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Return to sport testing at 6 months after arthroscopic shoulder stabilization reveals residual strength and functional deficits

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Objectives: A good outcome after arthroscopic stabilization for recurrent shoulder instability is often characterized by a successful return to sport while minimizing complications. There is currently no consensus regarding timing or objective criteria for return to sport. The objective of this study is to evaluate the ability of postoperative patients to meet expected goals by using standardized objective evaluations of strength and physical function.

Methods: Forty-three (10 females, 76.7% male) subjects (mean age, 18.1 ± 3.7 years) who underwent arthroscopic shoulder stabilization surgery (anterior or posterior) from 2016 until 2018 were referred during their postoperative rehabilitation for functional testing at 6 months postoperatively to evaluate their readiness for return to sport. The Closed Kinetic Chain Upper Extremity Stability test and Unilateral Seated Shot Put test were used to assess shoulder function. Posterior rotator cuff activation was evaluated using a repetition to failure technique with 5% body weight at 0° and 90° of abduction with the goal of 90% of nonoperative extremity. Isokinetic strength testing of external rotation (ER) and internal rotation (IR) was evaluated using a Biodex isokinetic dynamometer at angular velocities of 60° and 180° per second, and a passing score was considered achieving 90% of nonoperative shoulder strength at both 60° and 180° per second.

Results: All subjects were competitive athletes (20 collegiate, 23 high school). The dominant extremity was the surgical extremity in 22 subjects. Only 5 subjects were able to successfully pass the battery of tests for strength and function. Strength testing revealed that 7 patients achieved 90% of the strength of the nonoperative extremity in both repetitions to failure (23 of 43) and comparative isokinetic testing (7 of 43). More subjects were able to meet IR strength (20 of 43) than ER strength (12 of 43) goals. Functional test goals were more frequently achieved, with 26 of 43 subjects meeting both functional test goals (33 Closed Kinetic Chain Upper Extremity Stability, 34 Unilateral Seated Shot Put). Only 2 subjects were able to achieve strength goals but did not pass functional tests, whereas 21 subjects passed functional tests without meeting strength goals.

Conclusion: A substantial number of athletes in our cohort do not meet the expected goals for their operative shoulder in achieving appropriate function and strength, compared with the contralateral shoulder. Functional goals were more often met than strength. IR strength goals were more frequently achieved than ER strength. Strength and functional testing could provide more reliable criteria than arbitrary passage of time for return to play after shoulder stabilization surgery.

The University of Pittsburgh institutional review board approved this study (#PRO18020240).

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Successful return to sport after shoulder stabilization surgery requires re-establishing joint homeostasis. The static stabilizers must heal. The dynamic stabilizers must be restored to preinjury function. Recurrent instability in athletes after surgical stabilization has been reported to range from 3% to 23%.[1,5,15] The rates of returning to the preinjury level of sports participation have ranged from 50% to 80%.[8,12,15]

Much attention in the current literature on recurrent instability has focused on preoperative variables and surgical technique. Recent investigations have highlighted important variables to consider with regard to an open or arthroscopic approach,[11] the number and type of anchors,[1] and concomitant procedures to address variable amounts of glenoid and humeral bone loss.[14] Internal and external rotator weaknesses have been associated with recurrent instability in shoulders before surgical treatment;[6,14,9,20] therefore, modifiable factors during the postoperative recovery may be just as important to recurrence rates and unsuccessful return to sport.

Traditionally, returning an athlete to sports after shoulder stabilization surgery involves assessments of strength and range of motion (ROM). These assessments of strength and ROM may include both a clinician's measurement on physical examination and more standardized assessments by physical therapy, though the clinical utility, reproducibility, and meaningfulness of these assessments have not been established in this setting. Although strength and ROM can be normalized on physical examination, the ultimate assessment of functional ability is often left to coaches and trainers as the athlete returns to the team. Often, time-based restrictions such as 4 to 6 months after surgery are used to protect the athlete before returning to sports, with many surgeons using an arbitrary time point of 5-6 months as an appropriate time to clear for sports participation.[16]

Standardized return to sport testing has been popularized after anterior cruciate ligament (ACL) injury and reconstruction with the goal of reducing recurrent injury rates. In contrast, standard methods of assessing appropriate strength and restoration of functional ability for return to sport have not been established after shoulder stabilization surgery. Strength testing can be objectively measured in isometric, isokinetic, and endurance phases.[6,7,17] In addition, functional tests have been described, which may be useful in the decision pathway for safely returning an athlete to sport.[4,9,17,19]

The purpose of this study was to evaluate the ability of competitive athletes to meet expected goals of strength and function by using a standardized objective return to sport test after rehabilitation for shoulder stabilization surgery. Our hypothesis was that residual deficits would be detected even at 6 months after surgery.

Materials and methods

A retrospective case series was performed on competitive high school and collegiate athletes who underwent primary arthroscopic anterior and/or posterior labral surgery for traumatic dislocation or subluxation injury at our institution by a single surgeon from 2016 to 2018, completed at least 6 months of follow-up, and underwent the return to sport testing battery before formal clearance for return to sport. Patients who performed the return to sport testing after labral surgery with multidirectional instability or ligamentous laxity (2), isolated superior labral tears (1), prior labral surgery (2), or concomitant rotator cuff repair (0) were excluded. Surgical techniques were consistent during the collection period and involved capsulolabral plication and labral repair using suture anchors along the glenoid rim. The subscapularis was not violated during anterior repairs, whereas portals routinely traversed the infraspinatus for posterior repairs.

All patients completed a phased rehabilitation that was standard for our posterior and anterior labral repair surgery. Phase 1 (weeks 0-6) involved sling use for 4 weeks, avoidance of active ROM, and motion restrictions, including limited external rotation (ER) to 30° (primary anterior repairs) and avoidance of cross-adduction and internal rotation (IR) past midline (primary posterior repairs). Scapular posture and mobility were the focus of phase 1. Rotator cuff isometric exercises began at 4 weeks postoperatively. During the second phase (week 6-12), procedure-specific restrictions were removed and there was a gradual increase in ROM to goal and submaximal tissue loading. Dynamic stabilization and posture were the focus of phase 2. Neuromuscular control was the goal for week 12. Phase 3 lasted from week 12 until 24 weeks or beyond. This is where exercises focused on the normalization of strength and neuromuscular control. Beyond 12 weeks, athletes were allowed to begin working on developing power for higher level, sport-specific activities. Return to sport testing was performed at least 6 months postoperatively.

Strength was evaluated by isokinetic IR and ER, as well as the External Rotation Endurance test (ERET). The goal of strength testing was to reach 90% of the values for the contralateral extremity. Isokinetic IR and ER were measured on a Biodex isokinetic dynamometer (Biodex Corporation, Shirley, NY, USA) using peak torque at 60°/s and 180°/s (see Fig. 1). The ERET involved repetitions to failure with 5% of body weight at 0° of abduction (side-lying) and also at 90° of abduction (prone).

Figure 1 Isokinetic external and internal rotational strength was evaluated using a Biodex isokinetic dynamometer (Biodex Corporation). The patients were seated with their shoulders in a neutral position, at 45° of abduction, and with elbows at 90° of flexion. Strength was measured at angular velocities of 60° and 180°. After conditioning, 5 trials were performed and averaged for each phase.

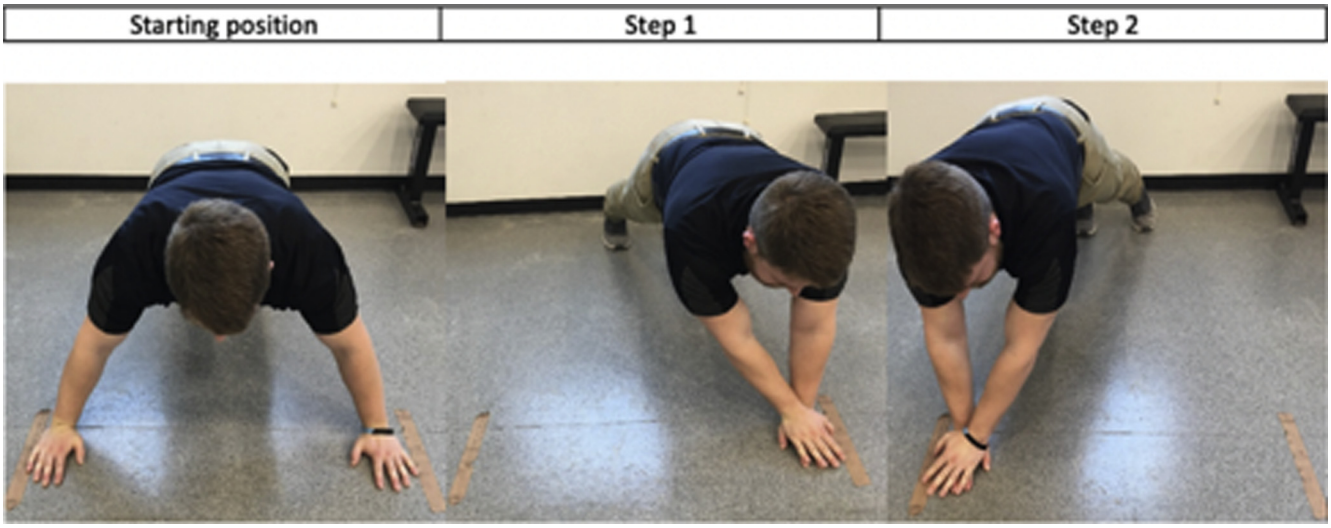

Figure 2 The Closed Kinetic Chain Upper Extremity Stability test is performed in a push-up position and measured by alternating touches.

Tests of function included the Closed Kinetic Chain Upper Extremity Stability (CKCUES) test and the Unilateral Seated Shot Put (USS) test. The CKCUES test involves an alternating touch and push-up position (see Fig. 2). Touches were measured across 3 rounds of 15 seconds with a 45-second break. The average of the 3 rounds was used for the final score. Scores were tabulated and touches per 15 seconds. One touch was defined as moving one hand from the floor to the contralateral hand and back. The results of the CKCUES test were compared against reference values determined from healthy and active males and females.[9,19] A passing score was greater than or equal to 21 touches, which represented the 75th percentile for active females and 85th percentile for active males.[9] The USS test was performed using a 6-pound medicine ball and was scored for distance (see Fig. 3). The goal was 90% of the distance of the nonoperative extremity, with a 10% adjustment for hand dominance.[4] The test was performed with the back flat against the wall and knees flexed at 90° on the floor. The mean distance of 3 trials was measured, and there were 30-second rests between each trial.

Statistical analysis

The pooled analysis of the isokinetic strength testing was performed with a paired *t*-test, which was performed to evaluate the difference between the involved and noninvolved extremity for each movement/speed. Simple summary statistics on pass/fail rates were reported. The comparison of proportions of pass/fail per repair type was evaluated with Fisher's exact test. Intrasession reliability for the CKCUES test was calculated as intraclass correlation coefficient, mixed model, and absolute agreement.

Figure 3 Unilateral Seated Shot Put test was performed using a 6-pound medicine ball and was scored for distance, with a 10% adjustment for hand dominance.

Table I Comparison of mean peak torque with contralateral extremity

Comparison of mean peak torque of operative vs. nonoperative extremity			
	Operative	Nonoperative	*P* value
ER 60	19.4	22.5	**.002**
ER 180	17.9	19.6	**.010**
IR 60	35.8	38.9	**.005**
IR 180	32.3	33.1	.380

ER, external rotation; *IR*, internal rotation. Bold indicates $P < 0.05$.

Results

A total of 43 individual athletes completed the return to sport testing battery. The average age was 18.1 (15.1-21.8) years. There were 33 (77%) males and 10 females. Approximately half of the athletes were collegiate athletes (n = 20), with the remainder being high school level athletes. The involved shoulder was the dominant shoulder in 51% of the individuals. A majority of the individuals underwent anterior stabilization surgery (n = 19), followed by posterior stabilization surgery (n = 15), followed by combined anterior-posterior repairs (n = 9) due to an extension of the primary pathology. Five individuals had superior labral repair concomitant with an anterior (2) or posterior labral repair (2) or both (1), due to extensions of the primary labral injury into the superior labrum. The athletes were most commonly involved with football (24), soccer (4), baseball (6), and other sports such as golf, basketball, gymnastics, and swimming (total, 9).

Isokinetic strength testing demonstrated that the mean peak torque of the operative extremity was significantly less than the nonoperative extremity for ER at 60°/s (19.4 vs. 22.5, $P = .002$), ER at 180°/s (17.9 vs. 19.6, $P = .010$), and IR at 60°/s (35.8 vs. 38.9, $P = .005$) (see Table I). IR at 180°/s was not significantly different (32.3 vs. 33.1, $P = .380$).

More subjects were able to meet IR strength goals of 90% of peak torque of the contralateral extremity (20/43) than ER strength goals (12 of 43) at both 60°/s and 180°/s. Results of each phase are displayed in Fig. 4. More than half of individuals failed in ER at both 60°/s (22 of 43, 51%) and 180°/s (24 of 43, 56%). Subjects were more likely to achieve IR goals with 17 of 43 (40%) failing at 60°/s and 13 of 43 (30%) failing at 180°/s. Only 7 (16%) subjects were able to pass all 4 phases of isokinetic testing, whereas 11 subjects failed by only 1 phase.

The failure rate for the ERET was similar at 0° (12 of 43, 28%) and 90° (14 of 43, 33%) of abduction in repetitions to failure (see Fig. 5). Twenty-three of 43 individuals (53.5%) failed at least 1 phase of endurance testing, whereas 6 individuals failed both. No difference was found comparing the proportions of individuals passing the strength tests, based on repair type (anterior 2 of 19, posterior 3 of 15, combined 2 of 9; $P = .7414$).

Functional tests showed lower failure rates. The mean number of touches for the CKCUES test was 23.4 ± 3.6, and 10 subjects (23%) did not meet the goal of 21 touches. Nine subjects (21%) failed to achieve the goal of 90% of the contralateral distance on the USS test. The intrasession reliability of the USS test was favorable (intraclass correlation coefficient, 0.86 [0.62-0.95]). Seventeen subjects (40%) failed at least 1 of the 2 functional tests, whereas 26 (60%) passed both CKCUES and USS tests (see Fig. 6). No difference was found comparing the proportions of individuals passing the functional tests, based on repair type

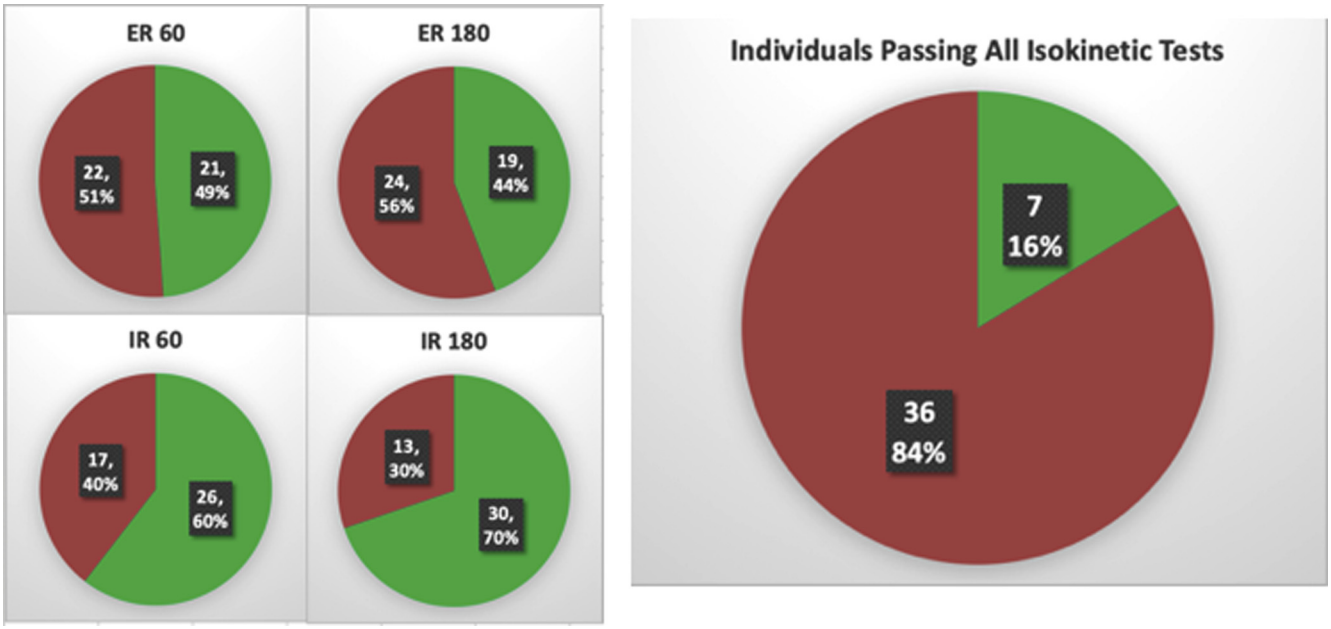

Figure 4 Results of isokinetic strength testing. The operative extremity was compared with the nonoperative extremity. To pass, the operative extremity must achieve 90% of the isokinetic strength value of the nonoperative extremity. *ER*, external rotation; *IR*, internal rotation. Green indicates proportion of passed tests.

(anterior 10 of 19, posterior 7 of 15, combined 5 of 9; $P = .928$).

The majority of individuals (38 subjects, 88.4%) failed at least 1 of the tests. Strength testing revealed that 7 subjects (16%) achieved the goal of 90% of the strength of the nonoperative extremity in both the ERET (23 of 43, 53%) and the Isokinetic Peak Torque test (7 of 43, 16%). Functional tests were more frequently achieved, with 26 of 43 subjects (60%) meeting both functional tests: 33 individuals passed the CKCUES test and 34 individuals passed the USS test. Only 2 subjects (5%) achieved strength goals but did not pass the functional tests. Conversely, 21 subjects (49%) passed functional tests without meeting the strength goals.

Discussion

At 6 months after arthroscopic shoulder stabilization, a substantial number of athletes, 88.4%, in our cohort, do not meet the expected goals for their operative shoulder in achieving appropriate function and strength when using an objective, criteria-based return to sport testing protocol. Compared with the contralateral extremity, strength deficits were seen in a majority of individuals tested with isokinetic and endurance strength measurements. Despite the measurable deficits, some subjects were able to pass functional testing. The results of our study suggest that athletes may be able to compensate functionally for focal and detectable strength deficits. These deficits call into question whether patients who look well on physical examination at 6 months postoperatively are truly ready to return to sports. Although the clinical relevance of these findings is unknown, our results suggest that many athletes who would otherwise be cleared to return to sports at 6 months demonstrate deficits that are detectable through functional testing. Standardized testing with objective measurements of strength and function may more accurately define the athlete's readiness to return to sport than time from surgery.

Several studies have identified the loss of isokinetic muscle strength as a contributor to recurrent instability in the preoperative state.[3,6,9,12,20] Therefore, optimal postoperative recovery should strive for restoration of isokinetic strength. Manual muscle testing may be insufficient for evaluating rotational strength before return to competitive sports. Compared with manual muscle testing, isokinetic dynamometry is able to assess for rotational strength while controlling for position, ROM, speed, rotational forces, and translational stresses.[7] In addition, the purpose of the ERET was aimed at evaluating the rate of fatigue of the postoperative shoulder girdle, which is another component of strength that should be considered in final stages of rehabilitation before returning to sport.

Strength recovery after shoulder stabilization surgery has been previously evaluated in limited studies. Rhee et al[18] reported faster return of strength in arthroscopic surgery vs. open anterior stabilization, with restoration of strength to 89%-90% of the uninvolved shoulder by isometric testing. In their cohort study, isokinetic testing was

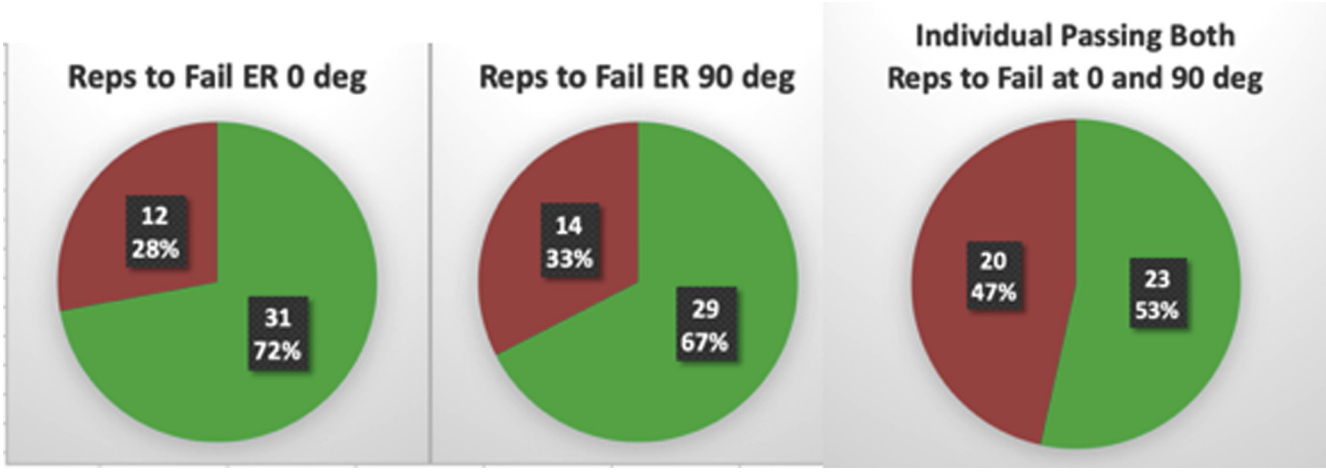

Figure 5 Results of the External Rotation test. *ER*, external rotation. Green indicates proportion of passed tests.

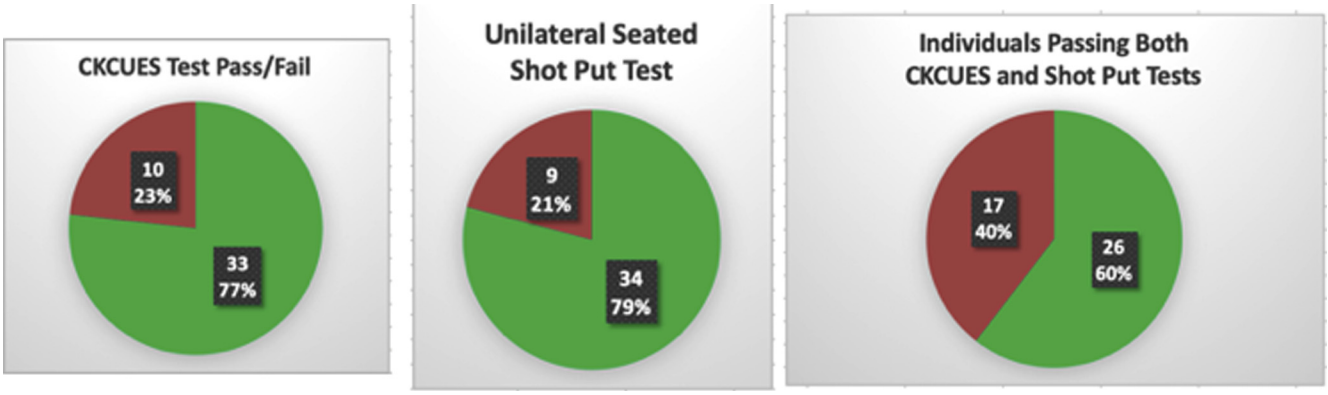

Figure 6 Results of functional testing for the CKCUES test and USS test. *CKCUES*, Closed Kinetic Chain Upper Extremity Stability; *USS*, Unilateral Seated Shot Put. Green indicates proportion of passed tests.

used to evaluate recovery of shoulder muscle rotational strength after both open and arthroscopic shoulder anterior stabilization surgeries.[18] Amako et al[2] reported that the ratio of peak torque on the operative shoulder to the contralateral shoulder measured with isokinetic dynamometry was not significantly different than preoperative levels by 4.5 months in a consecutive series of arthroscopic anterior stabilization subjects. The preoperative contralateral peak torque ratio was found to be 0.9 for both IR and ER.[2] Failure to restore to 90% of peak torque of the contralateral shoulder by 6 months seen in our series may differ from these findings due to differences in sample populations and rehabilitation protocols. It is possible that this series had a more significant initial strength deficit, but unfortunately preoperative and preinjury measurements were not possible. The Amako et al[2] sample population is predominantly male (95% vs. 77%). In addition, the follow-up testing rate is below 80%, leaving a potential for selection bias. In this study, we used simple comparison to the uninvolved shoulder with a 10% variance at the time of testing as a practical benchmark for trainers and therapists to apply during the rehabilitation process.

The high failure rate in this series may certainly be attributed to strict criteria for defining a test as passed. Although the thresholds were chosen for what would be reasonably expected for relatively young competitive athletes, the utility and clinical importance of meeting these thresholds remain unknown. The 90% of contralateral strength was chosen as a practical target and to match the benchmark of a limb symmetry index >90% that is established in ACL return to sport testing literature.[13,15] The CKCUES test goal of 21 touches was chosen based on previous studies, and marks the 75th percentile for active females and 85th percentile for active males.[18] Tucci et al[19] established high reliability when assessing sedentary and recreational athletes, with and without shoulder impingement syndrome. The threshold for competitive athletes would be expected to be even higher, as demonstrated by Goldbeck and Davies,[9] who found that college-age males had a test mean above 27 touches. The 90% of

contralateral distance with 10% adjustment for dominance threshold for the USS test was chosen to align with strength goals. The 10% difference between dominant and nondominant extremities was established in a cross-sectional study of 125 college-age athletes, adjusted for antropometric measures.[4]

The high failure rate for strength and functional tests at 6 months postoperatively in our results is similar to standardized testing of ACL subjects evaluated for return to sport. The Delaware-Oslo ACL cohort demonstrated disappointing results with standardized testing at 6 months, with 90% failing the return to sport testing at 6 months.[10] Meanwhile, greater than 50% of the Delaware-Oslo ACL cohort reported normal knee function on subjective measures.[15] Importantly, this study demonstrated that reinjury was substantially reduced with the delay in return to sport to 9 months irrespective of the results of the return to sport testing.[10]

The clinical significance of this retrospective cohort study remains unknown, and further investigation is warranted. The sample included a small cohort of athletic patients who underwent rehabilitation at 1 facility. Preinjury performance on the testing and compliance with physical therapy was not able to be evaluated. In addition, a prospective, randomized control group was not readily available. Whether criteria-based testing may be used to guide rehabilitation during the final phases of rehabilitation or whether return to sport testing plays a role in decreasing recurrence rates remains the target of future studies. Future directions should also focus on efforts to identify and refine those measures that are most accurate and clinically important. Eventually, return to sport testing vs. time-based criteria for clearance should be correlated to clinical outcomes and rates of recurrent instability.

Conclusion

A substantial number of athletes in our cohort do not meet the expected goals for their operative shoulder in achieving appropriate function and strength, compared with the contralateral shoulder. Functional goals were more often met than strength. IR strength goals were more frequently achieved than ER strength. Strength and functional testing could provide more reliable criteria than arbitrary passage of time for return to play after shoulder stabilization surgery.

Disclaimer

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