Screening To Predict Injury In Athletes

Purpose of a Screen

The general purposes of a screen are to
- identify at risk populations (Ex: Cancer screening) for more detailed examination
- in an examination sequence, to help determine what area or region to focus on (Ex: pain from low back to lower leg)

The purpose of the screens we will discuss is to identify athletes at risk for musculoskeletal injury or re-injury
- Predictive validity
- Prognostic variables

Session Learning Objectives

Examine existing literature on physical performance tests (PPTs)
- Standards
- Psychometric properties
- Quality of research

Discuss injury prediction in athletes

What Makes a Good Screen?

UK National Screening Committee
- Important based on frequency/severity
- Test should be simple, safe, precise
- Distribution of results and cut points known
- Agreed policy on investigation of +
- There should be an effective intervention
- RCTs show screen reduces morbidity
- Benefit outweighs harm
- Should be “worth it” - VALUE!

Disclosures

Dr Hegedus has presented this information in continuing education courses for which he is paid.

All Performance Tests Are NOT Equal!
Clinical Utility In Athletes

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Alexis Wright PT, PhD, DPT, OCS, FAAOMPT
Valuable Screening?

$144.6 million annually in NC HS athletes when medical costs, loss of future earnings, and lost quality of life are considered


– An NFL player who tears his ACL will make over $2 million less in the next 4 years than salary matched controls – Secrist et al. Ortho J Sports Med 2016

Important? Effective Intervention?

Athletic upper extremity injuries are common and return to prior level is low

According to the NCAA Injury Surveillance System, over a 16 year span, across 15 sports, upper extremity injuries accounted for 18.3% and 21.4% of game and practice injuries, respectively – Hootman et al. JAT 2007

Overhead athletes, in particular, are at increased risk with up to 30% of intercollegiate overhead athletes suffering a shoulder injury at some point in their athletic career. – Laudner et al. J Intercoll Sport 2009

Shoulder pain is the most frequent orthopaedic injury suffered in both men’s and women’s collegiate swimming and diving with a reported prevalence ranging from 34.7% to 66.7% – Roos et al. Am J Sports Med 2015; Kerr et al. BJSM 2015

52% of Professional BB players returned to previous or higher level of play after shoulder surgery – Cohen et al. SportsHealth 2015

Effective Intervention?

Collegiate Athletes Who Had Surgery Prior to College

<table>
<thead>
<tr>
<th>Event</th>
<th>Change in Injury Risk</th>
<th>Change in Repeat Surgery Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any knee surgery</td>
<td>7X</td>
<td>14X</td>
</tr>
<tr>
<td>ACL repair</td>
<td>20X</td>
<td>893X</td>
</tr>
</tbody>
</table>

(In)Effective Intervention?

Surgery fixes the structure but not the athlete!

Rehabilitation after surgery and injury is not good enough right now!

There are 2 Paths
What Screens Have We?

FMS
- Good reliability in general
- Inconsistent evidence that poor movement quality = LE injury
- Predictive in M/F college athletes?
  - 2 studies no; 1 study yes
  - Cohorts heavily male in other cohorts
  - Kazman et al. FA- Not uni-dimensional so total score should not be used
  - Whiteside et al. 3D vs real time- ambiguous grading criteria; assessing multi-dimensional movement from one vantage point is unwise

LESS
- Landing Error Scoring System
- Fewer studies
- Restricted to ACL population
- Mixed reviews
  - No
    - James et al. SportsHealth 2016. 182-186- LE injury
    - Fox et al. Scan J Med Sci Sports. epub- high risk landing postures
  - Yes
    - Padua et al. JAT 2015. 589-595- ACL-SN 86/SP64

Physical Performance Tests

PPTs are multi-joint, multi-system assessments that require the athlete to physically perform a task that represents some construct of athletic function such as power, stability, or anaerobic capacity.

They are convenient, efficient, and inexpensive

Can PPTs Predict Injury?


Elimination of articles deemed inappropriate after review of titles and abstracts (n=3230)

Kappa = 0.46 (0.034)

Elimination of articles deemed inappropriate after review of full text (n=129)

Breakdown by Topic Area

3579
169
60

Achilles: 13 studies
Entire Lower Extremity: 34 studies
Hip (2)/Thigh (2): 4 studies
Knee: 29 studies

Quality Assessment

Methods- COSMIN
- Reliability, Measurement Error/Agreement, Hypothesis Testing/Construct Validity, Criterion Validity, Responsiveness
- Measurement Properties- Terwee

Terwee Scale

Quality Criteria for Measurement Properties

<table>
<thead>
<tr>
<th>Measurement Property</th>
<th>Positive</th>
<th>Indeterminate</th>
<th>Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliability</td>
<td>ICC Weighted kappa ≥ 0.70 or Pearson r ≥ 0.80</td>
<td>ICC Weighted kappa &lt; 0.40 or Pearson r &lt; 0.40</td>
<td>Not determined</td>
</tr>
<tr>
<td>Measurement error</td>
<td>MCE ≤ 10% or MCE stable (±)</td>
<td>MCE ≥ 15% or MCE unstable (±)</td>
<td>Not determined</td>
</tr>
<tr>
<td>Response bias</td>
<td>Close to randomization</td>
<td>Close to randomization</td>
<td>Not determined</td>
</tr>
<tr>
<td>Hypothesis testing</td>
<td>Correlation with the hypothesis is ≥ 0.70 or ≤ 30% of the results are in accordance with the hypothesis and correlation with related construct is ≤ 30%</td>
<td>Correlation with the hypothesis is ≤ 0.30 or ≤ 30% of the results are in accordance with the hypothesis or correlation with related construct is &gt; 30%</td>
<td>Low</td>
</tr>
</tbody>
</table>

Adapted COSMIN

<table>
<thead>
<tr>
<th>Check-off present</th>
<th>Property</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>Reliability</td>
<td>Box A</td>
</tr>
<tr>
<td>Hypothesis Testing</td>
<td>Agreement Measurement Error</td>
<td>Box B</td>
</tr>
<tr>
<td>✔️</td>
<td>Hypothesis Testing / Construct validity (Discriminant &amp; Convergent)</td>
<td>Box C</td>
</tr>
<tr>
<td>No</td>
<td>Common Reference Validity</td>
<td>Box D</td>
</tr>
<tr>
<td>No</td>
<td>Responsiveness</td>
<td>Box E</td>
</tr>
</tbody>
</table>

BEST Evidence Synthesis

COSMIN (quality of the research) + Terwee Scale (quality of the measurement properties)
- Unknown - investigated in studies of exclusively poor methodology or not investigated in any study
- Strong - multiple studies of good methodological rating or at least 1 study of excellent methodology
- Moderate - multiple fair methodological studies or 1 study of good methodology
- Limited - one study of fair methodological quality
- Conflicting - contradictory findings

Methodology

Yuck!

FINDINGS OF THE SYSTEMATIC REVIEWS
How Useful Are UE Tests Clinically?

- CKQUEST: Moderate evidence for reliability and agreement; Fair evidence for discriminant validity (young active from old sedentary); limited evidence for convergent validity (with UQYBT)
- Unilateral Seated Shot Put: There is a 5-10% difference between dominant and non-dominant arms in healthy athletes
- Seated Shot Put: Fair evidence of criterion validity with 1-RM bench press
- Medicine Ball Throw: Limited evidence of responsiveness to training in healthy athletes

Unilateral Seated Shot Put- There is a 5-10% difference between dominant and non-dominant arms in healthy athletes

So in terms of use as an outcome measure to determine response to treatment

CKQUEST

<table>
<thead>
<tr>
<th>Variable</th>
<th>Notability</th>
<th>Agreement</th>
<th>Repetition</th>
<th>Criterion Validity</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-leg hop for distance</td>
<td>Yes</td>
<td>No studies</td>
<td>Poor</td>
<td>Good</td>
<td>Poor</td>
</tr>
<tr>
<td>1-leg hop for distance</td>
<td>Yes</td>
<td>No studies</td>
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Note that only studies of fair or better methodological quality were considered and PPTs that did not have more than 1 study examining their properties were eliminated

1 LEG HOP FOR DISTANCE

6 REALLY??!!
IT'S THE KNEE!!!

Do ANY UE Tests Predict UE Injury?

Table 1: Summary of methodological quality by statistical property by test

<table>
<thead>
<tr>
<th>Test</th>
<th>Notability</th>
<th>Agreement</th>
<th>Repetition</th>
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So in terms of use as an outcome measure to determine response to treatment
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MEDIAL HOP

HEXAGON HOP

This in addition to the 3 leg hop for distance as previously shown

Take Home Message from LE Tests

- Strong evidence - vertical leap and single leg hop are NOT predictors of injury.
- Strong evidence - beep test has NO ability to predict injury and moderate evidence that this test is responsive to sport-specific training.
- Moderate evidence - one leg hop for distance provides different results between athletes who have ankle instability and those who do not: discriminant validity.
- Moderate evidence - 6-meter timed crossover hop has NO ability to discern between a painful and non-painful hip in dancers.
- Moderate evidence - medial hop can distinguish between painful and normal hips in dancers: discriminant validity.
- Moderate evidence - hexagon hop can distinguish between normal and unstable ankles in military academy athletes: discriminant validity.

Do Any LE Tests Predict LE Injury?

The SEBT performed in 3 directions (Lower Quarter Y-balance Test) seems* to predict LE injury in high school basketball players:
- Both a composite reach score difference of less than 94% and an anterior reach difference of 4 cm or greater is associated with increased injury risk.
- Research was not independent - Plisky et al 2006.

Except it Doesn’t!

Association of Lower Quarter Y-Balance Test with lower extremity injury in NCAA Division 1 athletes: an independent validation study

Alexis A. Wright*, Steven L. Enschauer, James M. Smoliga, Jeffrey B. Taylor, Eric J. Hegedus

High Point University Department of Physical Therapy, One University Parkway, Box 67, High Point, NC 27268, USA.

Results: In our sample, 91% (32) of the 106 athletes participating received a lower composite score. The results differ for reach to the left, reach to the right, and reach forward. The reach to the right was associated with injury. The reach to the left was not. No significant differences were found between prior injuries and injury risk for the composite score. The athlete’s reach to the right was significant in injury risk.

Big Opportunity

UK National Screening Committee
- Test should be simple, safe, precise ✔
- Benefit outweighs harm ✔
- Should be “worth it” - VALUE! ?

♯ YUUUUUUUGE!
Why Is Screen Development So Difficult?

The definition of injury is variable.
The factors contributing to injury are often unclear—numerous and interrelated.
- Dynamic/complex system
  - Equifinality
  - Non-linearity
  - Ex: Dose effects response but not proportionally

Variable Injury Definition

- How you define an injury matters a great deal!
  - All complaints
  - Incidents that require treatment
  - Incidents that cause lost practice or playing time

Factors Are Many and Unclear

- All Complaints
- Treatment
- Missed Time

Factors Are Many and Unclear

A Different Approach

- A complex or dynamic system is composed of diverse yet related components such that the whole cannot be understood through the analysis of the individual components—Mennin S. J Eval Clin Pract 2010. 838-840
- Ex: Asymmetry ≠ Injury
- There are innumerable variables related to injury such that changing one affects all of the others

Dynamic System-Sports

- Each player in a team sport is an agent and these multiple agents create a dynamic system (team). To the untrained eye, the interaction of these agents and these 2 systems appears to be chaos. These 2 systems co-evolve as the game progresses, evolving independently and yet, the interaction among players of the same team and of opposite teams creates a complex adaptive system where a change by one agent effects all of the others.
“The multifactorial and complex nature of sports injuries arises not from the linear combination of isolated and predictive factors but from the interaction of...the web of determinants” - Bittencourt et al. BJSM 2016;50:1309-1314

No: $y' = a + b'1x'1 + b'2x'2 + b'3x'3$
Yes: Factor Analysis

The Web of Determinants
Dynamic or Complex Systems Model

PRE-SEASON SCREEN: PATTERNS ASSOCIATED WITH ATHLETIC INJURY

Recall
Studies examining clinical screening with performance tests seem promising but provide little substance

Therefore, Time to Gather the Troops
PT, S&C, AT
Create new tests based on clinical experience and consensus
Our Study
- 359 D1 athletes over 3 years
- Not including football, swimming, golf, or tennis
- 11 Tests
- Factor Analysis
- Univariate Regression
- Multivariate with Past Injury, Age, Beighton, BMI, and Gender

T.E.A.M. Screen

<table>
<thead>
<tr>
<th>PPT</th>
<th>Theorized Construct Represented</th>
<th>Scoring: QN = quantitative; SL = qualitative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical Leap</td>
<td>2-legged power</td>
<td>QN</td>
</tr>
<tr>
<td>In-Line Lunge for Distance</td>
<td>Hip mobility in the sagittal plane</td>
<td>QN</td>
</tr>
<tr>
<td>Lateral Lunge for Distance</td>
<td>Hip mobility in the frontal plane</td>
<td>QN</td>
</tr>
<tr>
<td>Side Plank Hip Abduction</td>
<td>Lateral hip strength/stability</td>
<td>QN</td>
</tr>
<tr>
<td>Side Plank Hip Adduction</td>
<td>Medial hip strength/stability</td>
<td>QN</td>
</tr>
<tr>
<td>Triple Hop for Distance</td>
<td>Single leg power</td>
<td>QN</td>
</tr>
<tr>
<td>Pelvis Rotation</td>
<td>Erector spinae strength</td>
<td>QN</td>
</tr>
<tr>
<td>Full Squat</td>
<td>Movement symmetry</td>
<td>SL</td>
</tr>
<tr>
<td>Downward Dog</td>
<td>Posterior flexibility</td>
<td>SL</td>
</tr>
<tr>
<td>Single leg squat</td>
<td>Motor control</td>
<td>SL</td>
</tr>
<tr>
<td>Active Straight Leg Raise</td>
<td>Hamstring flexibility</td>
<td>SL</td>
</tr>
</tbody>
</table>

Results
Study Discussion

Injury predicts re-injury but what used to be thought of as a certainty may no longer be so:
- Hip stability, active motion predict overall injury
- Motor control predicts non-traumatic/overuse injury

These findings are a big deal!
- We can fix these things!! If we use a dynamic systems approach!
- Predictors as dimensions/concepts
- Screening doesn’t answer why motor control or stability is poor, it only uncovers that they are poor
- Must work as a team

These findings are a beginning only!

THE JOURNEY TO TRUE ENLIGHTENMENT NEVER ENDS
Bittencourt et al. BJSM 2016. 50:1309-1314

"The focus should be on identifying the stable (sometimes complex) relationships among injury determinants that support the emergence of injuries and not on the contribution of isolated factors."

Other Steps in a Linear World

- Step 1- Prospective cohort to ID risk factors
- Step 2- Cut-off values
- Step 3- Validate model and cut-off values in multiple cohorts
- RCT- Test effect of combined screening and intervention program
  – Bahr R. BJSM 2016;50:776-780

Next Step in a Dynamic World

1. Ask: Age, Gender, Past Injuries [Epidemiology]
2. Questionnaire: Life stressors and anxiety [Psychosoc]
3. In-season: Mood, Energy Level, Stress, Sleep Quality, Muscle Soreness [Load]
4. Measure: Beighton, BMI [Physical structure]
5. Perform: [Performance tests]
   1. Motor control- SLS, DLS
   2. Hip/trunk stability- Side plank hip ab/adduction
   3. Active motion- in-line and lateral lunge
   4. Power/Plyo - medial hop

Questions?

Extraordinary Education
Inspiring Environment
Caring People