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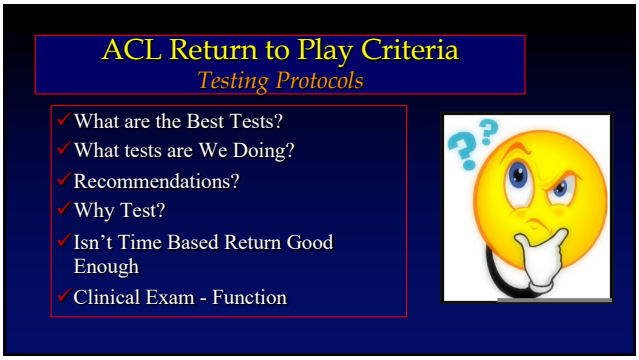


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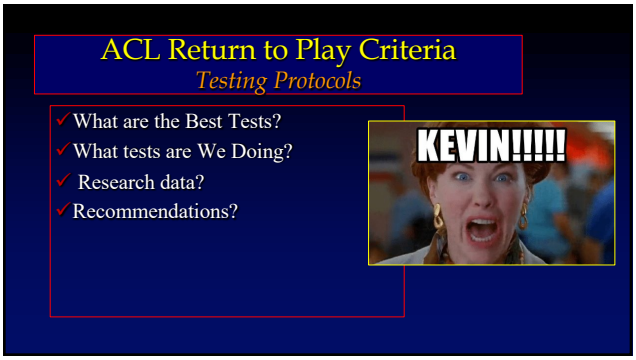


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*Grindem, Snyder-Mackler, Engebretsen, et al: BJSM '16*

- Can we reduce re-injury rates in ACLR pts
- Delaware-Oslo ACL Cohort Study
- 106 patients ACLR – 2yr FU

#2 *30% pts returning Level I sustained re-injury, 8% returning to a lower level (4x higher reinj rate)*

#3 *Every month delayed returned to sports until 9mos – rate of re-injury was reduced 51%*

#4 *More symmetrical quadriceps strength prior to return to sports sign. Reduced re-injury rate*

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2023

IJSPT

Wilk K, Thomas ZM, Arrigo CA, Davies GJ. The Need To Change Return to Play Testing in Athletes Following ACL Injury: A Theoretical Model. IJSPT. 2023;18(1):272-281.

Clinical Commentary/Current Concept Review

**The Need To Change Return to Play Testing in Athletes Following ACL Injury: A Theoretical Model**

Kevin Wilk, PT, DPT, FAPTA[1,2], Zachary M Thomas, PT, DPT, OCS, CSCS[3], Christopher A Arrigo, MS, PT, ATC[4], George J Davies, PT, DPT, ATC, CSCS[5,6,7]

[1] Vice President National Director Clinical Education & Research, Champion Sports Medicine, Select Medical, [2] Director of Rehabilitative Research, American Sports Medicine Institute, [3] Sports Physical Therapy Fellow, Champion Sports Medicine, [4] Advanced Rehabilitation, [5] Physical Therapy, Georgia Southern University, [6] Coastal Therapy & Sports Rehab, [7] Gundersen Health System

Keywords: ACL injury, neurocognitive training, reactive testing, return to play

https://doi.org/10.26603/001c.67988

International Journal of Sports Physical Therapy

Vol. 18, Issue 1, 2023

The incidence of knee injuries in sport, particularly involving the ACL, appears to be increasing yearly, especially in younger age athletes. Even more concerning is the

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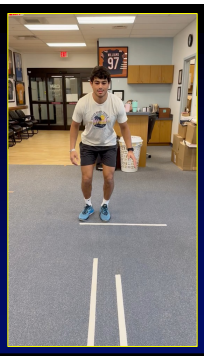

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Cognitive Motor Reaction Tests (30 sec)

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IJSPT

CLINICAL COMMENTARY

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

Kevin E. Wilk, PT, DPT, FAPTA[1,2]
Michael S. Bagwell, PT, DPT, OCS, CMPT[3]
George J. Davies, PT, DPT, ATC, LAT, MEd, SCS, FAPTA, CSCS[4,5,6]
Christopher A. Arrigo, MS, PT, ATC[7]

**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 ele-

2020

*RTP Articles:*
*Knee : 1988*
*Shoulder: 718*

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## Return to Play Testing & Criteria

- *Overhead Athletes:*
  - ✓ Satisfactory Clinical Exam
  - ✓ Appropriate ROM
  - ✓ Satisfactory Muscle Strength (HHD)
  - ✓ Specific Testing:
    - ✓ Prone Plyoball Ball Drop (30sec)
    - ✓ 90/90 Plyoball Wall Throws (30 sec)
    - ✓ Baseball Throws into Rebounder
    - ✓ 90/90 Plyoball Wall Throws w/ Neurocognitive
    - ✓ Single Leg Step Down (30 sec)

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## Return to Play Testing & Criteria

- *Collision Athletes:*
  - ✓ Clinical Exam
  - ✓ Satisfactory ROM (Functional)
  - ✓ Muscle Testing (HHD)
  - ✓ Specific Testing:
    - ✓ Single Arm Chest Press
    - ✓ Single Arm Rowing
    - ✓ UE Step Over Box (20 sec)
    - ✓ Target Lights (4) Plank
    - ✓ Target Lights (Red-Blue) Plank
    - ✓ Prone Ball Drop Test (30 sec)

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## Return to Play Testing & Criteria

- *Overhead Athletes:*
  - ✓ Satisfactory Clinical Exam
  - ✓ Appropriate ROM
  - ✓ Satisfactory Muscle Strength (HHD)
  - ✓ Specific Testing:
    - ✓ Prone Plyoball Ball Drop (30sec)
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    - ✓ Baseball Throws into Rebounder
    - ✓ 90/90 Plyoball Wall Throws w/ Neurocognitive
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- *Collision Athletes:*
  - ✓ Clinical Exam
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    - ✓ Single Arm Rowing
    - ✓ UE Step Over Box (20 sec)
    - ✓ Target Lights (4) Plank
    - ✓ Target Lights (Red-Blue) Plank
    - ✓ Prone Ball Drop Test (30 sec)

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## *Functional Testing for the UE in Athletes*

*Overhead Athletes* ⟷ *Collision Athletes*


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## Shoulder Injuries & Proprioception

*Deficits Occur Following Injury*

- Following Glenohumeral Joint Injury
- GH Joint Dislocations

✓Proprioception Deficits Occur

*Lephart et al: JSES '94*

*Zuckerman JSES '03*

✓Occurs alterations in CNS – feedback loop may be altered in some cases

*Warren et al: CORR '96*

*Lephart et JSES '94*

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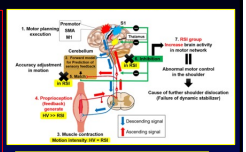
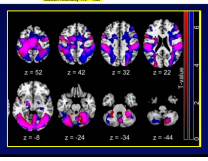
## *Shitara et al: Med Sci Sports Ex '22*

- Neuroplascity Caused by Shoulder Injury
- MRI Brain Scan – during shoulder PROM & Voluntary Muscle Contraction
- Subjects: RSI n=13, Healthy n=12

✓*Difference in Brain Activity b/t grps*

✓*Abnormal motor control & activation in RSI group*





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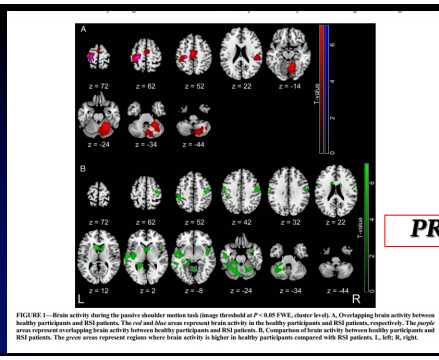

**PROM**

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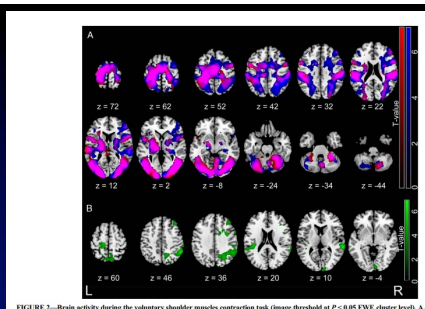

**Vol Mus Contraction**

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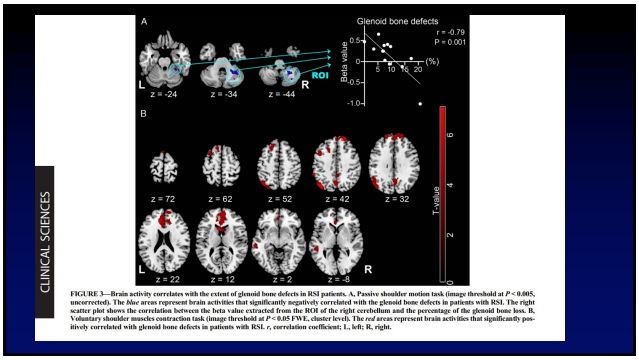

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## Functional Testing Overhead Athlete
*Specific Tests*

- ✓ Range of Motion
- ✓ Manual Muscle Testing (HHD)
- ✓ Special Tests
- ✓ *Functional Tests*
  - ✓ *Ball Drop Testing*
  - ✓ *Ball Wall Dribble Testing*
  - ✓ *Throws*
  - ✓ *Single Leg Squats*
- ✓ *Reactive Neurocognitive Testing:*
  - ✓ *Target Light Testing*
  - ✓ *Series of 4 Tests*

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## Neurocognitive Testing
*Four Throwers' Series*

- ✓ High Plank Triangle Reactive Blazepod
- ✓ High Plank 4 Blazepods ( Red- Blue)
- ✓ Standing 90/90 throws with contralateral target taps
- ✓ Standing 4 Blazepods (Red – Blue)

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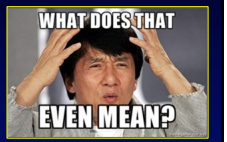
## What is NeuroCognitive Rehabilitation/Training?

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## What is NeuroCognitive Rehabilitation/Training?

- ✓ To be able to perform:
- ✓ Contributes to several areas of sports performance:
  - ✓ Skill & fine motor skills
  - ✓ Visual Processing, Sequencing, Memory
  - ✓ Dual tasking
  - ✓ Focus on task – concentration
  - ✓ Coordination - *Ability to recognize & react*
  - ✓ *Cognitive Reactive Motor Response*


*Recognize, React, Move Efficiently, & Skillfully*

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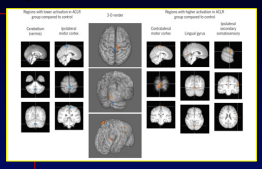
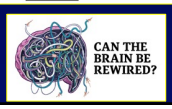
## Neuroplasticity in Sports Medicine
*Following Knee Injury - ACL*

- Changes in Brain Function:
- Brain is rewired – reorganized
- ✓ *Rewired to function in some way that differs from how it previously functioned*
- ✓ *Positive changes – adaptations*
- ✓ *Negative changes -*



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## Criteria to Return to Throwing
*Clinical Exam*

- ✓ Physician Clinical Exam
- ✓ Satisfactory exam
- ✓ Special tests
- ✓ Shoulder Joint
  - ✓ SLAP tests
  - ✓ Rotator Cuff tests
  - ✓ Laxity exam
- ✓ Elbow Joint
  - ✓ UCL testing
  - ✓ Ulnar nerve testing
  - ✓ …

*Valgus Stress Testing - Prone*

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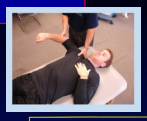
## Criteria Return to Throwing
*Shoulder Motion PROM*

- Full Non-Painful ROM
- Shoulder TROM within 5° bilateral
- Horizontal adduction 40° ≥
- GIRD < 15°
- Elbow full non-painful ROM
- Wrist full non-painful ROM

*Wilk et al: CORR '12*
*Wilk et al: AJSM '15*



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## The Thrower's Shoulder
*Range of Motion: ER/IR*

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*Visual inspection*

*Humeral Stabilization*

*Scapular Stabilization*

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[ Sports Physical Therapy ]

*J Sports Health '09*

Glenohumeral Internal Rotation Measurements Differ Depending on Stabilization Techniques

Kevin E. Wilk, PT, DPT,** Michael M. Reinold, PT, DPT, ATC, CSCS,† Leonard C. Macrina, MSPT, SCS,‡ Ron Porterfield, MS, ATC,§ and James R. Andrews, MD‖

Background: The loss of glenohumeral internal rotation range of motion in overhead athletes has been well documented in the literature. Several different methods of assessing this measurement have been described, making comparison between the results of studies difficult.

Hypothesis: Significant differences in the amount of internal rotation range of motion exist when using different methods of stabilization.

Study Design: Descriptive laboratory study.

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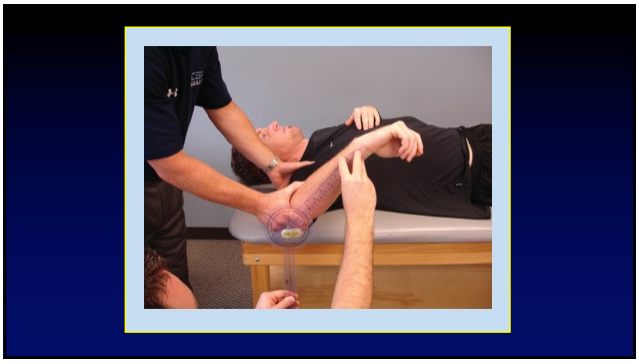

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*Wilk, Macrina, Porterfield et al: 2015*
*Pitchers Shoulder ROM ('05-'15)*

| | D | ND |
|---|---|---|
| • ER at 90° abduction: | 131.1 | 125.1 |
| • IR at 90° abduction | 53.3 | 63.2 |
| • Total Rotational ROM: | 184.3 | 187.4 |
| • Horizontal adduction: | 42.9 | 45.2 |
| • ER Horz Adduction: | 32.5 | 28.1 |

N= 1226

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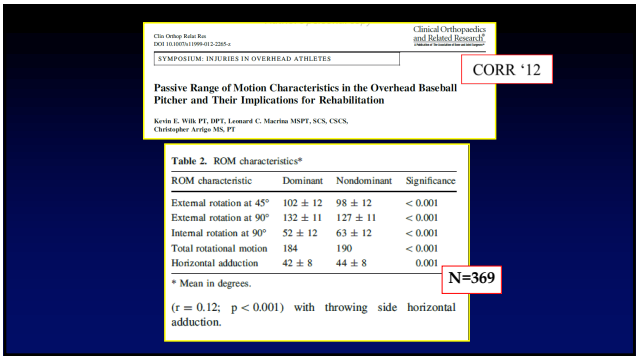


CORR '12

N=369

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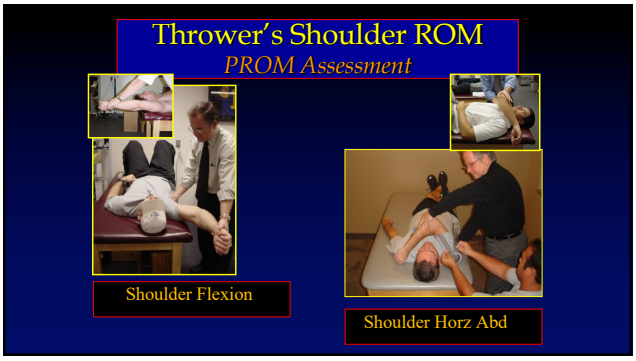


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## Criteria to RTP Thrower's
*Range of Motion Goals*

- ✓TROM within 5°
- ✓Horizontal adduction 40°>
- ✓GIRD < 20°
- ✓Elbow full ROM
- ✓Wrist full ROM
- ✓Non-painful ROM

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*J Sports Health 2021*

Effect of Forearm Position on Glenohumeral External Rotation Measurements in Baseball Players

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Table 3. Motion comparisons by position reported as mean (SD)

| | Pitchers (n = 32) | Position Players (n = 28) | P |
|---|---|---|---|
| Internal rotation | | | |
| Throwing | 24.8 (8.9) | 32.1 (6.5) | <0.01 |
| Nonthrowing | 34.4 (9.2) | 37.2 (7.0) | 0.20 |
| External rotation neutral | | | |
| Throwing | 85.2 (9.5) | 81.5 (9.2) | 0.13 |
| Nonthrowing | 86.2 (10.4) | 85.2 (5.5) | 0.67 |
| External rotation pronated | | | |
| Throwing | 73.4 (10.0) | 72.9 (9.0) | 0.82 |
| Nonthrowing | 81.4 (9.5) | 81.2 (5.7) | 0.91 |
| Total arc neutral | | | |
| Throwing | 110.0 (10.5) | 113.6 (11.8) | 0.21 |
| Nonthrowing | 120.6 (9.6) | 122.4 (9.1) | 0.45 |
| Total arc pronated | | | |
| Throwing | 98.3 (10.7) | 105.0 (10.4) | 0.02 |
| Nonthrowing | 115.8 (9) | 118.4 (10.1) | 0.30 |

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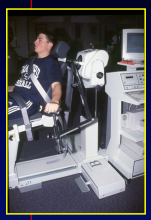
## *Return to Throwing Criteria*
*Biodex -Isokinetics*

- *ER / IR ratios*
  - ✓*72 - 76%*
- *ER / ABD ratios*
  - ✓*68 - 73%*
- *Torque / BW ratios*
  - ✓*ER 18 - 23%*
  - ✓*IR 26 - 32%*
- *Bilateral comparison*
  - ✓*ER 95-100%; IR 115%*

*Wilk et al: AJSM '93*
*Wilk et al: AJSM '95*



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## *Return to Throwing Criteria*
*Muscular Strength - HHD*

- *ER / IR ratios*
  - ✓ *66-72%*
- *ER / ABD ratios*
  - ✓*68 - 73%*
- *Torque / BW ratios*
  - ✓*ER 18 - 23%*
  - ✓*IR 26 - 32%*
- *Bilateral comparison*
  - ✓ *ER 95-100%; IR 115%*

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## Scapular Strength Ratios

*Wilk, Reinold, Hooks…Unpublished data '07*

| | Pitchers | | Non-throwers | |
|---|---|---|---|---|
| | D | ND | D | ND |
| Elev / Depress | 400% | 480% | 520% | 540% |
| Retract / Protract | 88% | 71% | 78% | 71% |

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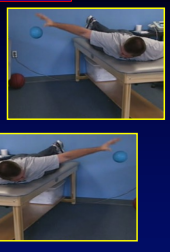
## Return to Throw Criteria

*Ball Drop Test*

- ✓ Dynamic stabilization tests
  - ✓ Prone ball drops
    - ✓ 30 sec test
    - ✓ prone on plinth – No Holding On!
    - ✓ number of releases/catches
    - ✓ 3 trials – mean of 3 trials
    - ✓ compare Dom to Non Dom
    - ✓ score: %
    - ✓ Goal: 90%>
    - ✓ Expectation: 110%>



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## Return to Throw Criteria

*Functional Testing*

- ✓ *Three years of Testing: (9/22)*
  - ✓ Healthy Professional: 193
  - ✓ Healthy College: 82
  - ✓ Healthy High School: 141
  - ✓ Healthy Totals: 416
  - ✓ Patients: UCLr & Brace: 129

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## Return to Throw Criteria
*Ball Drop Test (NT Side)*

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## Return to Play Criteria
*Ball Drop Test (T Side)*

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## Return to Throw Criteria
*Ball Drop Test (T Side)*

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## Reliability of UE Ball Drop Tests

IJSPT

IJSPT 2023

Original Research

**Reliability of Upper Extremity Functional Performance Tests for Overhead Sports Activities**

Bryan L Riemann[a], Kevin E Wilk, George J Davies

Keywords: Shoulder, Return to Sport, Limb Symmetry Index, Seated Single Arm Shot Put Test

https://doi.org/10.26603/001c.74368

International Journal of Sports Physical Therapy

Vol. 9 18, Issue 5, 2023

**Background**

There is lack of consensus on which tests, particularly upper extremity functional performance tests (FPT) that should be used for clinical decision making to progress a patient through a rehabilitation program or criteria for return to sport (RTS). Consequently, there is a need for tests with good psychometric properties that can be administered with minimal equipment and time.

**Purpose**

(1) To establish the intersession reliability of several open kinetic chain FPT in healthy young adults with a history of overhead sport participation. (2) To examine the intersession reliability of the limb symmetry indices (LSI) from each test.

**Study Design**

Test-retest reliability, single cohort study.

**Methods**

Forty adults (20 males, 20 females) completed four upper extremity FPT during two data

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## Return to Throw Criteria
*One Hand Ball Throws Against Wall*

- ✓ Ball Wall Throws
  - ✓ Baseball Style Throws
    - ✓ 2 lb plyoball
    - ✓ baseball style throws
    - ✓ 30 sec duration
    - ✓ bilateral comparison
    - ✓ Successful Criteria:
    - ✓ no pain
    - ✓ proper mechanics
    - ✓ no change with fatigue
    - ✓ bilateral difference: depends level

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## Return to Play Criteria
*Appropriate Rehab Progression*

- ✓ Throwing Activities:
  - ✓ painfree 1 hand throwing
  - ✓ 20 ft away
  - ✓ 1 lb plyoball
  - ✓ 15 sec of throwing

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## Return to Throw Criteria
*Single Leg Squat*

- ✓ Single leg squat test
  - ✓ Floor or 8 in step – 30 sec
    - ✓ count reps on each leg w/I 30 s
    - ✓ bilateral comparison
    - ✓ assess depth
    - ✓ assess valgus/varus
    - ✓ assess lateral trunk movt.
    - ✓ assess trunk flexion
    - ✓ looking for symmetrical motion with no pain &/or dysfunction
    - ✓ 80-85% symmetry

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## Return to Play Criteria
*Single Leg Squat*

- ✓ Single leg squat test
  - ✓ Floor
    - ✓ 30 sec test on each leg
    - ✓ assess technique & numbers
    - ✓ assess valgus/varus
    - ✓ assess lateral trunk movt.
    - ✓ assess trunk flexion
    - ✓ looking for symmetrical motion with no pain &/or dysfunction
    - ✓ *ability to maintain balance & form for all reps*

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## Closed Kinetic Chain Upper Extremity Stability Test – Davies

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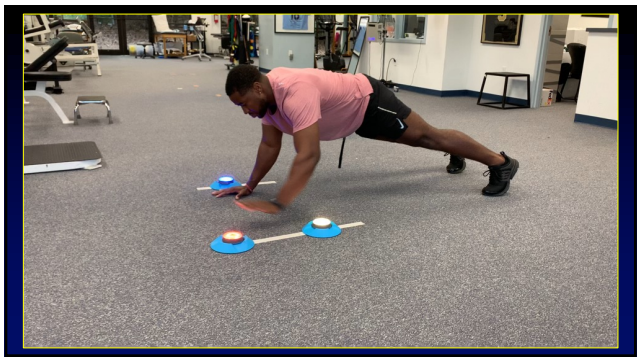

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## Closed Kinetic Chain Upper Extremity Stability Test – Cognitive Motor – Color Specific

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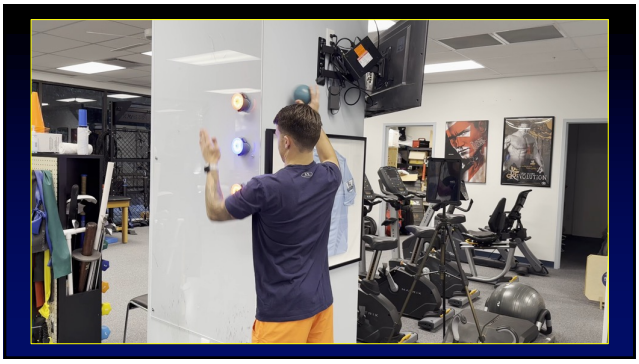

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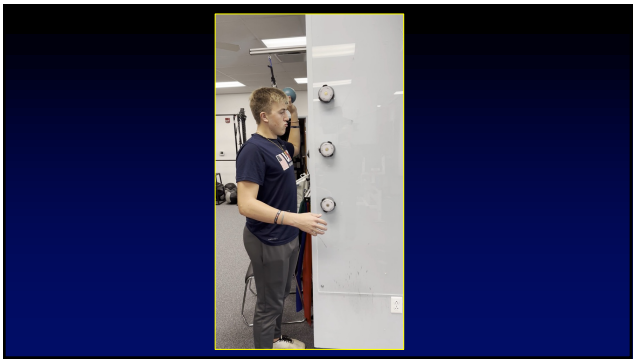

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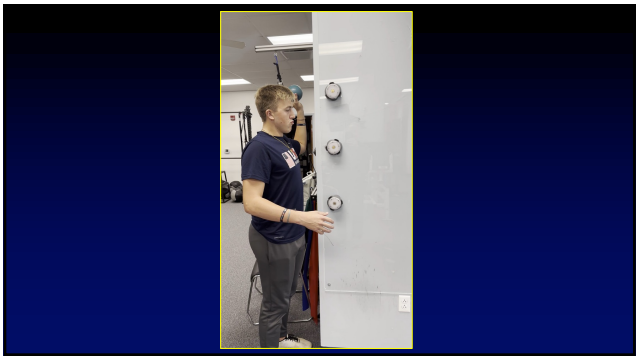

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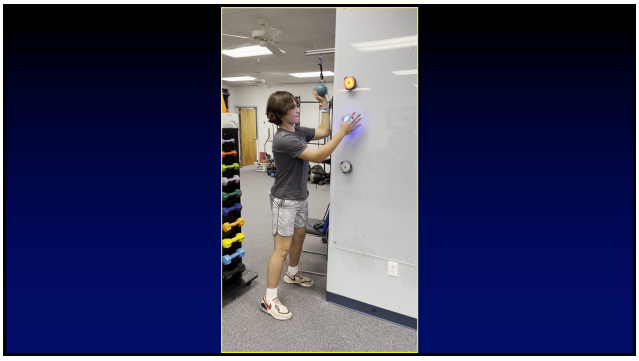

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## Neurocognitive Testing of the Upper Extremity in Overhead Athletes

- ✓College Baseball 40
- ✓College Softball 16
- ✓High School Bball 74
- ✓High School Sball 7
- ✓Totals 137

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## Test 1: Reactive CKCUEST

Results by sport:

| | # of hits | Reaction Time |
|---|---|---|
| Baseball (n=83) | R: 17.1; L: 16.4 | R: .400; L: .419 |
| Softball (n=23) | R: 16.0; L: 15.2 | R: .443; L: .483 |

Results by level :

| | # of hits | Reaction Time |
|---|---|---|
| High School Baseball (n=43) | R: 16.6; L: 16.3 | R: .406; L: .412 |
| High School Softball (n=7) | R: 15.8; L: 15.1 | R: .462; L: .495 |
| College Baseball (n=40) | R: 17.5; L: 16.5 | R: .394; L: .425 |
| College Softball (n=16) | R: 16.2; L: 15.2 | R: .425; L: .473 |

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## Test 2: Reactive Triangle CKCUEST

Results by sport

| | # of hits | Reaction Time | Errors |
|---|---|---|---|
| Baseball (n=83) | R: 23.8; L: 23.8 | R: .575; L: .530 | R: .08; L: .09 |
| Softball (n=23) | R: 21.1; L: 21.2 | R: .633; L: .635 | R: 0; L: .04 |

Results by level

| | # of hits | Reaction Time | Errors |
|---|---|---|---|
| High School Baseball (n=43) | R: 24.1; L: 24.1 | R: .607; L: .513 | R: .12; L: .07 |
| High School Softball (n=7) | R: 21; L: 21.1 | R: .589; L: .588 | R: 0; L: .07 |
| College Baseball (n=40) | R: 23.6; L: 23.5 | R: .543; L: .548 | R: .04; L: .11 |
| College Softball (n=16) | R: 21.3; L: 21.3 | R: .677; L: .682 | R: 0; L: 0 |

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## Test 3: Reactive Right vs. Left CKCUEST

Results by sport

| | # of hits | Reaction Time | Errors |
|---|---|---|---|
| Baseball (n=83) | 18.1 | .711 | .25 |
| Softball (n=23) | 14.8 | .935 | .12 |

Results by level

| | # of hits | Reaction Time | Errors |
|---|---|---|---|
| High School Baseball (n=43) | 17.9 | .727 | .35 |
| High School Softball (n=7) | 13.9 | 1.031 | .21 |
| College Baseball (n=40) | 18.2 | .695 | .15 |
| College Softball (n=16) | 15.7 | .840 | .03 |

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## Test 4: Reactive 90/90 Wall Throws

Results by sport

| | # of hits | Reaction Time | Errors |
|---|---|---|---|
| Baseball (n=83) | R: 22.0; L: 22.6 | R: .482; L: .550 | R: .54; L: .41 |
| Softball (n=23) | R: 21.4; L: 19.5 | R: .564; L: .628 | R: .77; L: 1.15 |

Results by level

| | # of hits | Reaction Time | Errors |
|---|---|---|---|
| High School Baseball (n=43) | R: 25.3; L: 24.8 | R: .503; L: .491 | R: .64; L: .25 |
| High School Softball (n=7) | R: 21.8; L: 20.8 | R: .607; L: .617 | R: .17; L: .42 |
| College Baseball (n=40) | R: 20.4; L: 21.5 | R: .472; L: .579 | R: .50; L: .49 |
| College Softball (n=16) | R: 21; L: 18.3 | R: .521; L: .640 | R: 1.38; L: 1.9 |

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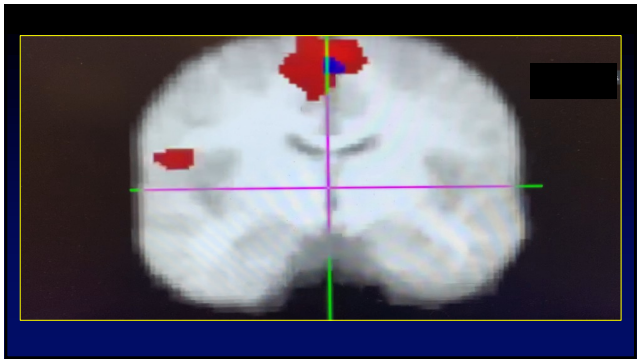
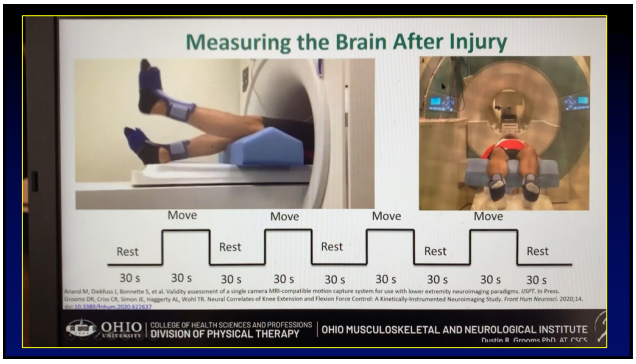
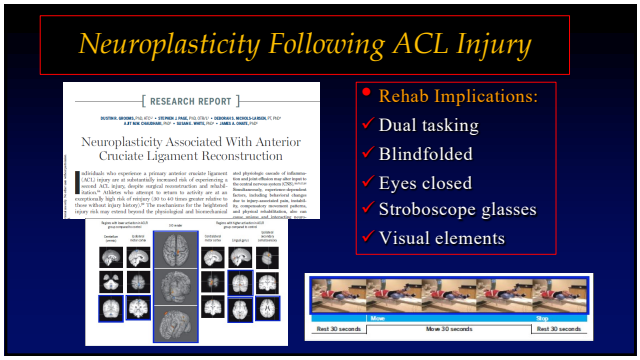


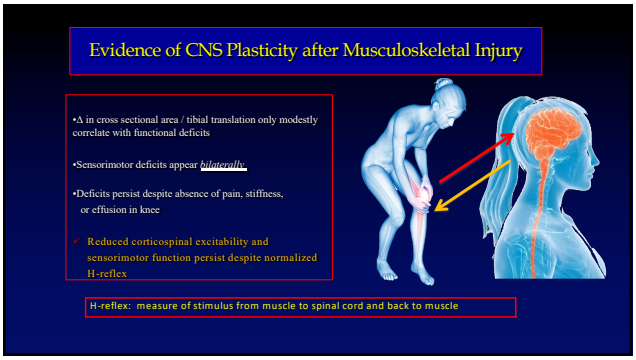
112



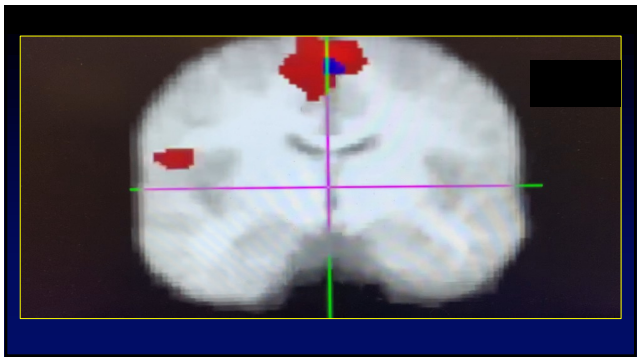

113




114




115



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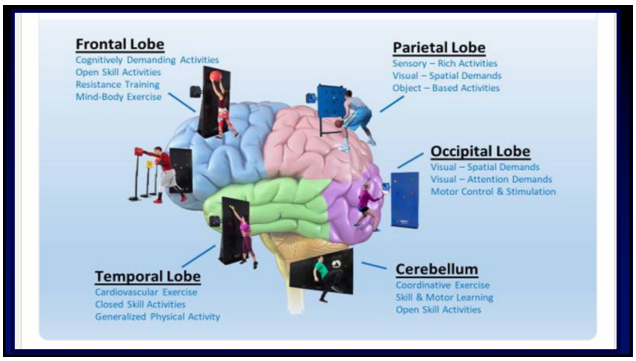


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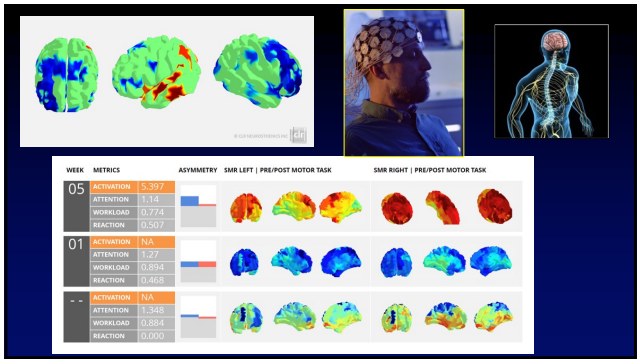


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## Functional Testing Overhead Athlete
*Specific Tests*

- ✓ Range of Motion
- ✓ Manual Muscle Testing (HHD)
- ✓ Special Tests
- ✓ *Functional Tests*
  - ✓ *Ball Drop Testing*
  - ✓ *Ball Wall Dribble Testing*
  - ✓ *Throws*
  - ✓ *Single Leg Squats*
- ✓ *Reactive Neurocognitive Testing:*
  - ✓ *Target Light Testing*
  - ✓ *Series of 4 Tests*

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## Return to Play Criteria
*Collision Athlete*

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## Return to Play Criteria
*Collision Athlete*

- Clinical Examination
- ROM
  - » Passive ROM
  - » Active ROM
- Muscular Strength
- Special Tests
- RTP Testing
- Rehab Progression
- Time from Surgery

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## RTP Shoulder Stabilization
*Clinical Examination*

- Range of Motion
  - » Necessary for sport/position
  - » Safe & painful
- Palpation
- Special tests
  - » Stability testing
  - » Labral tests (SLAP)
  - » Biceps tests

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## Return to Play Criteria
*Collision Athlete*

- ✓Unilateral Chest press
- ✓Involved v Uninvolved
- ✓1 RM
- ✓50% BW – number of repetitions
- ✓*85-90% of uninvolved*
- ✓ *Assess technique*

*Pain Free, Technique, Weight*

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## Return to Play Criteria
*Collision Athlete*

- ✓CKCUEST (*Davies*)
- ✓UE Stability Test
- ✓Tape 36" apart
- ✓15 sec test
- ✓Record # of touches
- ✓85-90%*

*Goldbeck et al: J Spts Rehab '00*
*Roush et al: NAJSPT '07*



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## Return to Play Criteria
*Collision Athlete*

- ✓Unilateral Prone Ball Drop Test
- ✓Involved vs Uninvolved
- ✓2 lb plyoball
- ✓30 sec test
- ✓Number of catches
- ✓90%> of UI side
- ✓Endurance test*

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## Return to Play Criteria
*Collision Athlete*

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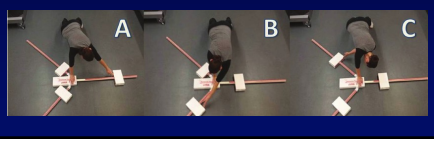
## Return to Play Criteria
*Collision Athlete*

- ✓Upper Quarter Y Balance Test

*Westerick et al: IJSPT '12*
*Gorman et al: JSCR '12*
*- Quantity: 85-90%, Quality Assessment: control*

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## Return to Play Criteria
*Collision Athlete*

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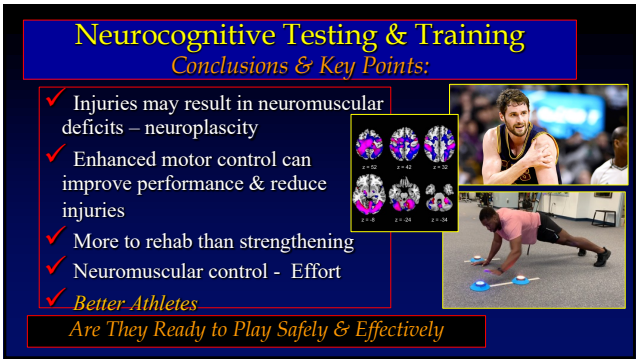
Neurocognitive Testing & Training
Conclusions & Key Points:
Injuries may result in neuromuscular deficits – neuroplascity
Enhanced motor control can improve performance & reduce injuries
More to rehab than strengthening
Neuromuscular control - Effort
Better Athletes
Are They Ready to Play Safely & Effectively

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Thank You !!!

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