Neuroplasticity in Athletic Training

Dustin Grooms, PhD, ATC, CSCS
Ohio University
Athletic Training

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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
Objectives

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• Understand how the brain changes after musculoskeletal injury
• How as athletic trainers they can induce neuroplasticity in their patients
• Apply novel concepts from neuroscience to athletic training practice to enhance injury prevention and rehabilitation
Overview

- How I get here
- Neuroplasticity
- Neuroimaging
- Clinical Implications

Overview

fMRI to assay neural control of human movement
Anterior Cruciate Ligament Rupture

- 1 in 20 collegiate level athletes\(^2,3\)
- 1 in 50 high school athletes\(^4,5\)
  - 70% are non-contact\(^8,9\)

- 50% - 100% Radiographic Osteoarthritis\(^11,12\)
  - Accelerated Knee Degeneration

- 30% failure rate of reconstruction and rehabilitation\(^13,14\)
  - Rehabilitation focus on joint adaptations
  - "Insufficient evidence for clinical effect"

- What are we missing?

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Athletic training

• What aspect of physiology changes first when you interact with a patient?
• Do you think an ankle sprain changes your nervous system?  
  — Permanently?
• Have you ever seen a noncontact injury?
Non-Contact Injury
Neural Control of Human Movement

![Diagram showing various neural control aspects related to human movement.]

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

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

Cortical
- Pre-central Gyrus
  - Primary Motor (M1)
- Post-central Gyrus
  - Primary Somatosensory (S1)
- Supplementary Motor Area
- Premotor Area

Subcortical
- Basal ganglia
- Cerebellum
Brain Anatomy

- Secondary Somatosensory area
  - Pain, chronic adaptation
- Lingual gyrus
  - Combined sensory-vision integration
- Dorsal & Ventral visual-motor processing
Neuroplasticity

- Ability of neurons to change their function, chemical profile (amount and types of neurotransmitters produced) or structure
- Recovery of function is associated with a return of activity and responsiveness in the motor network
- This is your job!
Neuroplasticity

- **Neural Efficiency**
- **Increased cortical area associated with skill**

Trained sequence

Untrained sequence

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Measuring the Brain

- Movement paradigm – 4 sets – Block Design
  - Rest 30 seconds
  - Knee Extension-Flexion
    - 30 seconds
    - 1.2 Hz movement frequency (36 cycles)
Knee Motor Control
Knee Motor Control

- Lingual gyrus$^{23}$
  - Visual processing
  - Visual memory
  - Altered sensory

- Secondary somatosensory$^{24}$
  - Adapted sensory processing
  - Pain

<table>
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<tr>
<th>Area</th>
<th>MNI Coordinates</th>
<th>Z Value</th>
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<tbody>
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<td>-68 -18 24</td>
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$^{23}$Servos CC 2002; $^{24}$Torquati NI 2005
Knee Motor Control

- Contralateral Sensorimotor
  - Motor drive
  - Conscious control
  - Sensory integration

- Ipsilateral Sensorimotor
  - Contralateral inhibition
  - Neural efficiency

N=30

21) Kapreli NI 2006; 22) Tinazzi NSL 1998
Action-Observation & Motor Imagery

Cortical control of gait in healthy humans: an fMRI study

ChiHong Wang · YanYau Wai · BoCheng Kuo · Ye-Yu Yeh · JiunJe Wang


Cortical Mapping of Gait in Humans: A Near-Infrared Spectroscopic Topography Study

Ichiro Miyai,*, Hiroki C. Tanabe,† Ichiro Sase,† Hideo Eda,† Ichiro Oda,‡ Ikuo Konishi,‡ Yoshio Tsun,¶ Tsuyoshi Suzuki,*, Toshio Yanagida,†§ and Kisou Kubota*†§

NeuroImage 14, 1186–1192 (2001)
Primary Findings

Red – ACLR Higher

- Parietal cortex – S1 BA1 L – supramarginal gyrus
  - Greater visual-sensory integration

Blue – Control Higher

- Visual cortex V2 - BA18 L – occipital pole - Dorsal
  - Greater internal motor control

- Occipital fusiform gyrus – V3V R – Ventral
  - Relative suppression in ACL group
  - Less external motor control
Structural Connectivity

ACLR

Control

Grooms 2015 ACL research retreat
Clinical Implications

- What can you do with this information?

- A few ways you can induce neuroplasticity in your patients TODAY!!!
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

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Environment & Anticipation

Use of an Overhead Goal Alters Vertical Jump Performance and Biomechanics

Kevin R. Ford,1 Gregory D. Myer,1 Rose L. Smith,2 Robyn N. Byrnes,2 Sara E. Dopirak,2 and Timothy E. Hewett1,2,3

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

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Internal Feedback Model

Frontal View

Sagittal View
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 $p < .001$. 
Feedback specific
cortical activation

Auditory
Perform without feedback >> decrease activation >> facilitate autonomous stage

Visual
Reliant on feedback >> Increase activation >> inhibit motor learning progression
Motor Imagery – Mental Practice

Can Mental Practice Increase Ankle Dorsiflexor Torque?

Physical Therapy

Can Mental Practice Increase Ankle Dorsiflexor Torque?

- Ben Sidaway, Amy (Robinson) Trzaska

Graph showing the percentage of change in ankle dorsiflexor torque:
- Control
- Mental Practice
- Physical Practice
Eccentrics

Regions with higher activation ACLR group (orange) and lower activation ACLR group (blue) compared to healthy matched controls.

Normal

Strength Training

Eccentrics

Regions with higher activation eccentric quadriceps contraction (orange) and lower activation (blue).

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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 the brain in all your intervention efforts
- **Neuroscience Tools can Optimize Interventions**
  - Motor Learning
  - Visual-motor
  - Virtual Reality
  - Neurocognition
  - Eccentric training
  - Motor Imagery
  - Taping
References


References


