Neuroplasticity and Patient-reported Outcomes after Anterior Cruciate Ligament Reconstruction

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Presenter Conflict

No Conflict

- The views expressed in these slides and the today’s discussion are ours
- Our views may not be the same as the views of my company’s clients or my colleagues
- Participants must use discretion when using the information contained in this presentation
Learning Objectives

At the end of this presentation participants will:

1. Be able to identify the importance of patient-reported outcomes following musculoskeletal injury.
2. Be able to describe the neuroplastic changes after musculoskeletal injury.
3. Be able to evaluate the relationship between patient-reported outcomes and neuroplasticity associated with injury and therapy.
Overview

- Patient Reported Outcomes
- Anterior Cruciate Ligament Injury
- Neuroplasticity
- Future Directions
Critical Issues Facing ATs

- Reimbursement for services provided
- Competition for traditional athletic training practice settings
- Healthcare Reputation
- Licensure
- Variety in Patients & Practice Settings
Perspectives

“The stark reality is that without documented evidence showing the effectiveness of clinical interventions rendered by ATCs, reimbursement is a pipe dream.” Hertel, J. JAT June 2005
Perspectives

“As other professionals, such as physicians and physical therapists, embrace the concept of EBM, so too should athletic training practitioners. Otherwise, we may run the risk of gaining the reputation that we do not regard evidence of effectiveness and critical thinking as highly as other professionals. This reputation may then affect patients as they decide who will provide their care.” Steves and Hootman, JAT 2004
Perspectives

“I appeal to our research and academic community to quickly develop and complete research projects that will demonstrate the value of athletic trainers to employers” “We need projects that demonstrate the cost-benefit analysis”  

Kimmel November 2005 NATA NEWS article
Reality is.....

• Without data demonstrating our services restore function, improve HRQOL, decrease re-injury rate, are cost effective...

Question the quality and nature of care ATs are allowed to provide according to patient types and practice settings
Healthcare Reputation

• Recognized as allied healthcare profession for more than 20 years!
  – Laypersons and medical professionals still have misconceptions about AT and what services ATs can provide

• Share our success and impact on community
  – Disablement models, Outcomes Research, EBP!
How Do We, as a Profession, Face These Challenges?
Most Challenges May Be Addressed with OUTCOMES RESEARCH
Patient-Based Outcome Measures

• Outcomes that are meaningful to patients
  – From patient perspective; surveys or questionnaires

• Examples
  – HRQOL, QOL
  – Mortality
  – Disability
  – Satisfaction
“Objective” marker versus PRO

Exercise test versus physical functioning, $r = 0.40$
Clinical Outcomes: General Categories

Clinician-Based

Patient-Based

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Clinician-Based Outcomes

- Evaluated by clinician
  - Often physiologic
  - Health Condition
  - Body Structures/Functions

- Objective (hard) evidence
  - Impairment infers function and quality of life
  - Not necessarily

Provide useful information

Lack of patient input makes it difficult to perform patient-centered care and generate POEM
Patient-Based Outcomes

- Evaluated by patient
  - Scales, Instruments, Surveys
- Objective
  - Psychometrically sound instruments
- Characteristics
  - Applicability
    - Generic/ general vs. specific
  - Length
    - Single vs. Multi-item

**Impact Clinical Practice**

1. Capture patient voice
2. Develop functional/HRQOL goals
3. Direct treatment towards functional limitations and disability
4. Evaluate treatment effectiveness
5. Improve clinical decision making
# Applicability: General vs. Specific

<table>
<thead>
<tr>
<th>Type</th>
<th>Appropriate Patients</th>
<th>Question Relevance</th>
<th>Responsiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Generic/General</strong></td>
<td>Diverse: wide variety of patients (healthy and injured or ill)</td>
<td>Broad range of health status dimensions; HRQOL</td>
<td>Less</td>
</tr>
<tr>
<td>eg. Pediatric</td>
<td>Quality of Life Inventory (PedsQL)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Specific</strong></td>
<td>Focused: disease, injury, illness, body region, injury location</td>
<td>Context of condition; narrow scope</td>
<td>More</td>
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<tr>
<td>eg. Lower Extremity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Functional Scale</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>(LEFS)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Benefits</td>
<td>Limitations</td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>--------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Single-Item</td>
<td>✔️ Quick  ✔️ Easy to Score/Interpret  ✔️ Little patient burden ✔️ Clinically Relevant to Patient</td>
<td>✔️ Limited information about a construct ✔️ Less reliable than multi-item PROs ✔️ Unable to evaluate HRQOL</td>
<td></td>
</tr>
<tr>
<td>eg. Global Rating of Change (GROC)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multi-Item</td>
<td>✔️ Comprehensive assessment of construct ✔️ Evaluation of HRQOL ✔️ Better understanding of impact of condition on patient</td>
<td>✔️ Time to complete and score ✔️ Burden on patient and clinician</td>
<td></td>
</tr>
<tr>
<td>eg. Lower Extremity Functional Scale (LEFS)</td>
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</tbody>
</table>
Do Self-Report Measures of Function & Disability Really Matter?

• Yes – without these measures...
  – Not assessing level of difficulty a patient has when performing a task
  – Not assessing the emotional impact of the disease on his/her job, activities, family, and/or social life (quality of life)
  – Focusing on impairments instead of function & disability

Not Measuring HRQOL!
Single-Item PROs

GROC

NPRS

SAT

SANE
Overall since your first athletic training visit, has there been any change in your shoulder status?

Please check only one answer.

A very great deal worse
A great deal worse
A good deal worse
Moderately worse
Somewhat worse
A little worse
About the same, no change
A little better
Somewhat better
Moderately better
A good deal better
A great deal better
A very great deal better

MDC

• 1.5 points
If I had to give my knee a grade from 1 to 100, with 100 being the best, I would give my knee a ____.
Satisfaction

Satisfaction Rating 2:
How satisfied are you with the care you received for your injured body part?

0 1 2 3 4 5 6 7 8 9 10
Not Satisfied
Completely Satisfied
Numeric Pain Rating Scale (NPRS)

Numeric Pain Rating Scale:
Please rate the pain associated with your injury on the following scale:

0 1 2 3 4 5 6 7 8 9 10
No Pain
Worst Imaginable Pain

MDC

• 2 points
Generic PROs

- Disablement in the Physically Active (DPA) Scale
- PROMIS
- SF-12
- PedsQL
- Generic PROs
Generic Example: Disablement in the Physically Active (DPA) Scale

• 16 Questions
  – Total Score
  – 3 domains (impairments, functional limitations, and disability)
• Adjectival scale (1=no probs to 5=severe probs)
• Complete and score: < 7 minutes

Vela et al. JAT 2010; Vela et al. JAT 2010

• Range: 0-64
• Higher scores = more disablement

MDC

• 9 points for persistent injuries; 6 points for acute injuries
Patient-Reported Outcomes Measurement Info System (PROMIS)

• Item banks for children and adults
  – Fatigue, pain, physical function, depression, anxiety, and social function
• Short forms (4-10 Q’s); computerized adaptive testing (3-7 Q’s)
• Scoring: (raw sum x number items possible)/ number of items answered. Generate T-score
• Completion: 2 minutes
• Scoring: 3 minutes

http://www.nihpromis.org
Lower Extremity PROs

- Anterior Knee Pain Scale (AKPS)
- IKDC
- Pedi-IKDC
- KOOS
- LEFS
- FAAM
IKDC Subjective Knee Form

• Adult: 18 Questions: 7 Symptoms, 10 Sports Activities, 1 Function
• Pedi: 22 Questions: 9 Symptoms, 10 Sports Activities, 2 Function, 1 person completing instrument (Kocher et al AJSM 2010)
• Range of scores: 0-100
  – Higher scores = lower levels of symptoms & higher level of function & sport activity
• Completion Time: ~ 3-5 minutes; scoring Time: ~3 minutes

<table>
<thead>
<tr>
<th>MDC</th>
<th>Meaningful change</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 scale pts.</td>
<td>11.5 scale pts.</td>
</tr>
<tr>
<td>(Irrgang 2001)</td>
<td>(Irrgang 2006)</td>
</tr>
</tbody>
</table>
Knee Injury and Osteoarthritic Outcome Score (KOOS)

• 42 items
• 5 scales: QoL, ADLs, Sport, Symptoms, and Pain
• Range of scores: 0-100
  – Higher scores = lower levels of symptoms & higher level of function & sport activity
• Completion Time: ~ 5 minutes; scoring Time: ~3 minutes

MDC

• 8-10 points depending on scale
Lower Extremity Functional Scale (LEFS)

• 20 Questions: All Function
• Scoring: Sum all responses
  – Minimum score = 0;
  – Maximum score = 80
  – Higher score = higher function
• Completion Time ~ 2 minutes
• Scoring Time = ~ 20 seconds
• Benefits to both types of patient instruments
• Lots of options
• Recommendation to use 1 generic and 1 specific when evaluating patient outcomes
### How Can we Impact PRO’s??

**Region-Specific Patient-reported Outcomes between Participants who Restored Function and Participants who did not Restore Function at Discharge**

<table>
<thead>
<tr>
<th></th>
<th>Restored Function (n=4)</th>
<th>Did not Restore Function (n=11)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time of Injury</td>
<td>Discharge from Treatment</td>
</tr>
<tr>
<td><strong>FAAM-ADL</strong></td>
<td>69±4</td>
<td>95±5</td>
</tr>
<tr>
<td><strong>FAAM-Sport</strong></td>
<td>50±5</td>
<td>90±8</td>
</tr>
<tr>
<td><strong>KOOS-Pain</strong></td>
<td>47±8</td>
<td>95±3</td>
</tr>
<tr>
<td><strong>KOOS-Symptoms</strong></td>
<td>64±4</td>
<td>90±4</td>
</tr>
<tr>
<td><strong>KOOS-ADL</strong></td>
<td>51±7</td>
<td>90±7</td>
</tr>
<tr>
<td><strong>KOOS-Sport</strong></td>
<td>20±4</td>
<td>86±2</td>
</tr>
<tr>
<td><strong>KOOS-QOL</strong></td>
<td>53±5</td>
<td>88±2</td>
</tr>
</tbody>
</table>
How Can we Impact PRO’s??

Single-Legged Hop Tests as Predictors of Self-Reported Knee Function in Nonoperatively Treated Individuals With Anterior Cruciate Ligament Injury

Hege Grindem, PT, MSc, David Logerstedt, PT, MPT, SCS, Ingrid Etzen, PT, PhD, Håvard Moksnes, PT, MSc, Michael J. Axe, MD, Lynn Snyder-Mackler, PT, DSc, SCS, ATC, FAPTA, Lars Engbretsen, MD, PhD, and May Arna Risberg, PT, PhD
Investigation performed at Hjelp24 Norwegian Sports Medicine Clinic (Hjelp24 NIMI), Ullevaal, Oslo, Norway

Single-Legged Hop Tests as Predictors of Self-Reported Knee Function After Anterior Cruciate Ligament Reconstruction

The Delaware-Oslo ACL Cohort Study

David Logerstedt, PT, PhD, MPT, SCS, Hege Grindem, PT, MSc, Andrew Lynch, PT, PhD, DPT, Ingrid Etzen, PT, PhD, Lars Engbretsen, MD, PhD, May Arna Risberg, PT, PhD, Michael J. Axe, MD, and Lynn Snyder-Mackler, PT, ScD, SCS, ATC, FAPTA
Investigation performed at University of Delaware Physical Therapy Clinic, Newark, Delaware, and Hjelp24 Norwegian Sports Medicine Clinic (Hjelp24 NIMI), Ullevaal, Oslo, Norway

Single-legged hop tests conducted 6 months after ACL reconstruction can predict the likelihood of successful and unsuccessful PROs 1 year after ACL reconstruction.
Neural Control of Human Movement

- Alpha Motorneuron Excitability
- Spinal Reflex Excitability
- Brain Activation
- Gait Mechanics
- Proprioception
- Force Control
- Strength
- Neurocognition
- Cutting Mechanics
- Somatosensory Potentials
- Gamma Motorneuron Excitability
- Cortical Excitability
- Postural Control
- Jump Landing Mechanics

Static.................................................Dynamic Variable

Sensory..............................................................Motor

Figure modified from Hertel 2008 Sensorimotor deficits with ankle sprains and chronic ankle instability
Creating a Motor Program

Slide Courtesy of Brain Pietrosimone NATA 2014
Creating a Motor Program

Slide Courtesy of Brain Pietrosimone NATA 2014
Creating a Motor Program
Creating a Motor Program

Slide Courtesy of Brain Pietrosimone NATA 2014
Measuring the Brain

- Movement paradigm – 4 sets – Block Design
  - Flexion
  - Knee Extension – 30 seconds

1.2 Hz movement frequency (36 cycles)
Measuring the Brain
Brain-Outcomes

ACL

Control
Knee Motor Control

Regions with Lower Activation in ACL Group Compared to Control
- Cerebellum (Vermis)
- Ipsilateral Motor Cortex

3D render

Regions with Higher Activation in ACL Group Compared to Control
- Contralateral Motor Cortex
- Lingual Gyrus
- Ipsilateral Secondary Somatosensory

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- Lingual gyrus\textsuperscript{23}:
  - Visual processing
  - Spatial memory

- Secondary somatosensory\textsuperscript{24}:
  - Sensory processing
  - Pain memory

\textsuperscript{23} Servos CC 2002; \textsuperscript{24} Torquati NI 2005; \textsuperscript{25} Kapreli NI 2006
ACL Brain-Outcomes

- KOOS – Sport Scale & Visual Activation

\[ r = .518, \ p = 0.033 \]
ACL Brain-Outcomes

- KOOS – Sport Scale & Sensory Activation

\[ r = 0.562, \ p = 0.019 \]
Implications

- ACLR induces sensory-visual-motor neuroplasticity
- Sensory-visual brain activation related to KOOS sport function
  - Lost proprioceptive input\textsuperscript{30,31}
    - Sense instability = Adapt motor control
  - Cortical excitability\textsuperscript{32,33}
    - Increased = Improved strength + function

\textsuperscript{30} Courtney G&P 2010\textsuperscript{5}  \textsuperscript{31} Courtney G&P 2006  \textsuperscript{32} Lepley SJMSS 2015  \textsuperscript{33} Pietrosimone 2015 JAT
What might this new Rehabilitation look like???
Cascade of Neuromuscular Control Dysfunction

• Video analysis of actual injury events
• Distractors
  – Ball
  – Another player
  – Stressful situation
  – Cognitive load
Visual Feedback Disruption

- Visual – Motor Disruption
  - Stroboscopic visual knockdown\textsuperscript{21,22}
    - Allows complex action
    - Improves visual processing and action anticipation

Virtual Reality
Environment & Anticipation

CASE REPORT
REHABILITATION STRATEGIES ADDRESSING NEUROCOGNITIVE AND BALANCE DEFICITS FOLLOWING A CONCUSSION IN A FEMALE SNOWBOARD ATHLETE: A CASE REPORT

John Faltus, DPT, MS, SCS, LAT, ATC, CSCS
Modifying Performance

- Neuromuscular system perform specific motor task

  - Easy to temporarily modify ≠ learning
External Feedback Model
Feedback specific

- Feedback specific cortical activation
  - Frontal pole – working memory & attention
  - Occipital pole – visual spatial processing
  - Precuneous – sensory integration

Figure 1: Areas of brain activation when participants used an external focus of attention compared to an internal focus of attention, all $p < .001$. 

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What if I just throw some tape on it?
Neuroplasticity of Tape

Changes brain motor and sensory activation!

- **DECREASE** activation
  - Sensory cortex – Efficient processing

- **INCREASE** activation
  - Motor cortex – Increased output
  - Supplementary motor
How Does this Change Clinical Practice

- THINK!
  - About ways to improve the outcome in all your intervention efforts
- Neuroscience Tools can Optimize Interventions
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References


