golf program: Chips = pitching wedge; short irons = W, 9, 8, medium irons = 7,6,5; long irons = 4,3,2; woods = 3,5; Drives = driverGuidelines for interval golfing program

1) Always monitor and analyze the mechanics of your golf swing. It may be important to have your swing analyzed by a certified teaching professional to optimize your mechanics and minimize injury risk.

2) Allow one day of rest after each hitting session to facilitate recovery.

3) It is important to complete each stage of the program without pain before progressing to the next step.

4) Minor discomfort is expected with the initiation of the return to golf-interval program, this minor discomfort should be intermittent and golf activity and progression should be stopped, if pain is present during the swing or following any stage of the golf program.

5) If pain and or swelling persist, discontinue the program until examined by a medical professional. Resume the program at the last step preceding the offending stage.

results of research by Elliott et al. will be presented [52]. Elliott et al. measured kinetic and kinematic variables of the serve in professional tennis players and characterized them as having either and effective "leg drive" (front knee flexion angle greater than 14.7°) or an ineffective leg drive (maximal front knee flexion less than 14.7°). Most important from an injury prevention risk was the finding in this study of significantly greater medial elbow loading (varus elbow torque 3.9 vs. 5.3 %) when comparing the group with greater knee flexion to the group with less knee flexion, respectively [52]. Additionally, the group with a more effective leg drive showed reduced shoulder internal rotation torques when the shoulder was placed in maximal external rotation than the group of elite players who had less leg drive during their serving motion [52]. This study shows the importance of the use of the entire kinetic chain to produce power during the tennis serve and highlights the ramifications of utilizing a pattern of serving biomechanics for the shoulder elbow when the lower extremity and trunk are not optimally integrated.

Additional research was published by Marshall et al. [53] who used a direct linear transformation

a b

Fig. 28.23 Statue of liberty oscillation exercise; **a** external rotation overload, **b** internal rotation overload

Fig. 28.24 Tennis groundstroke plyometric

(DLT) algorithm with eight markers to study the tennis serve of elite players. Using a simulation of delaying internal rotation of the humerus in the mechanical sequence of proximal to distal events, they produced a simulated load that was characterised by 53 % greater varus torque (valgus load) at the elbow. This simulation was meant to produce a mechanical pattern similar to the one used when the arm lags behind the body similar to hyperangulation and internal rotation of the humerus is delayed in the upper extremity sequence. This rapid humeral internal rotation required to "catch up" resulted in substantially higher medial elbow (valgus loading). These examples are meant to support the need for careful and appropriate biomechanical analysis of the patient's sport performance to ensure proper load sharing by other segments in the kinetic chain as well as proper sequencing and positioning of all segments of the kinetic chain. While the use of high level biomechanical analysis is optimal, it is not practical in many clinical or nonresearch settings, Davis et al. [54] have shown how visual

Table 28.3 Modified interval tennis program for patients following UCL reconstruction or medially based elbow injury

Interval tennis program guidelines
Begin at stage indicated by your physical therapist or doctor.
Do not progress or continue program if medial elbow pain is present.
Always stretch your shoulder, elbow, and wrist before and after the interval program, and perform a whole body dynamic warm-up prior to performing the interval tennis program.
Play on alternate days, giving your body a recovery day between sessions.
Do not use a wallboard or back board as it leads to exaggerated muscle
contraction without rest between strokes. Ball feeds or a ball machine are preferred.
Ice your injured arm after each session of the interval tennis program.
It is highly recommended to have your stroke mechanics formally evaluated by a qualified United States Professional Tennis Association (USPTA) tennis teaching professional.
Do not attempt to impart heavy topspin to your groundstrokes until later stages in the interval program.
Contact your therapist or doctor if you have questions or problems with the interval program.
Do not continue to play if you encounter localized medial elbow joint pain.
Interval tennis program:
Perform each stage ________ times before progressing to the next stage. Do not progress to the next stage if you have pain or excessive fatigue on your previous outing—remain at the previous stage until you can perform that part of the program without fatigue or pain.
Stage1
a. Have a partner feed 20 backhand groundstrokes to you from the net using a foam tennis ball. (Partner must use a slow, looping feed that results in a waist high ball bounce for player contact.)
b. Have a partner feed 20 forehand groundstrokes as in 1a above with a foam tennis ball.
c. Rest 5 min.
d. Repeat 20 backhand feeds as above.
Stage 2
Repeat stage 1 with a low compression tennis ball (i.e., International Tennis Federation, ITF orange ball). (See Fig. 28.25 for tennis ball varieties used during interval tennis programs.)
Stage 3
Repeat stage 1 with a real (regulation) tennis ball.
Stage 4
a. Begin as in stage 3 above, with partner feeding 30 backhands and 10 forehands from the net as a warm-up.
b. Rally with partner from baseline, hitting controlled groundstrokes until you have hit 50–60 strokes. (Alternate between forehands and backhands and allow 20–30 s rest after every 2–3 rallies.) Attempt to hit more backhands than forehands (3:1) ratio on average to provide a more gradual stress to the medial elbow.
c. Rest 5 min.
d. Repeat the rally instructions in “b” above.
Stage 5
a. Rally groundstrokes (forehands and backhands) from the baseline for 15 min.
b. Rest 5 min.
c. Hit 20–25 backhand and 10–15 forehand volleys, emphasizing a contact point in front of your body.
d. Rally groundstrokes for 15 additional minutes from the baseline.
e. Hit another 10–15 forehand and backhand volleys as listed above.
Pre-serve interval: (perform prior to stage 6)
(Note. This can be performed off court and is meant solely to determine readiness for progression into stage 6 of the interval tennis program.)
a. After stretching with racquet in hand, perform serving motion for 10–15 repetitions without a ball or any ball contact.
b. Using a foam ball, hit 10–15 serves without concern for performance result (only focusing on form, contact point, and the presence or absence of symptoms)
c. If successful and pain-free, progress to stage 6.

Table 28.3 (continued)

Stage 6
a. Hit 20–30 min of groundstrokes, mixing in volleys using an 80% groundstroke/20% volley format.
b. Perform 5–10 simulated serves without a ball.
c. Perform 5–10 serves using a foam ball.
d. Perform 10–15 serves using a standard tennis ball at approximately 75% effort. (Note: It is important to hit flat or slice serves not kick serves in the initial phase of the interval tennis program.)
e. Finish with 10–15 min of groundstrokes.
Stage 7
a. Hit 30 min of groundstrokes, mixing in volleys using an 80% groundstroke/20% volley format.
b. Perform 5–10 serves using a foam ball.
c. Perform 10–15 serves using a standard tennis ball at approximately 75% effort. d. Rest 5 min.
e. Perform 10–15 additional serves as in “d” above.
f. Finish with 15–20 min of groundstrokes.
Stage 8
a. Repeat stage 7 listed above increasing the number of serves to 20–25 instead of 10–15.
b. Before resting between serving sessions, have a partner feed easy short lobs to attempt 4–5 controlled overheads.
Stage 9
Prior to attempting match play, complete steps 1–8 without pain or excess fatigue in the upper extremity. Continue to progress the amount of time rallying with groundstrokes and volleys in addition to increasing the number of serves per workout until 60–80 overall serves can be performed interspersed throughout a workout. Initiate kick serves once the initial stages of the program have been completed. Remember that an average of up to 120 serves can be performed in a singles tennis match; therefore, be prepared to gradually increase the number of serves in the interval program before full competitive play is engaged.

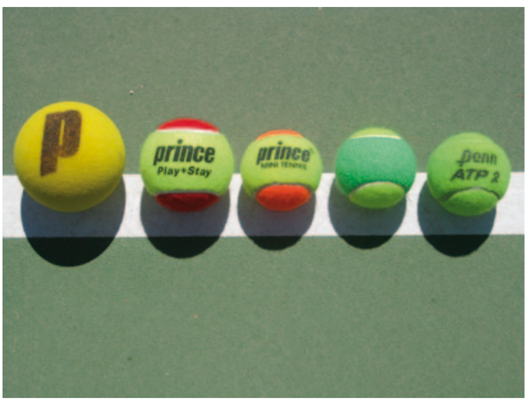

Fig. 28.25 Tennis ball progression (foam, low compression, and regulation)

observation and/or two-dimensional filming can provide meaningful feedback and identification of common flaws in the throwing/pitching motion of young athletes. This important part of the rehabilitation is emphasized and recommended by the authors of this chapter.

Summary

This chapter has provided a review of sport-specific rehabilitation and training principles and contains recommended rehabilitation progressions and kinetic chain interventions for the core, scapula, and glenohumeral regions that are integral parts of a comprehensive rehabilitation program for the patient following UCL reconstructions. Coupled with the protocols, guidelines, and specific rehabilitation interventions in the preceding chapter, these suggested interventions and areas of emphasis can ensure that a comprehensive rehabilitation program is provided for patients following UCL reconstruction.

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