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CLINICAL COMMENTARY

RETURN TO SPORT PARTICIPATION CRITERIA FOLLOWING SHOULDER INJURY: A CLINICAL COMMENTARY

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ABSTRACT

Context: The shoulder complex is frequently injured during sports. The tremendous mobility of the shoulder makes returning to sport participation following shoulder injury a challenging task for both the clinician and athlete. The purpose of this clinical commentary is to review the current literature on return to sport criteria and provide evidence-informed and clinically useful guidelines and recommendations to aid in clinical decision making for return to sports after shoulder micro- and macro-traumatic injuries.

Evidence Acquisition: A search of the PubMed database using the terms functional tests, upper extremity testing, return to play, and shoulder injury was performed. Further evaluation of the bibliographies of the identified articles expanded the evidence. This evidence was used to inform the clinical commentary.

Results: Return to sport decision making is a sequential, criterion-based process. Assessment of patient reported outcomes, range of motion, strength, and functional performance must all be considered. Numerous tests are available for the clinician to determine whether a patient is ready to return to sports following a shoulder injury or surgery. A different set of tests should be utilized for the overhead athlete (microtrauma injury) compared to the patient with a macrotraumatic shoulder injury because of the differing demands and sports requirements.

Conclusion: Use of pre-determined criteria, available in the literature, minimizes the reliance on the subjective element alone during takes athlete progression and provides everyone involved in the process with known, pre-established, measurable markers and goals that must be achieved prior to progressing to practice and returning to competition. This type of performance progression assessment testing provides the clinician with a useful set of tools to objectively assist and guide the determination regarding when an athlete can safely progress back to practice and then return to unrestricted athletic activities

Level of evidence: 5

Keywords: Glenohumeral joint, return to play, overhead athlete, functional tests, rehabilitation, movement system

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INTRODUCTION

The shoulder complex is frequently injured during sports and everyday activities. In sports like baseball, the shoulder produces the highest angular velocities of any human movement (greater than 7,200 °/s)[1] and places tremendous stress on the shoulder complex (Up to 1x body weight), making the it susceptible to various non-contact injuries. At the NFL combine 9.7% of athletes had shoulder instability and shoulder stabilization procedures were in the top four most commonly performed surgical procedures.[2] The shoulder has the greatest range of motion of any joint in the human body. This tremendous mobility makes returning to sport participation following a shoulder injury, whether non-operative or post-operative, contact or non-contact, a challenging task for both the clinician and the athlete.

"When can I play again?" This is possibly the most frequently asked question by an athlete following any type of injury. The simple answer is the athlete can resume athletic activity again when they are ready and not before. While this answer may sound flippant, it is in fact very true. Nothing is more demoralizing to an athlete, and produces a more problematic set back in the rehabilitation process than developing reactive symptoms when trying to resume athletic activity before an athlete is functionally ready and capable. Additionally, the use of time as the sole determination of when an athlete may resume practice or play following a shoulder injury or surgery is a critical error. The time from the injury itself is not the primary element that will determine readiness to return to practice or competition. The recovery and return to play of an athlete after injury is a multifaceted clinical decision. However, because of soft tissue healing constraints, it is also important to consider the temporal aspects, particularly following surgery.

Alentorn-Geli et al studied return to sport after arthroscopic shoulder capsulolabral repair and reported an 86% return to sport with 73% of the subjects returning to the same level of play.[3] Return to sport was allowed once pain free range of motion and $\geq$80% of strength compared with the contralateral side was achieved.[3] Similarly a study assessing return to sport after arthroscopic shoulder plication for multidirectional instability reported a 90% return to the same level of play.[4] Return to play was determined by range of motion, time from surgery (three months for non-contact and six months contact sports), and the Oxford Instability scores pre- and post-operatively.[4] However, recently Aboaloata et al[5] reported a return to the same level of sport at significantly lower rates in a study looking at the long term outcomes after arthroscopic Bankart repair for anterior-inferior shoulder instability. This case series evaluated the results of 143 cases with an average follow up of 13.3 years. While the results of the study revealed a high rate of patient satisfaction at 92.3%, the return to sport at the same level was only 49.5%.[5] The cessation of rehabilitation was determined by presence of dyskinesia, subjective apprehension, and presence of range of motion deficits, or lack thereof.[5] No mention was made of functional testing or sport specific testing being assessed prior to discontinuing rehabilitation. This suggests that while the overall satisfaction was high, return to sport could have possibly been higher had a comprehensive criteria-based approach been utilized to determine cessation of rehabilitation. Also of interest, those who performed rehabilitation for less than six months had a significant reinjury rate compared to those who performed physical therapy greater than six months, 23.1% and 9.6% respectively.[5] Thorsness et al[6] has also illustrated that return to play outcomes are often poorly described when evaluating overhead athletes specifically.

Advocacy for the use of subjective rating via the Numeric Pain Rating Scale (NPRS) or Visual Analog Scale (VAS), objective criteria, patient reported outcomes including those related to athlete confidence, and the successful performance of specific objective functional tests should be promoted by all sports physical therapists, in order to determine when an athlete is ready to begin practice and return to participation. Using specific criteria to progress an athlete through the rehabilitation course assists in guiding the process and in progressing the athlete only when they are physically capable of advancement, rather than based solely on an arbitrary time frame.

Using specific objective functional tests and predetermined criteria minimizes the reliance on the subjective element alone during athlete progression

and provides everyone involved in the process with known, pre-established, measurable markers and goals that must be achieved prior to progressing to practice and returning to competition. An objective format, using a criterion-based process, serves both to motivate the athlete and to eliminate as much of the guesswork as possible out of answering the question of, "when can I play again?" In addition, subjective patient reported outcomes (PROs) including the athlete/patient's psychological feedback are also necessary. The patient must return to sport without the fear of re-injury (kinesiophobia), fear that the shoulder is not ready, or any apprehension during shoulder movement. Such considerations are well reported in the knee literature following ACL injury and surgery[7,8] and should be applied to return after shoulder injury and surgery. Tjong and colleagues[9] conducted a case series of 25 patients after arthroscopic Bankart repair and detailed the multimodal factors that contribute to return to sport. Although functional scores and stability were good there was only a 44% return to sport. Fear of re-injury (kinesiophobia) was one of the most common concerns discussed by all patients who had returned to sport at some capacity as well as those who returned to the same level or higher. The participants recalled their apprehension with shoulder use that they initially felt after injury and described the same apprehension with returning to sport and not all were able to overcome this intrinsic fear.[9]

The purpose of this clinical commentary was to review the current literature on return to sport criteria and provide evidence-informed and clinically useful guidelines and recommendations to aid in clinical decision making for return to sports after shoulder micro- and macro-traumatic injuries. A select number of functional tests for assessing the overhead athlete's shoulder (microtrauma) and the shoulder after macro traumatic injury will be described followed by brief mention of additional relevant tests described within the literature. The current literature has over 500 articles written on return to play guidelines, criteria, and suggestions following knee injuries; whereas by comparison articles addressing return to play following shoulder injury are lacking in volume. Finally, the tests the authors prefer to use will be discussed.

RETURN TO PARTICIPATION PROCESS AND CRITERIA

The transition from rehabilitation back to sport following a shoulder injury or surgery follows three sequential steps. The first is a return to high-level performance rehabilitation and training. The second step is the resumption of participation in practice that sequentially progresses from limited, controlled activity to unrestricted practice. Finally, the third step is a return to unrestricted participation and competitive play. This program is referred to as the "3 P Program: Performance, Practice and Play" (Table 1). The first two steps must be successfully accomplished prior to the athlete attempting any level of unrestricted play.[7]

P1: Performance Training. The first step in the sequential progression of shoulder injury rehabilitation involves the restoration of function through sport-specific training for athletes returning to competition. This must include the ability to successfully and asymptomatically perform sports specific drills including plyometrics, agility drills, end range proprioceptive exercises, and perturbation drills in the clinical setting. These drills differ by sport and activity but should mimic the activity demands and nature of the sport in a progressive and sequential manner. During this mode of training the specific movement patterns required for asymptomatic shoulder function are learned and integrated. A progression of challenges is provided in a controlled setting that focuses on achieving and maintaining end-range stability during challenging athletic activities similar to those encountered during competition.

P2: Practice Participation. Next an athlete advances from the performance training phase of rehabilitation into controlled participation in a practice setting. This process involves the gradual progression of participation via sequentially increasing the volume/dosage, including time, intensity, and repetitions performed by the athlete during practice. This progression begins at lower intensities and gradually increases from 50-60% up to a 75% level, advancing to 80-90% and finally 100% effort and exertion. Once 100% intensity and effort are obtained in practice the athlete should be advanced to a practice game or scrimmage activities. In addition, in

Table 1. *The 3 P Program.*	
3 P Program: Performance, Practice and Play	
P1: Performance Training	Restoration of function through sport-specific training for athletes returning to competition
P2: Practice Participation	Gradual progression of participation via sequentially increasing the time, intensity and repetitions performed by the athlete during practice.
P3: Play	Following the successful advancement through a controlled practice progression the athlete is evaluated for readiness to resume competition in game situations at 100% effort.
RETURN TO PARTICIPATION CRITERIA	
1) Appropriate time from injury or surgery for healing	
2) Successful completion of a formal rehabilitation program	
3) Full sport-specific non-painful ROM	
4) Excellent stability with no pain during special tests	
5) Strength which meets specific participation criteria	
6) Satisfactory scores on functional tests	
7) Sport specific testing	
8) Acceptable patient reported subjective score	
9) Patient has no kinesiophobia (assessed with the Tampa Kinesiophobia Index)	

this practice phase exposure time is also controlled, to gradually improve endurance. For example in baseball, a pitcher would be placed on a pitch count and in football, the player will be on a play count or time monitored program.

P3: Play. Following the successful advancement through a controlled practice progression the athlete is evaluated for readiness to resume competition in game situations at 100% effort.

Successfully advancing functional activity beyond performance training back into participation in practice and then competitive play, requires more than just a decision based on subjective criteria, such as how the athlete says their shoulder feels. The complex nature of progressing an athlete back into unrestricted participation following any shoulder injury or surgery requires assessing and measuring the key functional elements necessary for symptom-free athletic performance of the shoulder and upper extremity. The athlete must also demonstrate sufficient confidence in the affected extremity to successfully return to sport without any fears or limitations. The criteria evaluated to assist in determining when an athlete can return to practice and then unrestricted competition are presented in Table 1.

A battery of tests is incorporated that are designed to determine activity readiness prior to the introduction of demanding functional athletic practice or competitive participation to reduce the risk of re-injury or contralateral injury as well as promote psychological confidence in the involved shoulder. The program described herein rank-orders the relative demand of functional activities required for athletic participation and guides advancement back to unlimited activity via defined criteria to determine readiness for resuming practice and then unrestricted participation following shoulder injury. The tests performed and criteria used to progress an athlete back to participation in practice and then competition are outlined in Tables 2 and 3.

Patient Reported Outcome Tools

The American Shoulder and Elbow Surgeons (ASES) Shoulder Score assessment tool is administered to

Table 2. *Criteria to begin participation in practice.*

- Western Ontario Shoulder Index (WOSI) Shoulder Score of ≥ 90
- Full, non-painful passive range of motion (PROM)
- Satisfactory clinical examination without positive findings or apprehension
- Ball Drop Test: 90% involved to uninvolved
- Push-up Test: Ability to perform more repetitions in second testing bout
- Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST) ≥ 21 repetitions
- Bench Press ≥ 75% of pre-injury 1 repetition maximum (1RM) without substitution
- Unilateral Pulling Assessment (>95% limb symmetry index)
- Unilateral Pushing Assessment (>95% limb symmetry index)
- Isokinetic test that fulfills criteria (Bilateral comparisons for limb symmetry index, Unilateral ratios, allometric scaling, sport specific normative data, position specific normative data)

Table 3. *Clearance Criteria for Return to Sport.*

- Western Ontario Shoulder Index (WOSI) Shoulder Score of ≥ 95
- Full, non-painful passive range of motion (PROM)
- Satisfactory clinical examination without positive findings or apprehension
- Ball Drop Test: 100% involved to uninvolved
- Push-up Test: Ability to perform more repetitions in second testing bout
- Closed Kinetic Chain Upper Extremity Stability Test ≥ 25 repetitions
- Bench Press ≥ 95% of pre-injury 1 repetition maximum (1RM) without substitution
- Unilateral Pulling Assessment (>100% limb symmetry index)
- Unilateral Pushing Assessment (>100% limb symmetry index)
- Isokinetic test that fulfills criteria
    - External rotator peak torque/Body weight ratio @180°/sec: 18-23%
    - Internal rotator peak torque/Body weight ratio@ 180°/sec: 26-32%
    - External Rotation/Internal Rotation (ER/IR) ratios @180°/sec: 72-76%
    - Bilateral comparison: ER 95-100%, IR 100-110%
    - No pain or apprehension during test

assist in determining the athlete's self-assessment of the functional status and confidence in their shoulder. Patient's self-reported functional scoring can be performed with one of these two self-assessments: The Western Ontario Shoulder Instability Index (WOSI) or the Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow Score (KJOC). Kirkley et al.[10] developed the WOSI. It includes 21 questions which evaluate components of the patient's physical and psychological status (Appendix A). Alberta et al.[11] developed the KJOC self-assessment for overhead athletes. This evaluation form is beneficial for the overhead athlete who has been treated for shoulder injury or instability. (Appendix B)

The Design and Testing of the Degree of Shoulder Involvement in Sports (DOSIS) scale by Blonna et al.[12] was developed to assess athletes affected by shoulder instability. It was based on three parameters: 1) Type of sport, 2) Frequency with which the sport is played, and 3) Level at which sport is played. It was developed with 85 patients who were affected by recurrent anterior shoulder instability who underwent either a Bristow-Latarjet procedure (41/85) or Bankart repair (44/85). The average age of follow up was 33 years old (range 19-63 years). The scale showed good criterion validity when compared against the Tegner activity scale. The test-retest reliability using ICCs was found to be 0.96. Blonna et al. reported that it represented acceptable psychometric features and was a valid instrument for shoulder assessment after instability. The DOSIS scale is another scale that can be used for sport-specific shoulder assessment following surgical procedures that address anterior shoulder instability.

Range of Motion (ROM)

Active and passive ROM of the shoulder is evaluated to ensure that the athlete exhibits full sport-specific,

non-painful and non-apprehensive ROM of the shoulder joint. Elevation, internal and external rotation (ER) in the supine 90/90 position, as well as, horizontal abduction and adduction are all assessed. The athlete should also present with a normal clinical examination including, no pain, tenderness, apprehension or other abnormal findings, particularly in the assessment of provocative instability signs. In patients who have experienced episodes of instability, it is important to evaluate apprehensiveness with passive external rotation ROM.

Overview of Functional Tests Described in the Literature

Recommended Functional Tests and Range of Motion for the Overhead Athlete (Microtrauma) (Table 4)

Range of Motion

Prior to the return to practice participation (P2) the overhead athlete must demonstrate the following requirements. The athlete should have full, non-painful ROM. For the overhead athlete full ROM is shoulder total rotational range of motion (TROM) within ± 5 of the non-throwing shoulder for both internal rotation (IR) and ER motions for a total of a 10˚ window.[13] The athlete should also exhibit horizontal shoulder adduction ≥ 40˚ on the throwing shoulder. Total glenohumeral internal rotation deficit as compared to the non-dominant shoulder should be <15˚ and elbow and wrist range of motion should be deemed within normal limits for each individual athlete.[14]

Isokinetic Testing and Hand-held Dynamometry

Isokinetic testing or hand-held dynamometer assessment of the shoulder IR and ER is also conducted in order to assess shoulder strength and power. It is important to evaluate specific parameters to ensure that the athlete exhibits appropriate strength and power relative to the unilateral ratio between their shoulder IR and ER musculature, their ability to generate torque in relation to their body weight (allometric scaling) as well as bilateral comparison of strength. Normative values for these key parameters include: ER/IR ratio 72-76%, ER torque to body weight ratio of 18-23%, IR torque to body weight ratio of 26-32%, bilateral comparison of ER 95-100% and bilateral comparison of IR 100-115%.[15,16] Prior to the return to throwing on a flat ground the authors recommend specific goals for these values, as outlined in Table 4.

Ball Drop Test

The ball drop test has been developed to evaluate endurance of the shoulder complex, willingness to move quickly, and dynamic stability. It is performed in the prone position with the arm abducted at 90˚ with the elbow extended, using a 2-pound weighted

Table 4. *A list of recommended Upper Extremity Tests for use after Micro- and Macro-Trauma.*

Upper Extremity Tests for the Overhead Athlete (Microtrauma)	Upper Extremity Tests after Macrotrauma
• Kerlan-Jobe Orthopaedic Clinic Shoulder and Elbow Score • Range of Motion • Isokinetic Testing • Ball Drop Test • Wall Throws 90˚/90˚ test • Functional Throwing Performance Index • Single Leg Step Down Test • Underkoeffler Overhand softball throw for distance	• Western Ontario Shoulder Instability Index • Range of Motion • Isokinetic Testing • Push up Test • Pullup Test/Modified Pullup Test • Flexed Arm Hang • Medicine Ball Tests • Closed Kinetic Chain Upper Extremity Stability Test • One Repetition Maximum Bench Press Test • Unilateral Maximum Chest Press Test • Unilateral Pulling Assessment • Single Arm Pushing Assessment • Upper Quadrant Y-Balance Test • Single Arm Seated Shot Put Test • Upper Extremity Hop Test

ball with the arm being tested completely off the plinth as a measure of dynamic stability of the shoulder. (Figure 1) The test is performed for a bout of 30 seconds counting the number of releases and catches and then compared involved to uninvolved side for a performance percentage. A satisfactory score is $\geq$ 110% on the dominant extremity based on the number of catches, compared to the non-dominant. Scoring is based on unpublished clinical data collected by the authors.

Wall Throws Test at 90˚/90˚

Another test for assessing the overhead throwing athlete's endurance, strength, mechanics and proprioception is the wall throws test at 90˚/90˚ (Figure 2). The patient stands in a doorway and throws a 2 lb plyoball against the wall at 90 degrees of abduction for 30 sec. The number of throws on both the dominant and non-dominant shoulder are calculated. Based on unpublished data collection on overhead throwing athletes the bilateral comparison should be 112% or greater on the dominant side. In addition, higher level athletes (professional baseball players) exhibit a higher difference than high school or collegiate athletes. Unpublished clinical data collected by the authors have shown the ratios between dominant and non-dominant arms of the athletes has remained consistent despite number of repetitions and level of play.

Figure 2. *Wall Throws 90˚/90˚ Test: The patient stands in a doorway and throws a 2 lb plyoball against the wall at 90 degrees of abduction for 30 sec. The number of throws are calculated on both the dominant and non-dominant shoulder.*

Functional Throwing Performance Index

The Functional Throwing Performance Index (FTPI), a test described by Davies et al.[17] is a functional assessment of the throwing athlete. The test is used to assess the athlete's ability to utilize the entire kinetic chain during the throwing motion, their throwing mechanics, and willingness to throw. The FTPI is a test that involves throwing a rubber ball 21 inches in diameter 15 feet from a target that is 4 feet high from the floor and a target one square foot in size. The test requires a warm up of 4 sub-maximal to controlled maximal throws (25,50,75,100% effort). The test is performed and the clinician records three trials of the total number of throws divided by accurate throws within a 30 second timeframe. Davies et al[18] also described FTPI normative data for both males (47%) and females (29%). The test-retest reliability is ICC = 0.91[17]

Figure 1. *Ball Drop Test: Patient is in prone position on table with 2 lb plyoball in hand performs ball drops & catches for 30 second with the shoulder abducted to 90˚ and elbow extended.*

Single Leg Step Down Test:

The single leg step down test is a test utilized to assess the strength and stability of the pelvis and

lower extremities. The time allotted for this test is 30 seconds, in order to achieve a satisfactory score, the athlete must be able to perform 10 repetitions. The clinician must make qualitative note of the pelvis and trunk positioning, specifically the presence of a contralateral drop and ipsilateral lean as compensatory patterns for weakness. Although this test is not a test of the shoulder specifically, weakness of the lower extremities in single leg stance can contribute to altered mechanics in the throwing motion potentially making the shoulder more susceptible to re-injury. The test is performed bilaterally to assess both the lead leg and hind leg of the throwing athlete.

Interval Throwing Program

The interval throwing program (ITP) is designed and is commonly utilized to gradually return motion, strength, and confidence in the throwing arm after injury or surgery by progressing through the graduated throwing distances outlined in the program. The ITP is designed so that each step must be completed without complications or pain before advancing to the next step. This sets up a criterion-based progression with successful completion of the next step as the goal rather than advancing on a timeframe. The ITP can be used for all levels of competition from high school to professional. Progression through the program will vary from athlete to athlete due to the individual variability of injury severity and ability level. There is no set timeframe in terms of days to complete it. The ITP should be completed using the crow-hop method and approximately 60% of maximal effort for steps 1 through 10. After successful completion of step 10, position players can begin simulating game situation throws with a graduated intensity level. Pitchers should advance through steps 11 and 12 at an intensity of 70-75% before they begin to throw off the mound. Successful completion of the entire program should be achieved by pitchers before progressing to game situations. (Table 5)

Functional Tests After Macrotrauma: (Table 4)

Push-up Test

A push-up test is performed as a measure of muscular endurance of the upper body and shoulder complex.[19] The test is performed in either a standard push-up position for men or a modified push-up position for women. The athlete is to lower their body from the "up" position, with the arms fully extended, towards the testing surface until the upper arm is parallel with the surface. After a warm up is completed, a series of three 15 second maximal effort trials are performed. Each trial is accompanied by 45 seconds of rest. The test is a measure of the average number of correct form push-ups an athlete can perform. The test has a known test-retest reliability of ICC = 0.96.[18]

Closed Kinetic Chain Upper Extremity Stability Test

The Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST) is administered as a measure of upper quarter stability, agility and power.[20,21,22,23] The test is performed in a pushup position with the hands placed 36 inches apart on strips of athletic tape. The person reaches with alternating hands across the body to touch the piece of tape under the opposing hand. (Figures 3a&3b) The number of cross-body touches performed in 15 seconds is recorded, followed by 45 second rest, for a total of three sets. The number of total touches is averaged. The test-retest reliability is ICC = 0.922.[20]

One Repetition Maximum Bench Press Test

A one repetition maximum (1RM) bench press is utilized as an assessment of upper extremity strength.[24] The test is evaluated for symmetrical performance without compensation, lag or substitution. If available, pre-injury 1RM maximum lift scores are utilized as a comparison to assist in determination of functional strength. The test re-test reliability of this test has been established at ICCs = 0.997 for males and ICCs = 1.000 for females, in total the ICCs = 0.999.[24]

Unilateral Maximum Chest Press Test

A unilateral maximum (1 RM) chest press test can be utilized by the clinician using a chest press isotonic weight machine. The senior author of this manuscript has used this test on athletic patients with the goal being 80% or greater on the involved side compared to the uninvolved side. Although a clinically useful test, there is no data or research to validate this test method. (Figure 4)

Table 5. *Interval Throwing Program.*

45' Phase	60 & 75' Phase	90' & 120' Phase	Throwing Off the Mound
Step 1:	Step 5:	Step 9:	**Stage 1: Fastballs only**
A) Warm-up throwing	A) Warm-up throwing	A) 60' (10 throws)	(Use Step 9 as Warm-up)
B) 45' (25 throws)	B) 60' (25 throws)	75' (if needed)	
C) Rest 3-5 minutes	C) Rest 3-5 minutes	B) 90' (5-7 throws)	Step 1: Interval Throwing
D) Warm-up throwing	D) 60' (25 throws)	C) 120' (15 throws)	15 throws off mound 50%
E) 45' (25 throws)	E) Warm-up throwing	D) Rest 3-5 minutes	
Step 2:	F) 75' (25 throws)	E) 60' (5-7 throws)	Step 2: Interval Throwing
A) Warm-up throwing	Step 6:	75' (if needed)	30 throws off mound 50%
B) 45' (25 throws)	A) Warm-up throwing	F) 90' (5-7 throws)	
C) Rest 3-5 minutes	B) 60' (25 throws)	G) 120' (15 throws)	Step 3: Interval Throwing
D) Warm-up throwing	C) Rest 3-5 minutes	Step 10:	45 throws off mound 50%
E) 45' (25 throws)	D) Warm-up throwing	A) 60' (5 throws)	
F) Rest 3-5 minutes	E) 75' (25 throws)	75' (if needed)	Step 4: Interval Throwing
G) Warm-up throwing	F) Rest 3-5 minutes	B) 90' (10 throws)	45 throws off mound 50%
H) 45' (25 throws)	G) Warm-up throwing	C) 120' (15 throws)	
60' Phase	H) 75' (25 throws)	D) Rest 3-5 minutes	Step 5: Interval Throwing
Step 3:	**75 & 90' Phase**	E) 60' (5-7 throws)	70 throws off mound 50%
A) Warm-up throwing	Step 7:	75' (if needed)	
B) 60' (25 throws)	A) 60' (10 throws)	F) 90' (10 throws)	Step 6:
C) Rest 3-5 minutes	B) 75' (5-7 throws)	G) 120' (15 throws)	45 throws off mound 50%
D) Warm-up throwing	C) 90' (15-20 throws)	H) Rest 3-5 minutes)	30 throws off mound 75%
E) 60' (25 throws)	D) Rest 3-5 minutes	I) 60' (5 throws)	
Step 4:	E) 60' (10 throws)	J) 90' (10 throws)	Step 7:
A) Warm-up throwing	F) 75' (5-7 throws)	K) 120' (15 throws)	30 throws off mount 50%
B) 60' (25 throws)	G) 90' (20 throws)	**Flat Ground Throwing**	45 throws off mound 75%
C) Rest 3-5 minutes	Step 8:	Step 11:	
D) Warm-up throwing	A) 60' (10 throws)	A) 60' (10-15 throws	Step 8:
E) 60' (25 throws)	B) 75' (5-7 throws)	B) 75' (5-10 throws)	65 throws off mound 75%
F) Rest 3-5 minutes	C) 90' (18 throws)	C) 90' (10 throws)	10 throws off mound 50%
G) Warm-up throwing	D) Rest 3-5 minutes	D) 120' (10 throws)	
H) 60' (25 throws)	E) 60' (7 throws)	E) Using pitching mechanics	**Stage 2: Fastballs only**
	F) 75' (7-10 throws)	60' (20-30 throws)	Step 9:
	G) 90' (18 throws)	Step 12:	60 throws off mound 75%
	H) Rest 3-5 minutes	A) 60' (10-15 throws	15 throws in batting practice
	I) 60' (7 throws)	B) 75' (10 throws)	
	J) 90' 18 throws)	C) 90' (10 throws)	Step 10:
		D) 120' (10 throws)	50-60 throws off mound 75%
		E) Using pitching mechanics	30 throws in batting practice
		60' (20-30 throws)	
		F) Rest 3-5 minutes	
		G) 60-90 ft (10-15 throws)	
		H) Using pitching mechanics	
		60' (20- throws)	

*Throwing program should be performed every other day, with one day of rest between steps, unless otherwise specified.
** Perform each step 2 times before progressing to the next step

Unilateral Pulling Assessment

A unilateral pulling assessment using a cable machine to perform a standing pull back is performed for 20 repetitions with each arm to assess efficiency and imbalances during pulling movements.[24] In addition to a side-to side strength comparison, the movement is evaluated for undesired compensations, such as, arching the low back, shoulder elevation and forward head positioning. The authors use a side to side comparison of 95% or better is used as a passing score in assessing this measure.

Single Arm Pushing Assessment

Like the pulling assessment, a single arm pushing assessment is performed to assess movement efficiency and imbalances during pushing activity.[24] Again, the test is administered using a cable machine and 20 repetitions are performed with each arm. This evaluates both the amount of weight that the athlete can use for the test and the presence of undesired movement compensations. Like the pulling assessment above, the authors use a side to side comparison of 95% or better as a passing score when assessing this measure.

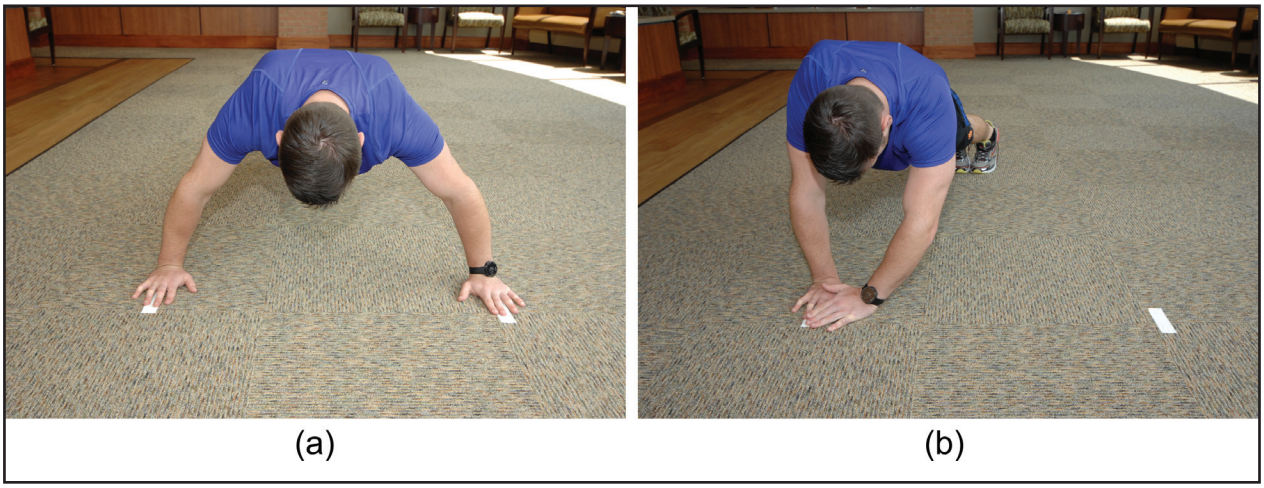

Figure 3. *Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST): a) The patient assumes the pushup position with the hands placed 36 inches apart on strips of athletic tape. b) The patient reaches with alternating hands across the body to touch the opposing piece of tape as many times as possible in 15 seconds.*

Upper Quadrant Y-Balance Test

The Upper Quadrant Y-Balance Test (YBT-UQ), a test similar to the Lower Quadrant Y-Balance Test (YBT-LQ) except for the upper quadrant, was first published by Westrick, et.al[35] as an assessment of upper quarter closed kinetic chain performance in the rehabilitation setting. The test involves maintaining sustained unilateral stance with one upper extremity (UE) while the other reaches out in a smooth and controlled manner in the medial, superolateral, and inferolateral directions. The average distance reached based on three trials is then recorded. Westrick et al.[26], and Gorman et al.[27] have demonstrated good test-retest (ICC: 0.91,0.92 and 0.80-0.99 respectively) and inter-rater reliability (ICC: 1.00) as well as the establishment of normative data for active adults and young adults. Taylor et al.[28] has also documented normative data for male and female collegiate athletes using this test.

Single Arm Seated Shot-Put Test

The Single Arm Seated Shot-Put test was first described in the literature as an assessment of upper body power in adolescent wrestlers in 1992 by Mayhew et al.[29] The test is conducted utilizing a six pound ball, while the participant is seated with their back against the wall, and knees bent so that their feet are flat on the floor. The participant is then required to push the ball from shoulder level maintaining contact with the wall behind them, minimizing the use of the legs and trunk. After two practice trials, the distances of three maximal effort trials are then recorded for a successful test session, with an average distance being used as the final test value. Negrete et al.[18] has also recorded good test-retest reliability for the non-dominant (ICC:0.97) and dominant arm (ICC: 0.99) in young male and female subjects within the literature. Negrete et al.[18] and Chmielewski et al.[30] document normative data in the literature for select populations including young males and females (average age 24.3 years) and the following collegiate sports, men's football, men's baseball, women's basketball, women's lacrosse, women's softball, and women's volleyball.

Upper Extremity Hop Test

The Upper Extremity Hop Test is a test described by Falsone et al.[31] The test was designed by the University of North Carolina Sports Medicine staff and used to simulate the axial loading required in sports such as wrestling, gymnastics, and football. The test requires the patient to place one arm in weight bearing in a push-up position while the non-weight bearing limb is placed on the lumbar spine. The patient then uses the weight bearing extremity to hop onto a step (10.2 cm in height) and off the step five times as quickly as possible. Falsone et al.[31] documented test-retest reliability amongst male collegiate wrestlers (ICC: 0.81) and male collegiate football players (ICC: 0.78). Also documented within the study, Falsone

Figure 4. *Unilateral seated isotonic chest press test (1 RM test). The patient is seated on an isotonic chest press machine. With one upper extremity at a time the patient performs a unilateral press while the contralateral upper extremity is relaxed in a neutral position. The test is complete once a 1 Repetition Max (1RM) has been achieved for each upper extremity.*

et al.[31] found on average the non-dominant upper extremity performance times were 4.4% slower than the dominant. Although this was not found to be statistically significant it may be of clinical significance.

Flexed Arm Hang

The flexed arm hang is a test that has been utilized in the military for females in lieu of pull ups to assess upper extremity endurance. The amount of time a subject can keep their chin above the bar is recorded.[32] A minimum passing score is a 15 second hold and a maximum score is attained by hanging for at least 70 seconds.

Modified Pullup Test/Pullup Test

Negrete et al.[18] has described the timed modified pullup test in which the subject lies supine with a bar just above arms length. Men are supported at the heels and women are supported just below the knees. The subject pulls their body to the bar from a hanging position until the upper arms are parallel with the floor. After a warm up is completed, a series of three 15 second maximal effort trials are performed. Each trial is accompanied by 45 seconds of rest. Score is attained by calculating the average repetitions performed. The modified pullup test has a test-retest reliability of (ICC = 0.99)[18] The pullup test described by Reiman et al[33] is a test commonly used within the military to assess upper extremity strength and endurance. The number of repetitions is recorded each time the patient returns to the hanging position. The test-retest reliability for the pull-up test has been described as ICC = 0.88 in a study performed by Burnstein et al.[34]

Underkoffler Softball Throw

Collins et al.[35] has described the Underkoffler Softball Throw for Distance (UOSTD) in which the subject throws a softball as far as they can with one crow hop step, with the resultant distance recorded. This test is a progression from the FTPI test which is submaximal to the UOSTD being performed with a maximal intensity effort. The UOSTD is a maximal total body effort test which needs to be performed in a large area. When the subject performs the test, the clinician performs a qualitative movement analysis as well as the quantitative performance outcome. The results can be evaluated by using test-retest data for serial reassessment. Collins et al.[35] has established the test re-test reliability to be ICC = 0.95

Medicine Ball Tests

In the seated medicine ball 2-arm chest pass, the athlete is seated with their back against the wall and the ball is then tossed from the level of the chest with both hands.[36] Similarly there is also a backward overhead medicine ball toss in which the patient performs a counter-movement and then continues to throw the medicine ball over their head as far as they can, a measure of total body kinematic power.[37,38] Ikeda et al.[39] described a sidearm medicine

Table 6. *(a) Criteria to return to Phase I Throwing (Long Toss), (b) Criteria to return to Phase II Throwing (Mound Throwing).*

- Full Non-painful Range of Motion (ROM)
    - Shoulder total rotational ROM (TROM) within 5˚ of non-throwing shoulder
    - Shoulder horizontal adduction 40˚ ≥ on throwing shoulder
    - Glenohumeral Internal Rotation Deficit (GIRD) of <15˚
    - Elbow & wrist Passive ROM (PROM) Within Normal Limits (WNL)
- Satisfactory shoulder, elbow & wrist strength (manual muscle test, hand held dynamometer, or isokinetics)
    - External Rotation/Internal Rotation (ER/IR) ratio: 72-76%
    - ER/ Abduction (ABD) ratio: 68%-73%
    - Throwing shoulder IR 115%> compared to non-throwing shoulder
    - Throwing shoulder ER 95%> compared to non-throwing shoulder
    - Elbow flexion/extension (flex/ext) 100-115%, compared to non-throwing elbow
    - Wrist flex/ext & forearm, 100-115% compared to non-throwing wrist/forearm
- Satisfactory clinical examination without positive findings or apprehension
    - Physician clearance
- Successfully has completed appropriate rehabilitation program
    - Completed all steps of rehabilitation
- Satisfactory functional tests' scores
    - Prone ball drop test (throwing side 110%>)
    - One arm ball throws against the wall at 90/90 (2 lb plyoball) 30 sec. test without pain 115%>
    - Single leg step down for 30 sec. (8 in step)
- Satisfactory score on the Kerlan-Jobe Orthopedic Clinic (KJOC) throwers' assessment

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- Full Non-painful Range of Motion (ROM)
    - Shoulder total rotational ROM (TROM) within ±5˚ of non-throwing shoulder
    - Shoulder horizontal adduction 40˚ ≥ on throwing shoulder
    - Glenohumeral Internal Rotation Deficit (GIRD) of <15˚
    - Elbow & wrist PROM WNL
- Satisfactory shoulder, elbow & wrist strength (manual muscle test, hand held dynamometer, or isokinetics)
    - External Rotation/Internal Rotation (ER/IR) ratio: 72-76%
    - ER/Abduction (ABD) ratio: 68%-73%
    - Throwing shoulder IR 120%> compared to non-throwing shoulder
    - Throwing shoulder ER 100%> compared to non-throwing shoulder
    - Elbow flexion/extension (flex/ext) 110-115%, compared to non-throwing elbow
    - Wrist flex/ext & forearm, 110-115% compared to non-throwing wrist/forearm
- Satisfactory clinical examination without positive findings or apprehension
    - Physician clearance
- Successfully has completed appropriate rehabilitation program
    - Completed all steps of the long toss throwing program
    - Completed flat ground throwing at 70-75% intensity
- Satisfactory functional tests' scores
    - Throwing into rebounder from 20 feet with 1 Ib plyoball for 45 sec at 66% intensity without pain, fatigue & with good mechanics
    - Prone ball drop test (throwing side 115%>)
    - One arm ball wall throws (2 Ib plyoball) 30 sec test with no pain 115% or greater
    - Single leg step down for 30 sec (8 in step) without compensation
- Satisfactory score on the Kerlan Jobe Orthopedic Clinic (KJOC) throwers' assessment

Table 7. *Shoulder Instability Performance Progression Assessment Testing Form.*

Name: _____ **Date:** _____

Right **Left** **Bilateral** **Injury/Procedure:** _____

Evaluation for Clearance to Begin: **Practice Participation** **Competition**

1. WOSI* Shoulder Evaluation Form: Score_____ Pass_____ Fail_____
2. Full Sport-Specific ROM: Pass_____ Fail_____
3. Satisfactory Clinical Examination: Pass_____ Fail_____
4. Ball Drop Test: Score ____ Pass_____ Fail_____
5. Push Up Test: Score ____ Pass_____ Fail_____
6. CKCUEST**: Score ____ Pass_____ Fail_____
7. Bench Press Assessment: Score ____ Pass_____ Fail_____
8. Unilateral Pulling Assessment: Score ____ Pass_____ Fail_____
9. Unilateral Pushing Assessment: Score_____ Pass_____ Fail_____
10. Isokinetic testing (or hand held dynamometer): Pass_____ Fail_____
11. Physician approval for Return to Sport

Test Summary: PASS FAIL

Rationale for Failure:

*Western Ontario Shoulder Index
**Closed Kinetic Chain Upper Extremity Stability Test

ball throw to assess total body kinematic power. The patient stands with their arms straight out in front of their body. The subject then performs a counter movement prior and then forcefully rotates and extends their body throwing the medicine ball in a sideways direction.

TESTS UTILIZED IN CLINICAL PRACTICE

There are numerous tests available for the clinician to determine whether a patient is ready to return to sports following a shoulder injury or surgery. A different set of tests should be utilized for the overhead athlete (microtrauma injury) compared to the patient with a macro trauma injury because of the demands different sports require of the shoulder. Test selection in P1 attempts to clinically replicate specific sport demands as much as possible to better assess functional capacity prior to release to P2 and ultimately P3. Table 6a outlines the clinical exam and requirements for the overhead athlete to return to Phase I throwing. In Table 6b the requirements to return to Phase II (throwing off the mound) are outlined. Table 7 outlines the performance progression assessment tests we most commonly utilized for patient's following shoulder instability or surgery. Each component of the testing is important, however, there are certain components which are vital to the successful and non-restricted return to sports. These include ROM, no apprehension, clinical stability on specific testing (drawer & fulcrum tests), appropriate strength and endurance (ball drop test), and patient's psychological response (level of confidence). The WOSI subjective scoring is an excellent and valid indicator of shoulder stability in the general orthopaedic patient or collision athlete. Table 9b details how the athlete must score in each of the previously mentioned areas in order to begin participation in practice and Table 9c depicts how the athlete must score in order to be cleared to return to sport.

CONCLUSIONS

The type of performance progression assessment presented herein provides the clinician with a useful set of tools to objectively assist and guide the determination regarding when an athlete can safely progress back to practice and ultimately return to unrestricted athletic activities. In addition, the results of the testing will provide information regarding the patient's status in the rehabilitation program and it may provide incentive for patients who require additional strength and neuromuscular retraining. The testing battery purposely incorporates a qualitative subjective analysis, conducted by the clinician, regarding the athlete's functional ability. A lack of confidence, kinesiophobia, or any compensation strategies used during these tasks indicates an athlete who requires continued training and counseling prior to returning to unrestricted athletics.

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Appendix A. *Western Ontario Shoulder Instability Index (WOSI)*
Shoulder Instability Index (WOSI).

Date: _____

Clinician's Name:_____ **Patient's Name:_____**

The following questions concern the symptoms you have experienced due to your shoulder problem. In all cases, please record the amount of the symptom you have experienced in the last week on the scale provided. (please place a mark at the appropriate part on the line)

1. How much pain do you experience in your shoulder with overhead activities?	**12. How much has your shoulder affected your ability to perform the specific skills required for your sport or work? (If your shoulder affects both sports and work, consider the area that is most affected)**
0 25 50 75 100 ----------	**0 25 50 75 100** ----------
2. How much aching or throbbing do you experience in your shoulder?	**13. How much do you feel the need to protect your arm during activities?**
0 25 50 75 100 ----------	**0 25 50 75 100** ----------
3. How much weakness or lack of strength do you experience in your shoulder?	**14. How much difficulty do you experience lifting heavy objects below shoulder level**
0 25 50 75 100 ----------	**0 25 50 75 100** ----------
4. How much fatigue or lack of stamina do you experience in your shoulder?	**15. How much fear do you have of falling on your shoulder?**
0 25 50 75 100 ----------	**0 25 50 75 100** ----------
5. How much clicking, cracking or snapping do you experience in your shoulder?	**16. How much difficulty do you experience maintaining your desired level of fitness**
0 25 50 75 100 ----------	**0 25 50 75 100** ----------
6. How much stiffness do you experience in your shoulder?	**17. How much difficulty do you have rough housing or horsing around with friends?**
0 25 50 75 100 ----------	**0 25 50 75 100** ----------
7. How much discomfort do you experience in your neck muscles as a result of your shoulder?	**18. How much difficulty do you have sleeping because of your shoulder**
0 25 50 75 100 ----------	**0 25 50 75 100** ----------
8. How much feeling of instability or looseness do you experience in your shoulder?	**19. How conscious are you of your shoulder**
0 25 50 75 100 ----------	**0 25 50 75 100** ----------

Appendix A. *Western Ontario Shoulder Instability Index (WOSI) Western Ontario Shoulder Instability Index (WOSI). (continued)*

9. How much do your compensate for your shoulder with other muscles? **0 25 50 75 100** ----------	**20. How concerned are you about your shoulder becoming worse** **0 25 50 75 100** ----------
10. How much loss of range of motion do you have in your shoulder? **0 25 50 75 100** ----------	**21. How much frustration do you feel because of your shoulder?** **0 25 50 75 100** ----------
11. How much has your shoulder limited the amount you can participate in sports or recreational activities? **0 25 50 75 100** ----------	**Physical symptoms score: _____%** **Sports/recreation/work score: _____%** **Lifestyle score: _____%** **Emotion score: _____%**
	The WOSI Score is: _____%

Appendix B. *The Kerlan-Jobe Orthopaedic Clinic Shoulder & Elbow Score (KJOC).*

Kerlan-Jobe Orthopedic Clinic Shoulder & Elbow Score

Name _____ Age _____ Sex _____ Dominant Hand (R) _____ (L) _____ (Ambidextrous) _____

Date of Examination _____ Sport _____ Position _____ Years Played _____

Please answer the following questions related to your history of injuries to **YOUR ARM ONLY:**

	YES	NO
1. Is your arm currently injured?	☐	☐
2. Are you currently active in your sport?	☐	☐
3. Have you missed game or practice time in the last year due to an injury to your shoulder or elbow?	☐	☐
4. Have you been diagnosed with an injury to your shoulder or elbow other than a strain or sprain? If yes, what was the diagnosis? _____	☐	☐
5. Have you received treatment for an injury to your shoulder or elbow? If yes, what was the treatment? (Check all that apply) ☐ Rest ☐ Therapy ☐ Surgery (please describe): _____	☐	☐

Please describe your level of competition in your current sport:
(Use Professional Major League, Professional Minor League, Intercollegiate, High School as the choices)

6. What is the highest level of competition you've participated at? _____
7. What is your current level of competition? _____
8. If your current level of competition is not the same as your highest level, do you feel it is due to an injury to your arm? ☐ ☐

Please check the ***ONE category only*** that best describes your current status:
☐ Playing without any arm trouble ☐ Playing, but with arm trouble
☐ Not playing due to arm trouble

Instructions to athletes:
The following questions concern your physical functioning during game and practice conditions. Unless otherwise specified, all questions relate to your **shoulder or elbow.** Please answer with an X along the horizontal line that corresponds to your current level.

1. How difficult is it for you to get loose or warm prior to competition or practice?

Naver feel loose during games or practice ●———● Normal warm-up time

2. How much pain do you experience in your shoulder or elbow?

Pain at rest ●———● No pain with competition

3. How much weakness and/or fatigue (i.e., loss of strength) do you experience in your shoulder or elbow?

Weakness or fatigue preventing any competition ●———● No weakness, normal competition fatigue

4. How unstable does your shoulder or elbow feel during competition?

"Popping out" routinely ●———● No instability

5. How much have arm problems affected your relationship with your coaches, management, and agents?

Left team, traded or waived, lost contract or scholarship ●———● Not at all

The following questions refer to your level of competition in your sport. Please answer with an X along the horizontal line that corresponds to your current level.

6. How much have you had to change your throwing motion, serve, stroke, etc., due to your arm?

Completely changed, don't perform motion anymore ●———● No change in motion

Appendix B. *The Kerlan-Jobe Orthopaedic Clinic Shoulder & Elbow Score (KJOC). (continued)*

7. How much has your velocity and/or power suffered due to your arm?

Lost all power, became linesse or distance athlete — No change in velocity/power

8. What limitation do you have in endurance in copetition due to your arm?

Significant limitation (became relief pitcher, switched to short races for example) — No endurance limitation in competition

9. How much has your control (of pitches, serves, strokes, etc.) suffered due to your arm?

Unpredictable control on all pitches, serves, strokes, etc. — No loss of control

10. How much do you feel your arm affects your current level of competition in your sport (i.e., is your arm holding you back from being at your full potential)?

Cannot compete, had to switch sports — Desired level of competition