Considerations In Designing a Rehabilitation Program For the Injured Athlete

Disclaimer ----
These Are Big Shoes to Fill! – Soooooo I decided to take you in this direction

Functional Performance Testing: A Patient Oriented Approach

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Director of Athletic Training Education
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Learning

"All of life should be a learning experience, not just for the trivial reasons but because by continuing the learning process, we are challenging our brain and therefore building brain circuitry”

Learning Lab Objectives

- Background & Relevance
- Physiology & Biomechanics
- Specific Functional Performance Tests
- Reliability & Validity
- Take Home Message

What is Function?

- Function – from Latin “functio” meaning to perform, the special action or physiologic property of an organ or other part of the body
- What constitutes LE “function”?  
  - Speed  
  - Agility  
  - Hopping  
  - Landing  
  - Proprioception  
  - Proximity  
  - Strength  
  - Kicking  
  - Muscle Reaction Time  
  - Subjective considerations
Goals of Rehabilitation

- Acute care
- Minimize pain & swelling
- Restore ROM
- Restore muscular function
- Re-establish neuromuscular control
- Improve balance
- Maintain cardiorespiratory fitness
- Functional progression back to activity

Functional Performance Testing

- “These tests are designed to simulate, in a controlled manner, the stresses produced and imposed on the LE during athletic participation”
  (Drouin & Riemann, 2004 – ATT)
- Outcome measures:
  - Sensorimotor function
  - Muscle strength and power
  - Flexibility
  - Pain
  - Confidence

Why Do Clinicians Find These Tests Useful?

- Quantitative measure utilized to define function
- Simulates real-life forces
- Indirectly assesses the extent to which pain inhibits the task execution
- Indirectly quantifies muscular strength
- Indirectly assesses the ability of a limb to absorb force
- Assesses the ability of muscles to dynamically stabilize joints
- Quantitatively assesses progress within rehab
- Qualitatively assess compensation or asymmetry via clinical observation
- Provides psychological reassurance to the athlete

Key Concepts

- Keep RTP criteria in mind...
  1) No acute Sx/Sy
     - Pain
     - Swelling
  2) Athlete’s profile
     - full ROM
     - normal strength
     - muscle endurance
     - CV endurance
     - appropriate proprioception
     - agility & coordination
Keep RTP criteria in mind...

1) No acute Sx/Sy
2) Athlete’s profile
3) Pre-injury levels
   - Athlete is able to perform any and all sport specific activities at least as well as (s)he could before the injury

Keep RTP criteria in mind...

1) No acute Sx/Sy
2) Athlete’s profile
3) Pre-injury levels
4) Athlete has full confidence in abilities to perform without doubt/hesitation or with any modification to performance

Functional Testing Concepts

• “Involves having the athlete/patient perform certain tasks appropriate to the stage in the rehabilitation process in order to isolate and address specific deficits”
  (Mullin, 2000 – ATT)

• Function is “quantified” using maximal performance of an activity
  (Titter, 1996 – JSR)

• Purposes:
  - Determine risk of injury due to limb asymmetry
  - Provide an objective measure of progress
  - Measure the ability of the individual to tolerate forces

Can the injured area tolerate the forces inherent in a functional performance task?

• Criteria to consider:
  - General health status (PAR-Q)
  - Full ROM
  - Absence of pain, effusion & crepitus
  - Symmetrical gait
  - Appropriate strength
  - Limb Symmetry Index
  - Execution of 1 RM squat
  - Single leg stance ≥45 sec.

Making Comparisons:

• Normative values
• Pre-injury baseline values
• Functional levels of other team members
• Limb symmetry scores
• Agonist/Antagonist muscle group ratios
• Error scores
• Timed performance comparisons

“Single most important activity that an athlete has to accomplish successfully prior to a return to play is change of direction, specifically the cutting mechanism”
(Chu, 1995 – Clin Sports Med)

Two types of cutting techniques:
- Sidestep Cut – planting the foot opposite to the direction of intended movement
- Crossover Cut – planting the foot on the same side of the new direction then crossing the opposite leg in front to provide acceleration in the new direction

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Functional Skills and Performance Tests

Skill-Related Fitness Element - Speed
- Relates to the ability to perform movement within a short period of time
- Typically sprint testing
  - Set distance (40 yd, 100 yd, 100 meters)
  - Time the distance
  - Mean of 3 - 5 trials
  - Compare pre vs. post

The 40 Yard Dash

Wingate Sprint Test
- The Wingate Anaerobic Test
  - Ability to exercise for a short time at high power levels
  - Requires pedaling or arm cranking on a bicycle ergometer for 30 seconds @ maximal speed
  - Power is determined by counting pedal revolutions
  - Watts = kp x rpm

Wingate Anaerobic Test – Peak Power Norms (Young Adults)

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<td>10%</td>
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Line & Shuttle Drills
- Anaerobic Power
  - Line Drill for Basketball
    - Timed trials
    - Performed with partner of equal capacity
    - Course completed in two separate trials
      - 5’ rest between
      - Average of 2 trials

- 300-yard Shuttle Run
  - Timed trials
  - Performed with partner of equal capacity
  - Course completed in two separate trials
    - 5’ rest between
    - Average of 2 trials
Skill-Related Fitness Element - Agility

- Relates to the ability to rapidly change the position of the entire body in space, with speed and accuracy
- Typically involves use of props (i.e., cones, ladders, etc.)

SEMO Agility Drill

- Timed test
- Average of 3 to 5 trials
- Normative Values:
  - 1 range from 12.19 to 14.50 sec.
  - 2 range from 10.72 to 13.80 sec.

Illinois Agility Run Test

- 10 (l) x 5 (w) meter course
- 4 cones mark start, turning points and finish
- Middle cones are spaced at 3.3 meters
- Begin face down at start
- Object to move as quickly as possible through the course

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<th>Gender</th>
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<td>14.1</td>
<td>12.3</td>
<td>13.7</td>
<td>16.0</td>
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</table>

Other Agility Tests

- Other various agility patterns exist:
  - “Figure of 8”
  - Box or cone configurations
  - Zigzag runs
  - 90° lunge
  - “W”-sprint course
  - Carioca
    - 40’ distance for time

Skill-Related Fitness Element - Power

- Relates to the rate at which one can perform work (strength over time) or (force x distance / time)
- The ability to engage and produce force early in the activation pattern (rate of force production) is becoming an important feature of the acute functional ability of muscle

A Closer Look @ Power

- Theoretical Repetition Continuum
- Loading Effects: Linear, Quadratic, Exponential, Power, Strength
- Repetition Minimum: 25, 12, 10, 8
- Repetition Maximum: 2, 1, 0.5

Figure 10.4: Theoretical repetition continuum for loading of lift

A Closer Look @ Power
Vertical Jump Testing

- Use the appropriate test to match the sport’s demands
  - i.e., VB vs. FB
- Reach distance subtracted from jump distance
- Examples:
  - Vertical jump
  - Step and jump
  - One foot vs. two foot takeoff
  - Standing vs. squat start

http://www.youtube.com/watch?v=DZQ6Du0u17M

Vertical Jump Mat

- Athlete wears waist belt attached to measuring tape that is grounded to the mat
- Other systems use computers to measure amount of time and distance traveled

Comparing VJ Data

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<th>Rank</th>
<th>Females</th>
<th>Males</th>
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<tr>
<td>1</td>
<td>16.55 – 18.10 cm</td>
<td>56.33 – 61.45 cm</td>
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<tr>
<td>2</td>
<td>15.15 – 16.70 cm</td>
<td>61.30 – 66.35 cm</td>
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<tr>
<td>3</td>
<td>13.85 – 15.40 cm</td>
<td>66.05 – 71.40 cm</td>
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<tr>
<td>4</td>
<td>12.55 – 14.20 cm</td>
<td>71.10 – 76.20 cm</td>
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<tr>
<td>5</td>
<td>11.25 – 12.95 cm</td>
<td>76.85 – 81.95 cm</td>
</tr>
<tr>
<td>6</td>
<td>10.00 – 11.70 cm</td>
<td>81.60 – 86.70 cm</td>
</tr>
<tr>
<td>7</td>
<td>08.80 – 10.55 cm</td>
<td>86.35 – 91.35 cm</td>
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</tbody>
</table>

** Data on World Class Athletes

Plyometric Testing

- Reactive Neuromuscular Training
  - Explosive power = strength x speed
  - Stretch-shortening principles (precede a CON muscle action with an ECC muscle action)
  - Dr. Donald Chu – “Jumping into Plyometrics”

Squat Depth Jump
Power Skipping
Standing Long Jump
Tuck Jump
**Plyometric Box Jumps**

**Skill-Related Fitness Element – Balance**

- Relates to the maintenance of equilibrium while stationary or moving
- The muscles, as the termination of the final pathway of the SM system, particularly contribute to the maintenance of body balance

**Balance Testing**

- Numerous variations of the Romberg test
- Valid & reliable
- Scoring may include time references
  - Balance Error Scoring System (BESS)
- Can be performed on a variety of surfaces

**Balance Error Scoring System (BESS)**

- Reliable with SL and TS on a firm surface, and DL, SL, and TS on a foam surface!

**Tekscan Mobile Mat Demo**

**Star Excursion Balance Test (SEBT)**

- A test of dynamic stability (strength, hip, knee, & ankle ROM, proprioception, NM control) as an alternative to those involving a quiet stance
- Reliable
- Goal is to reach as far as possible with one leg in each of 8 directions while balancing on the contralateral leg
- Three reaches in each direction are averaged
- Posteromedial reach is highly representative of all 8 components

(Haar, 2010)
Demonstration of the SEBT

http://www.youtube.com/watch?v=UxDbm7_CWec

Simplified SEBT

- Posteromedial reach direction was most highly correlated with computed factor in both groups (R² > 0.9)

Y-Balance Test Procedure

SEBT Scoring

- Average across 3 trials
- Reach distance is normalized to limb length
  - Reach Distance x 100
  - Limb Length
- A composite reach distance = sum of the 3 reach directions (normalized)

Comparing SEBT Scores

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<tr>
<th></th>
<th>Total</th>
<th>Girls</th>
<th>Boys</th>
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<tr>
<td>Reach distance</td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
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<tr>
<td>Anterior</td>
<td>78.2 ± 8.2</td>
<td>73.1 ± 5.9</td>
<td>92.3 ± 7.6</td>
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<tr>
<td>Posteromedial</td>
<td>107.0 ± 11.7</td>
<td>98.6 ± 9.3</td>
<td>113.8 ± 8.9</td>
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<tr>
<td>Posteriorlateral</td>
<td>100.4 ± 12.0</td>
<td>93.0 ± 9.7</td>
<td>108.4 ± 10.3</td>
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<tr>
<td>Composite</td>
<td>285.6 ± 30.0</td>
<td>285.6 ± 22.8</td>
<td>302.2 ± 24.3</td>
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<tr>
<td>Limb length*</td>
<td>94.3 ± 6.1</td>
<td>89.9 ± 3.9</td>
<td>97.9 ± 5.1</td>
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<tr>
<td>Normalized reach distance†</td>
<td>83.9 ± 7.1</td>
<td>81.4 ± 6.2</td>
<td>84.1 ± 7.6</td>
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<tr>
<td>Anterior</td>
<td>113.4 ± 6.7</td>
<td>101.1 ± 10.0</td>
<td>116.1 ± 8.5</td>
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<tr>
<td>Posteromedial</td>
<td>108.4 ± 10.8</td>
<td>103.8 ± 10.7</td>
<td>108.7 ± 10.3</td>
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<tr>
<td>Composite</td>
<td>100.9 ± 8.4</td>
<td>98.4 ± 8.2</td>
<td>103.0 ± 8.0</td>
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</table>

*Average of right and left limb in centimeters
†Normalized reach distance = reach distance divided by limb length multiplied by 100

Other Balance Training Techniques

(Plisky et al., 2006 – JOSPT)
Skill-Related Fitness Element – Reaction Time

- Relates to the time elapsed between stimulation and the beginning of the reaction to it.
- Hick’s Law: reaction time increases proportionally to the number of possible responses until a point at which the response time remains constant despite the increases in possible responses.
- Anticipation is a strategy used by athletes to reduce the time they take to respond to a stimulus.

FASTEX

- Consists of 8 deformable force platforms with piezoelectric sensors
- The shock impulses are then transformed into quantifiable variables (time, speed, force, etc...)

X Box Drill

Wii-habilitation

Fitness Elements and Performance Tests
**Health-Related Fitness Element – Cardiorespiratory Endurance**

- Ability to continue or persist in strenuous tasks involving large muscle groups for extended periods of time.
- Gold standard measure is VO$_2$ max.

**Various CV Field Tests**

- Endurance tests:
  - 1-mile run time
  - YMCA 3-minute step test
    - 12" step
    - Metronome set @ 96 beats/min
    - Record time to recover to resting heart rate

**YMCA 3-Minute Step Test**

- **YMCA 3-Minute Step Test**
- **Post Exercise 1-Minute Heart Rate (beats/min)**

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**Average**

- Excellent 91-97
- Very Good 80-90
- Good 70-80
- Fair 60-70
- Poor 50-60


**Health-Related Fitness Element – Musculoskeletal Fitness**

- Comprised of 3 components:
  - **Flexibility**
  - **Muscular Strength** – the maximal one-effort force that can be exerted against a resistance
  - **Muscular Endurance** – the ability of the muscles to apply a submaximal force repeatedly or to sustain a muscular contraction for a certain period of time.
**Co-Contraction Arc Test**
- Semicircular pattern
- Originally designed to provide a dynamic pivot shift in the ACLD knee
- Athlete completes 5 repetitions in shortest time
  - 3 lengths R to L
  - 2 lengths L to R
  - Average of 3 trials
- Tubing is stretched to 48” (4') beyond recoil length

**Hopping Tests**
- Background:
  - Sensitive enough to evaluate functional abilities
  - Involve strength, cutting, balance, landing, etc.
  - Performed with single or both legs

**Implementation Strategies**
- Explicit directions need to be given on how to complete the task
- Single best trial or the average?
  - Average of the trials ⇒ most reliable
- How much rest?
- Practice trials?
  - 3-4 (80%, 75%, 100% effort)

**Single Leg Hop Test**
- **Goal:**
  - To hop as far forward as possible on 1 leg
- **Directions:**
  - Patient stands on test leg with heels on the zero mark. Hop as far forward as possible, landing on the test leg.
- **Measurement:**
  - Horizontal distance measured from heel at starting point to heel on landing
  - Average of 3 jumps normalized as a % of the persons total height

**Functional Hop Test Scoring Template:**
- Jump #1 Distance = _______ cm
- Jump #2 Distance = _______ cm
- Jump #3 Distance = _______ cm
- Average Distance = _______ cm
- Average Jump Distance/Height in cm = _______
- Percentage Value = _______
  - Acceptable _______ Unacceptable _______

**Single Leg Triple Hop**
- **Goal:**
  - To hop as far forward as possible 3 consecutive times
- **Directions:**
  - Patient stands on test leg with heels on the zero mark. Hop 3 consecutive times on the same foot. On the final hop, hop for maximal distance and hold landing foot stable for 1 sec.
- **Measurement:**
  - Horizontal distance measured from heel at starting point to heel after 3rd hop
Single Leg Triple Crossover Hop

- **Goal:**
  - To hop as far forward as possible 3 consecutive times across a 15 cm interval marked on the floor.

- **Directions:**
  - Patient stands on test leg with heels on the zero mark. Hop 3 consecutive times on the same foot, crossing over the tape strip with each hop. On the final hop, hop for maximal distance and hold landing foot stable for 1 sec.

- **Measurement:**
  - Horizontal distance measured from heel at starting point to heel at final landing.

Single Leg 6 m Hop for Time

- **Goal:**
  - To hop a 6 m distance as quickly as possible.

- **Directions:**
  - Stand on one leg, crouch with arms at sides, then hop forward for 6 m as quickly as possible.

- **Measurement:**
  - Time to the nearest 0.01 sec.

Single Leg Vertical Jump

- **Goal:**
  - To jump as high as possible and land on one leg.

- **Directions:**
  - Patient standing reach is recorded. Jump on one leg, touch the wall with chalked fingertips, and land on same leg.

- **Measurement:**
  - Maximum height jumped minus patient’s standing reach height.

Interpretation of Hopping Tests

<table>
<thead>
<tr>
<th>Age (yrs)</th>
<th>Recreational Athlete</th>
<th>High School Athlete</th>
<th>College Athlete</th>
<th>Not Indicated</th>
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<tbody>
<tr>
<td>Single leg hop</td>
<td>Avg 28.8, 2.0</td>
<td>Avg 33.6, 1.3</td>
<td>Avg 37.8, 4.5</td>
<td>Avg 38.5, 5.1</td>
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<tr>
<td>Single leg hop-1</td>
<td>Avg 37.8, 2.0</td>
<td>Avg 43.6, 1.3</td>
<td>Avg 47.8, 4.5</td>
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<td>Avg 47.8, 2.0</td>
<td>Avg 53.6, 1.3</td>
<td>Avg 57.8, 4.5</td>
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<td>Avg 57.8, 2.0</td>
<td>Avg 63.6, 1.3</td>
<td>Avg 67.8, 4.5</td>
<td>Avg 68.5, 5.1</td>
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<tr>
<td>Single leg jump</td>
<td>Avg 28.8, 2.0</td>
<td>Avg 33.6, 1.3</td>
<td>Avg 37.8, 4.5</td>
<td>Avg 38.5, 5.1</td>
</tr>
<tr>
<td>Single leg jump-1</td>
<td>Avg 37.8, 2.0</td>
<td>Avg 43.6, 1.3</td>
<td>Avg 47.8, 4.5</td>
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<tr>
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<td>Avg 47.8, 2.0</td>
<td>Avg 53.6, 1.3</td>
<td>Avg 57.8, 4.5</td>
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<tr>
<td>Single leg jump-3</td>
<td>Avg 57.8, 2.0</td>
<td>Avg 63.6, 1.3</td>
<td>Avg 67.8, 4.5</td>
<td>Avg 68.5, 5.1</td>
</tr>
</tbody>
</table>

Validity of Hopping Tests

- Very little evidence to suggest strong correlations with proprioception, muscle strength & power, joint laxity and self-assessment measures of function.
- Hop tests provide additional information independent of these other measures of function.
- Hop test scores are a summary variable that reflect the net outcome of the sensorimotor components contributing to performance.
Functional Octagonal Hop Test

• A novel test that will utilize agility, speed, jumping, landing, cutting, strength, and balance ability
• Performed with one foot

Functional Octagonal Hop Test Pattern

Steps are 18" apart

Functional Octagonal Hop Test

• ICC measurements taken on 13 subjects indicates good (0.60) to excellent (0.81) reliability
• Non-dominant foot more reliable than dominant
• Familiarization trials are the key to improving the reliability of this task

Functional Octagonal Hop Test

Functional Octagonal Hop Test

Functional Octagonal Hop Test

Functional Octagonal Hop Test

Combined Functional Assessment Protocols

Carolina Functional Performance Index (CFPI)

• Developed to evaluate LE functional performance
• CFPI index was determined based on the results:
  • Carioca test
  • Co-contraction test
  • Prediction equations: (x_1 = co-contraction score in seconds & x_2 = carioca score in seconds)
    • Males: 1.09 (x_1) + 1.415 (x_2) + 8.305 = CFPI
    • Females: 1.26 (x_1) + 1.303 (x_2) + 8.158 = CFPI
• CFPI = \(31.551\) \(\downarrow\) CFPI = \(36.402\)

Functional Fatigue Protocol

• Subjects perform a series of running, cutting, hopping and jumping cutting activities until termination criteria is met
**Functional Fatigue Protocol**

**Functional Movement Screen**

Web Site Link: [http://www.functionalmovement.com/](http://www.functionalmovement.com/)

### Background

- Developed by:
  - Gray Cook, MSPT, OCS, CSCS, RKC
  - Lee Burton, PhD, ATC, CSCS
- Visual of movement patterns
- Purposes:
  - 7 test movement assessment
  - Identify imbalances and limitations
  - Pinpoints weak links
  - Minimizes risk of non-contact injuries
  - Provides a basis for corrective exercises to restore corrective movement patterns

### Purpose

- FMS can be used as a pre-test/post-test
- Warm-up not necessary
- Test materials:
  - 2x6 Board
  - 5’ Dowel
  - Hurdle
  - Tape Measure
- Scoring System (Cook et al., 2006 – AJSPT)
  - 0 – 3 pts/test
  - Compare (L) vs. (R)

### The Functional Movement Screen

- Overhead Deep Squat
- Hurdle Step
- In-Line Lunge
- Shoulder Mobility
- Active Straight Leg Raise
- Trunk Stability Push-up
- Rotary Stability
Where Do We Go From Here?

- As clinicians become more comfortable with the various functional performance tests available to them, it is hoped that they will incorporate them into their clinical practice.
- There are a variety of resources available to obtain normative data for comparison.

Take Home Message

- Functional Performance Testing should be incorporated into the clinical setting:
  - Determine performance deficits
  - Used to classify stability status
  - As a measure of RTP status
  - Make bilateral comparisons
  - Most tests are reliable and easy to use

Helpful References

- http://www.brianmac.demon.co.uk/
- http://www.afpafitness.com/articles/?page_id=37

Thank You

For more information, visit: http://www.udel.edu/chs/atep/lectures