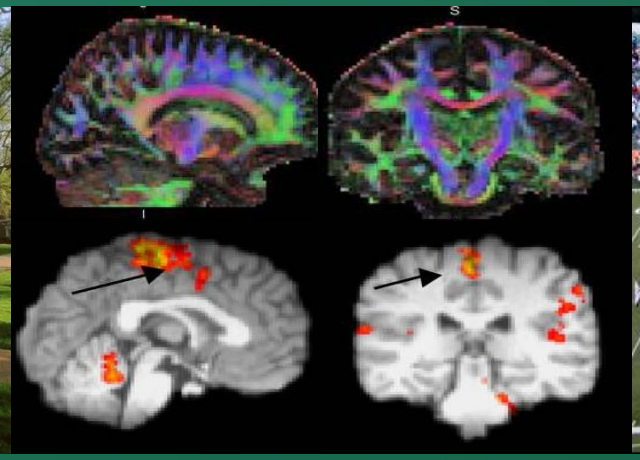
Neuroplasticity and Patient-reported Outcomes after Anterior Cruciate Ligament Reconstruction


Janet Simon PhD, ATC

Dustin Grooms PhD, ATC, CSCS

Ohio University Athletic Training

The best student-centered learning experience in America

OHIO UNIVERSITY

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

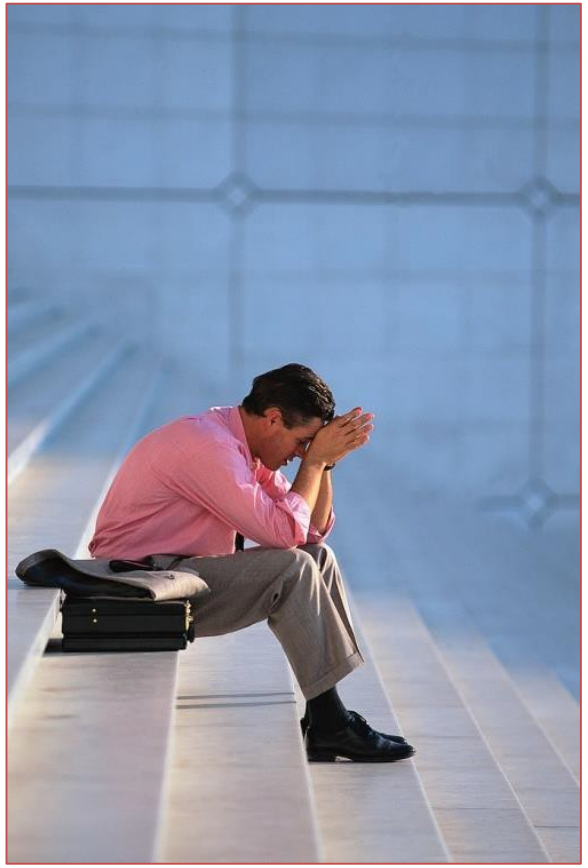
"As other professionals, such as physicians and physical therapists, embrace the concept of EBM, so too should athletic training practitioners. Otherwise, *we may run the risk of gaining the reputation that we do not regard evidence of effectiveness and critical thinking as highly as other professionals*. 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
- Perform like other health professions
  - Disablement models, Outcomes Research, EBP!

How Do We, as a Profession, Face These Challenges?

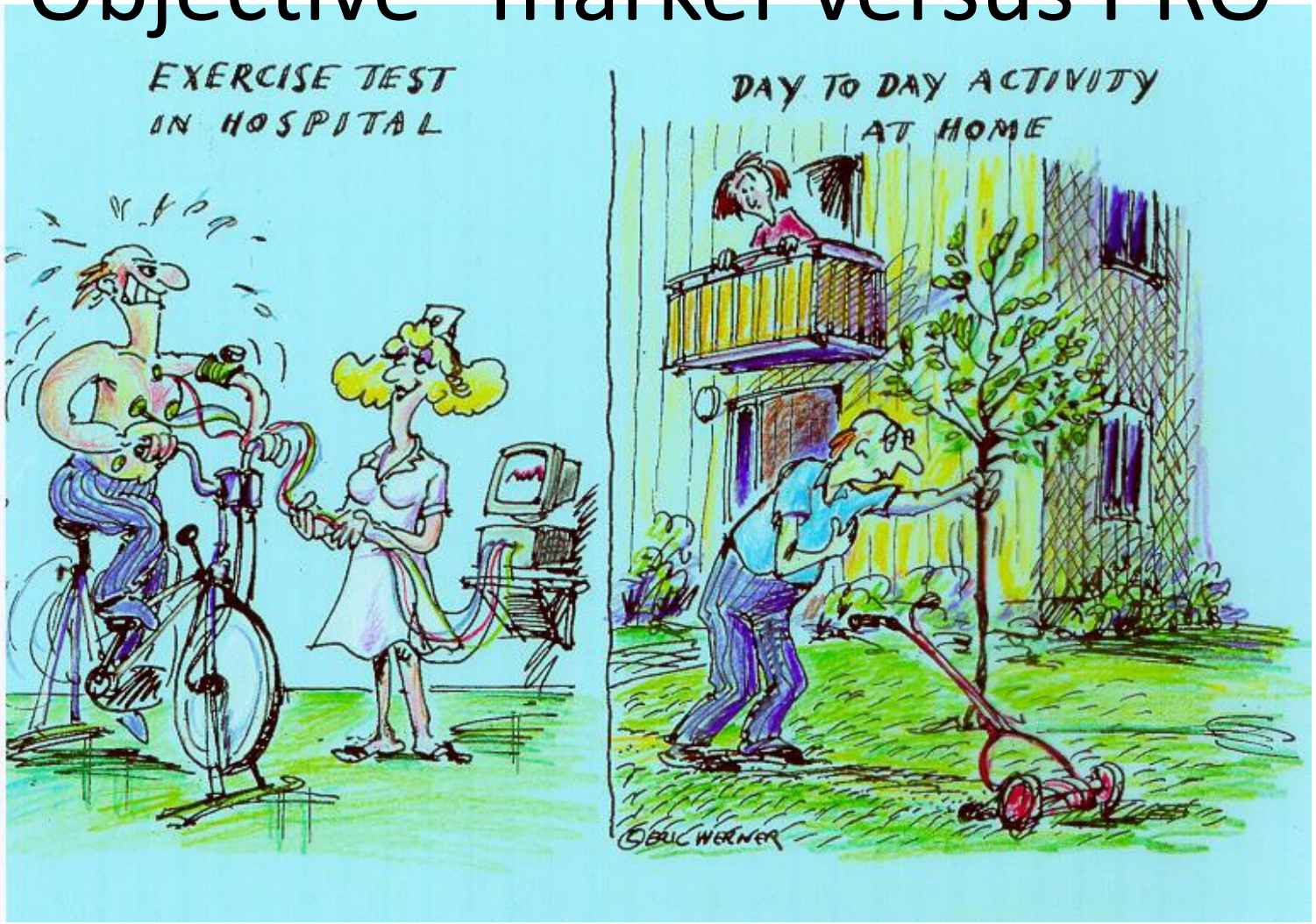
Most Challenges May Be Addressed with

OUTCOMES RESEARCH

Patient-Based Outcome Measures

- Outcomes that are meaningful to patients
  - From patient perspective; surveys or questionnaires
- Examples
  - HRQOL, QOL
  - Mortality
  - Disability
  - Satisfaction

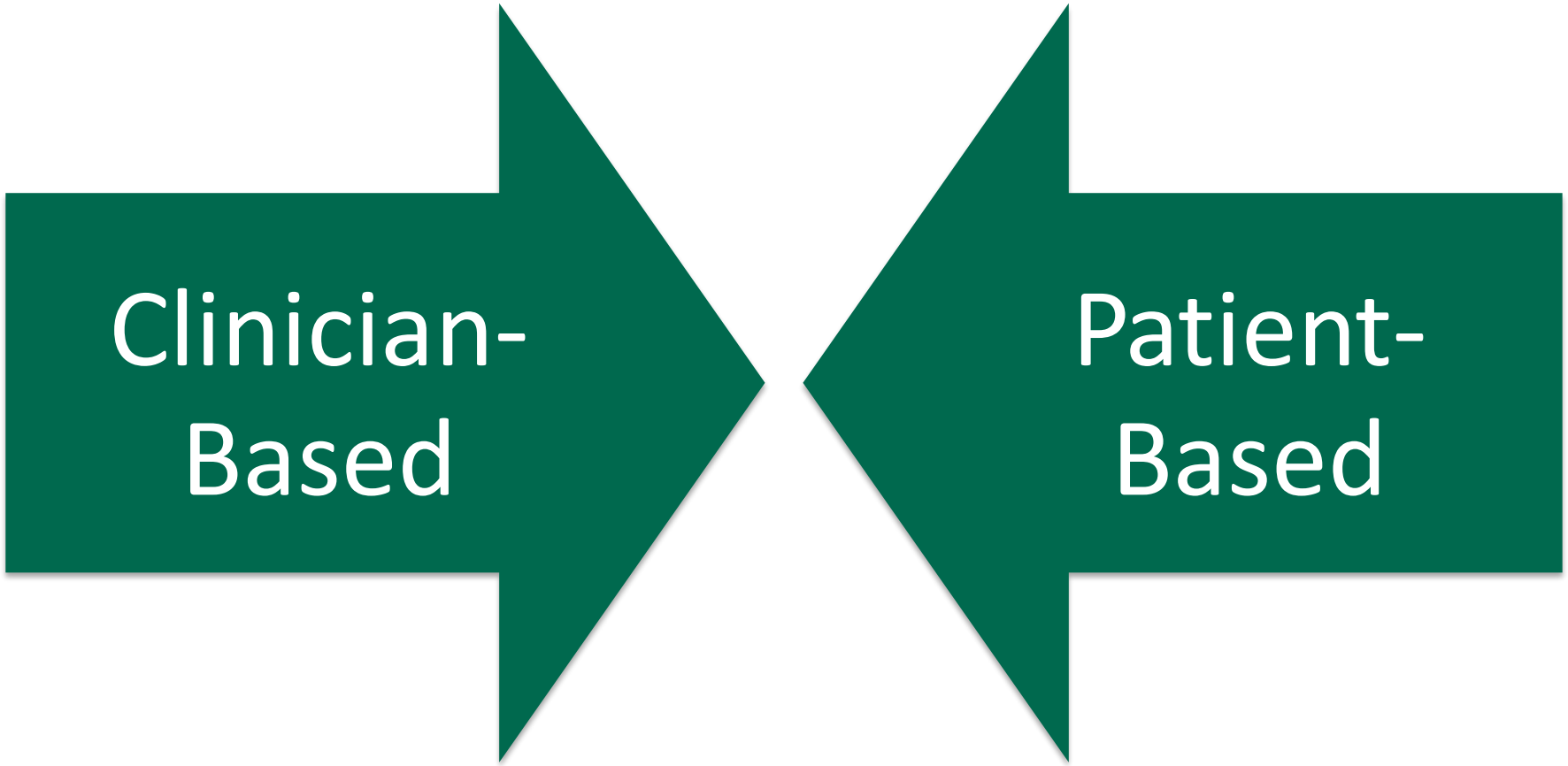
“Objective” marker versus PRO



“Objective” measure “Subjective” measure

Exercise test versus physical functioning, r = 0.40

Clinical Outcomes: General Categories



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

Type	Appropriate Patients	Question Relevance	Responsiveness
Generic/General eg. Pediatric Quality of Life Inventory (PedsQL)	Diverse: wide variety of patients (healthy and injured or ill)	Broad range of health status dimensions; HRQOL	Less
Specific eg. Lower Extremity Functional Scale (LEFS)	Focused: disease, injury, illness, body region, injury location	Context of condition; narrow scope	More

Length: Single- vs. Multi-Item

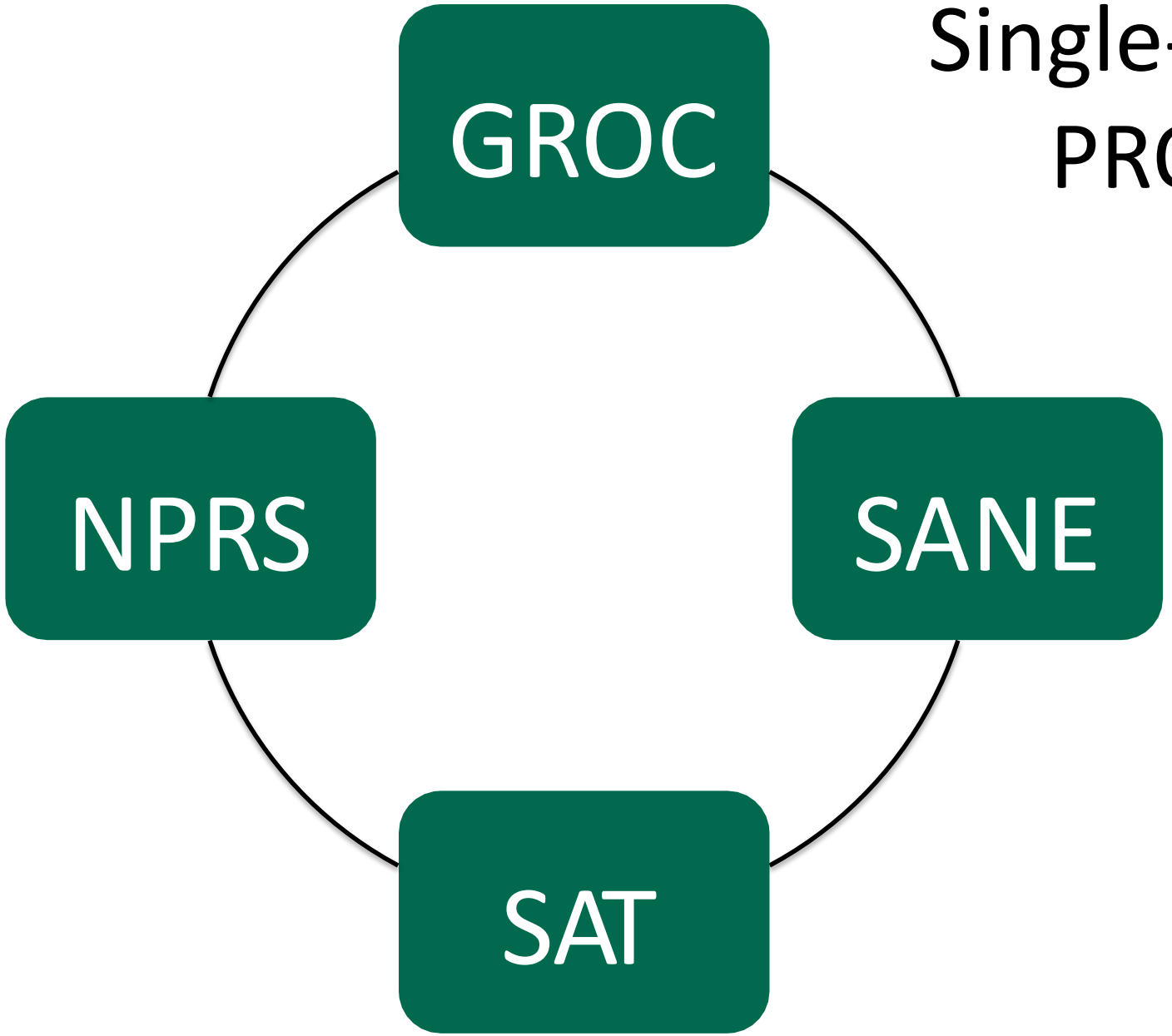
Type	Benefits	Limitations
Single-Item eg. Global Rating of Change (GROC)	✓Quick ✓Easy to Score/Interpret ✓Little patient burden ✓Clinically Relevant to Patient	✓Limited information about a construct ✓Less reliable than multi-item PROs ✓Unable to evaluate HRQOL
Multi-Item eg. Lower Extremity Functional Scale (LEFS)	✓Comprehensive assessment of construct ✓Evaluation of HRQOL ✓Better understanding of impact of condition on patient	✓Time to complete and score ✓Burden on patient and clinician

Do Self-Report Measures of Function & Disability Really Matter?

- Yes – without these measures…
  - Not assessing level of difficulty a patient ha… ming a task
  - Not assessing the emotional im… se on his/her job, activities, family, and/or… ity of life)
  - Focusing on i…
  - Making as… that impairments are directly related to function & disability

Not Measuring HRQOL!

Single-Item PROs



Global Rating of Change (GROC)

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

Single Assessment Numeric Evaluation (SANE)

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)

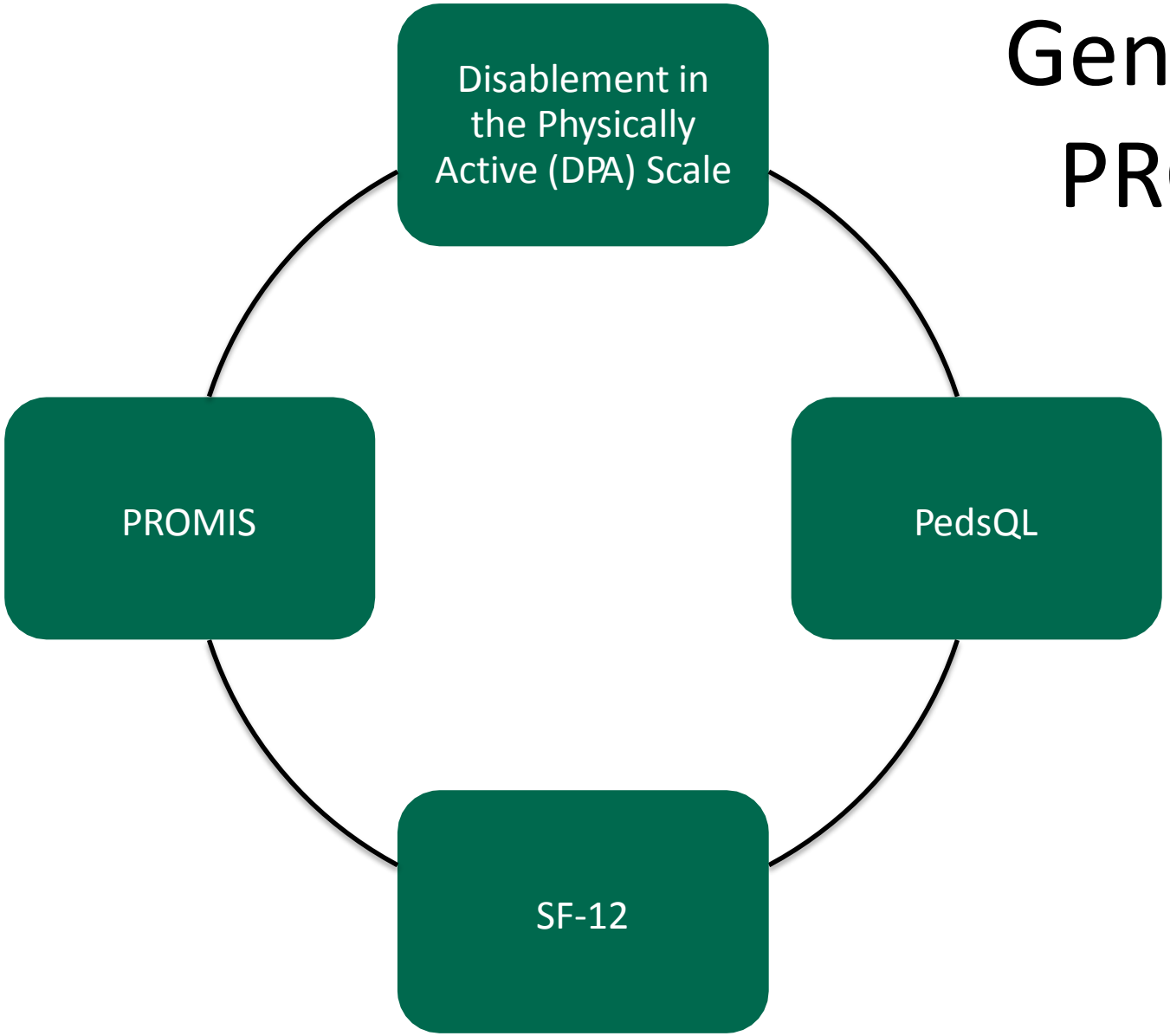
Numeric Pain Rating Scale:
Please rate the pain associated with your injury on the following scale:

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

MDC

- 2 points

Generic PROs



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

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

MDC

- 9 points for persistent injuries; 6 points for acute injuries

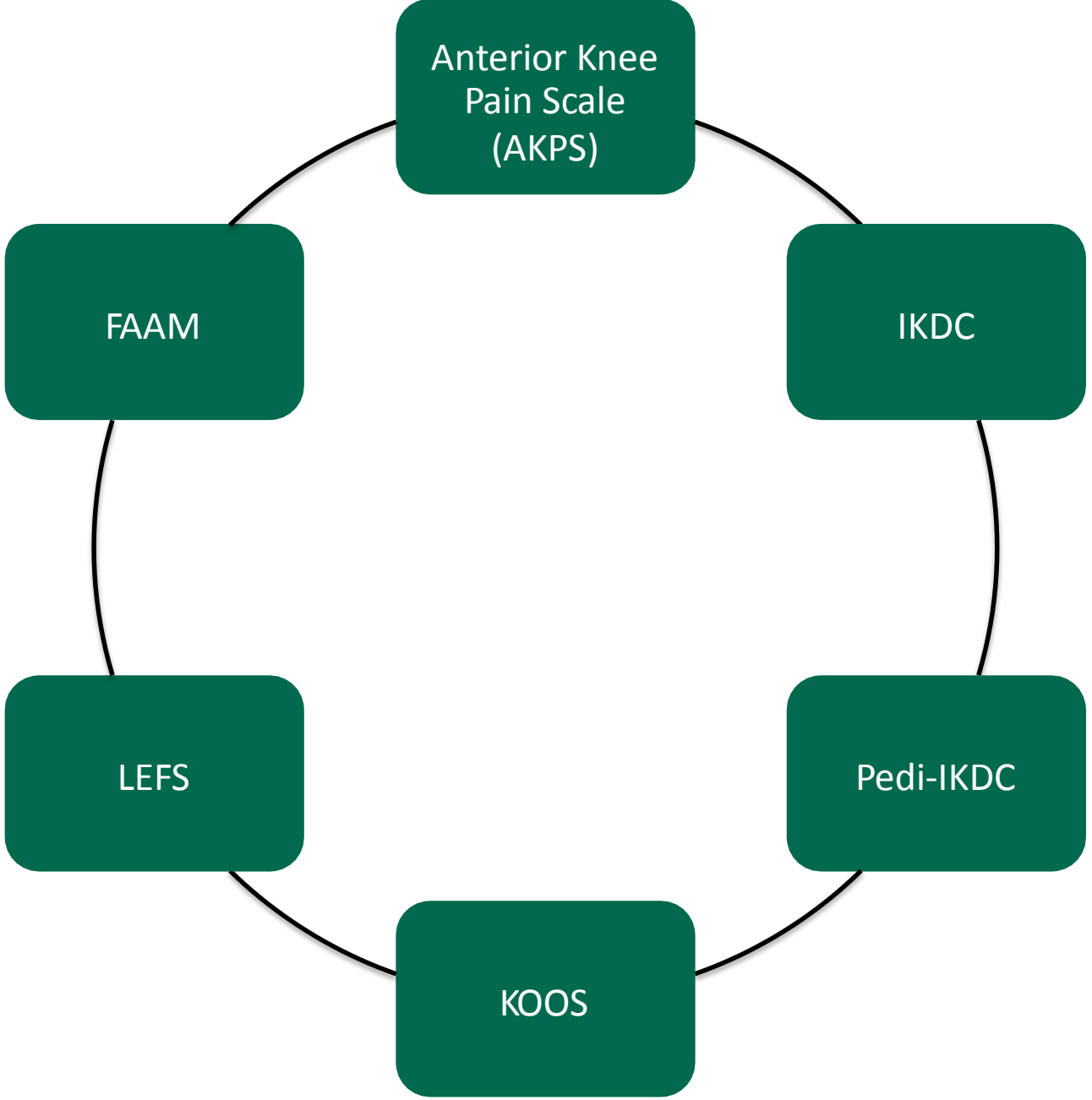
Vela et al. JAT 2010; Vela et al. JAT 2010

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



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

MDC	Meaningful change
• 9 scale pts. (Irrgang 2001) • 12.8 scale pts. (Irrgang 2006)	• 11.5 scale pts. (Irrgang 2006)

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

MDC
• 8 points

- 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

	Restored Function (n=4)			Did not Restore Function (n=11)		
	Time of Injury	Discharge from Treatment	% Change	Time of Injury	Discharge from Treatment	% Change
FAAM-ADL	69±4	95±5	37	68±15	73±7	7
FAAM-Sport	50±5	90±8	80	52±11	72±10	38
KOOS-Pain	47±8	95±3	102	47±23	70±9	49
KOOS-Symptoms	64±4	90±4	40	66±15	81±7	22
KOOS-ADL	51±7	90±7	76	52±22	69±10	32
KOOS-Sport	20±4	86±2	330	24±31	62±20	158
KOOS-QOL	53±5	88±2	66	53±17	74±10	39

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 Eitzen,† PT, PhD, Håvard Moksnes,† PT, MSc, Michael J. Axe,§ MD, Lynn Snyder-Mackler,‡‖ PT, DSc, SCS, ATC, FAPTA, Lars Engebretsen,¶ 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 Eitzen,‡ PT, PhD, Lars Engebretsen,‖ 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

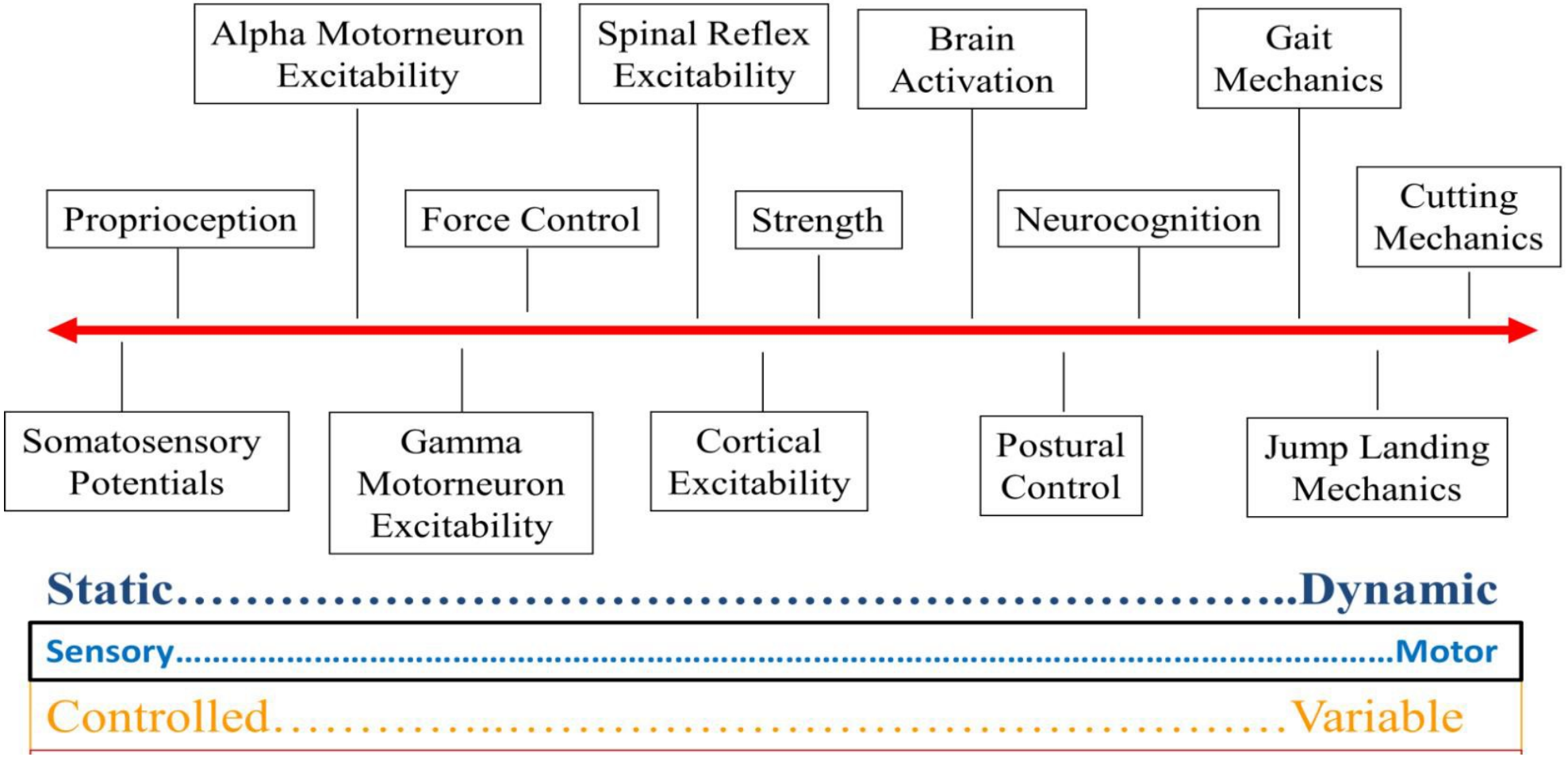
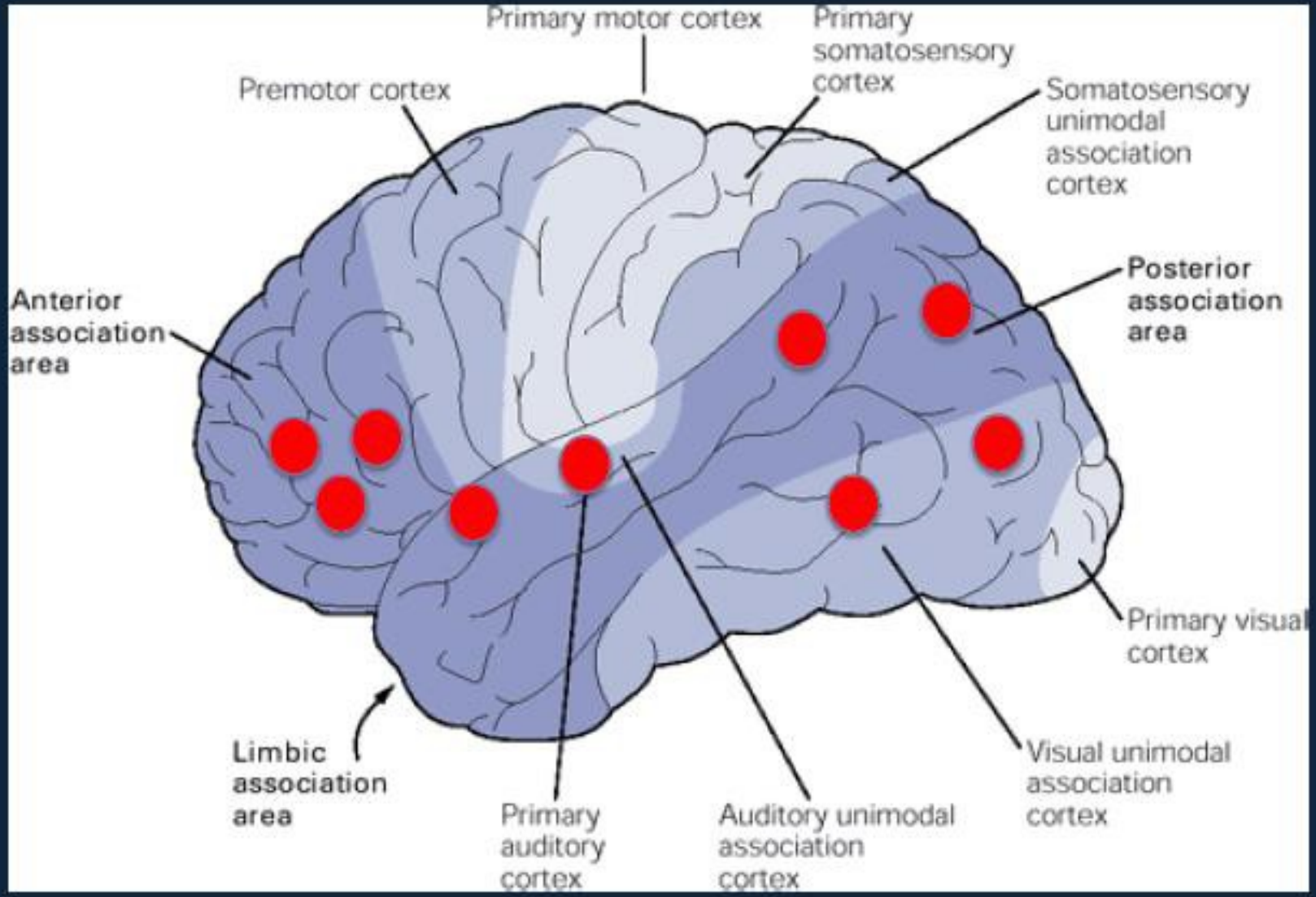


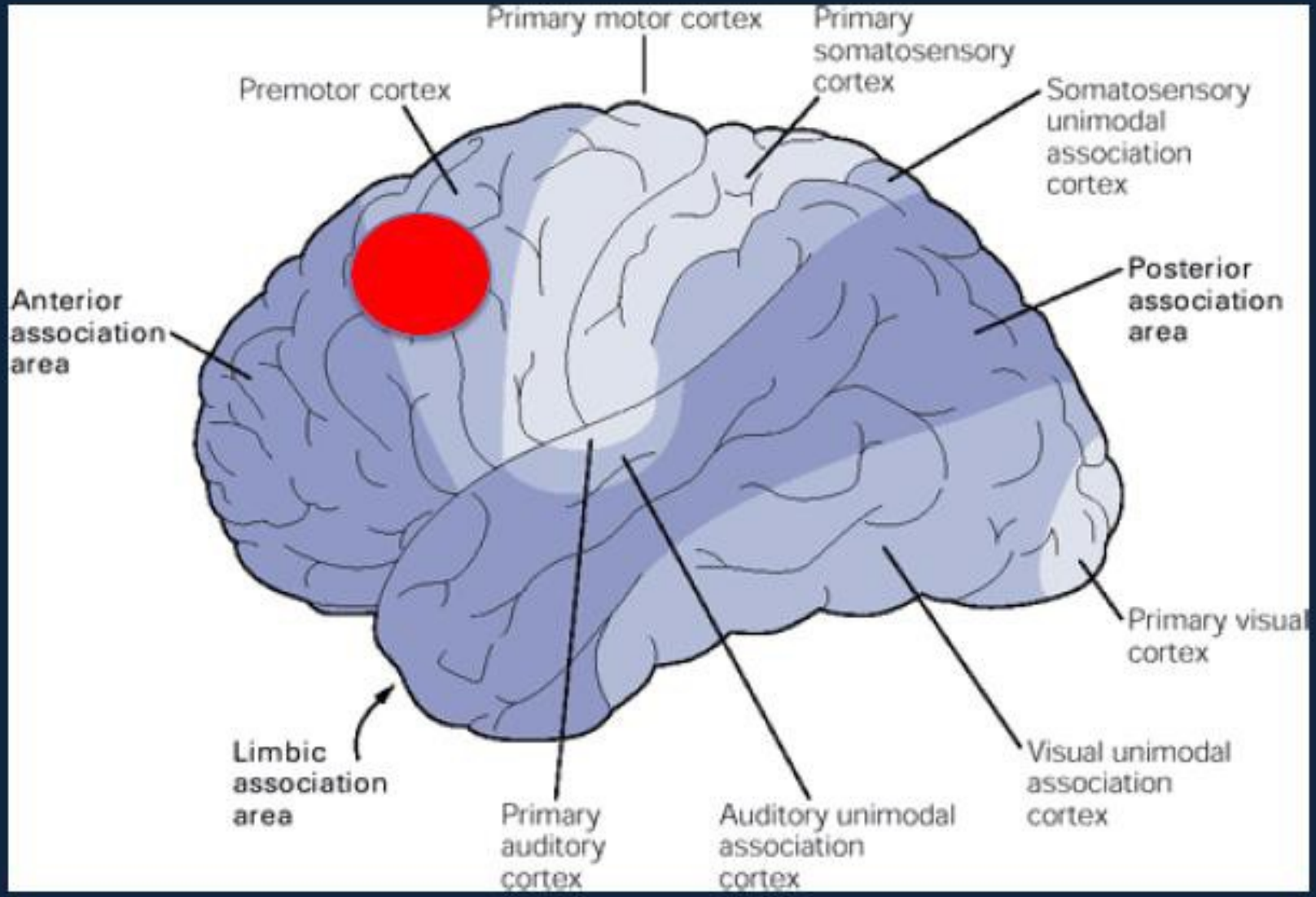
Figure modified from Hertel 2008 Sensorimotor deficits with ankle sprains and chronic ankle instability

Creating a Motor Program



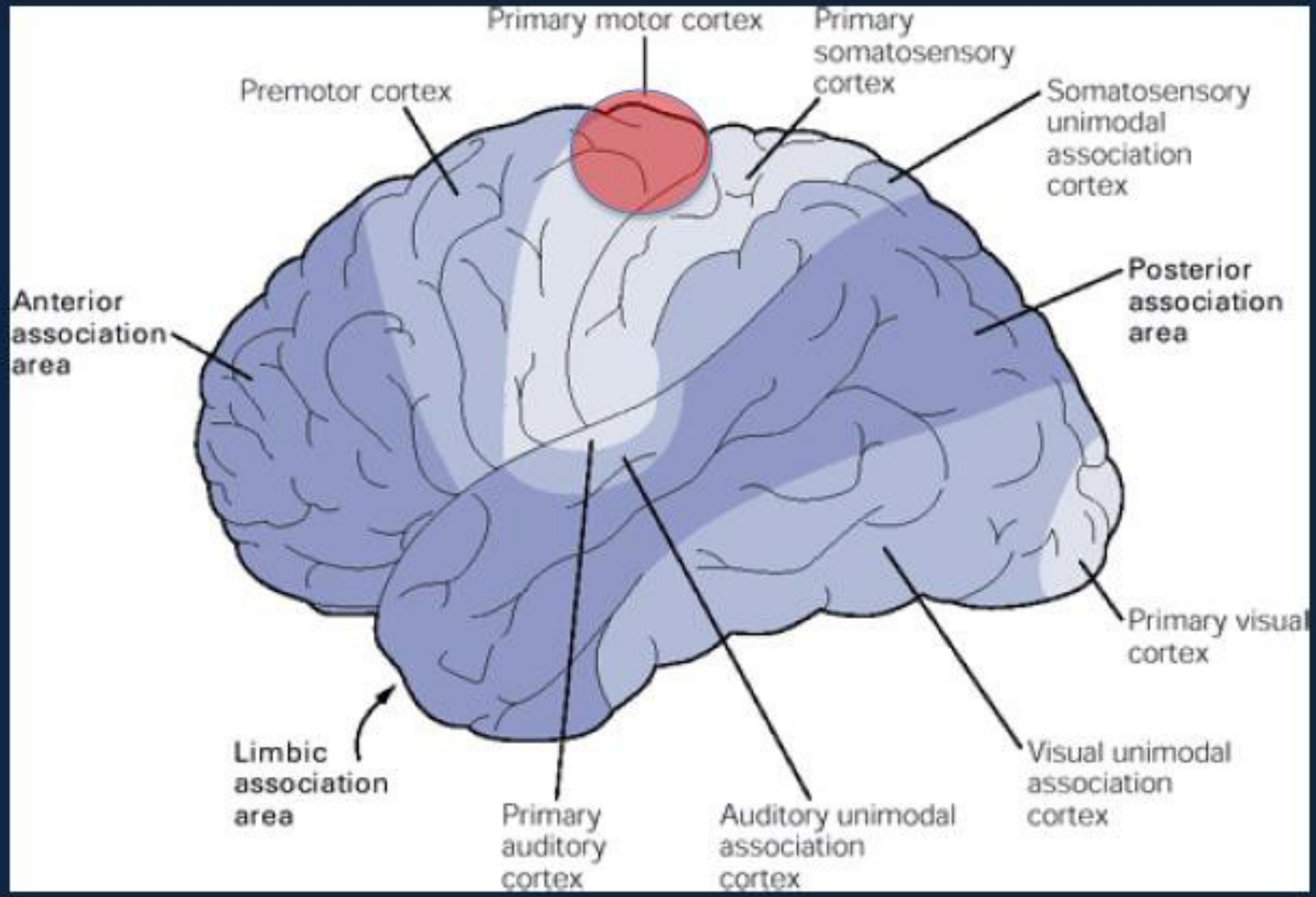
Slide Courtesy of Brain Pietrosimone NATA 2014

Creating a Motor Program



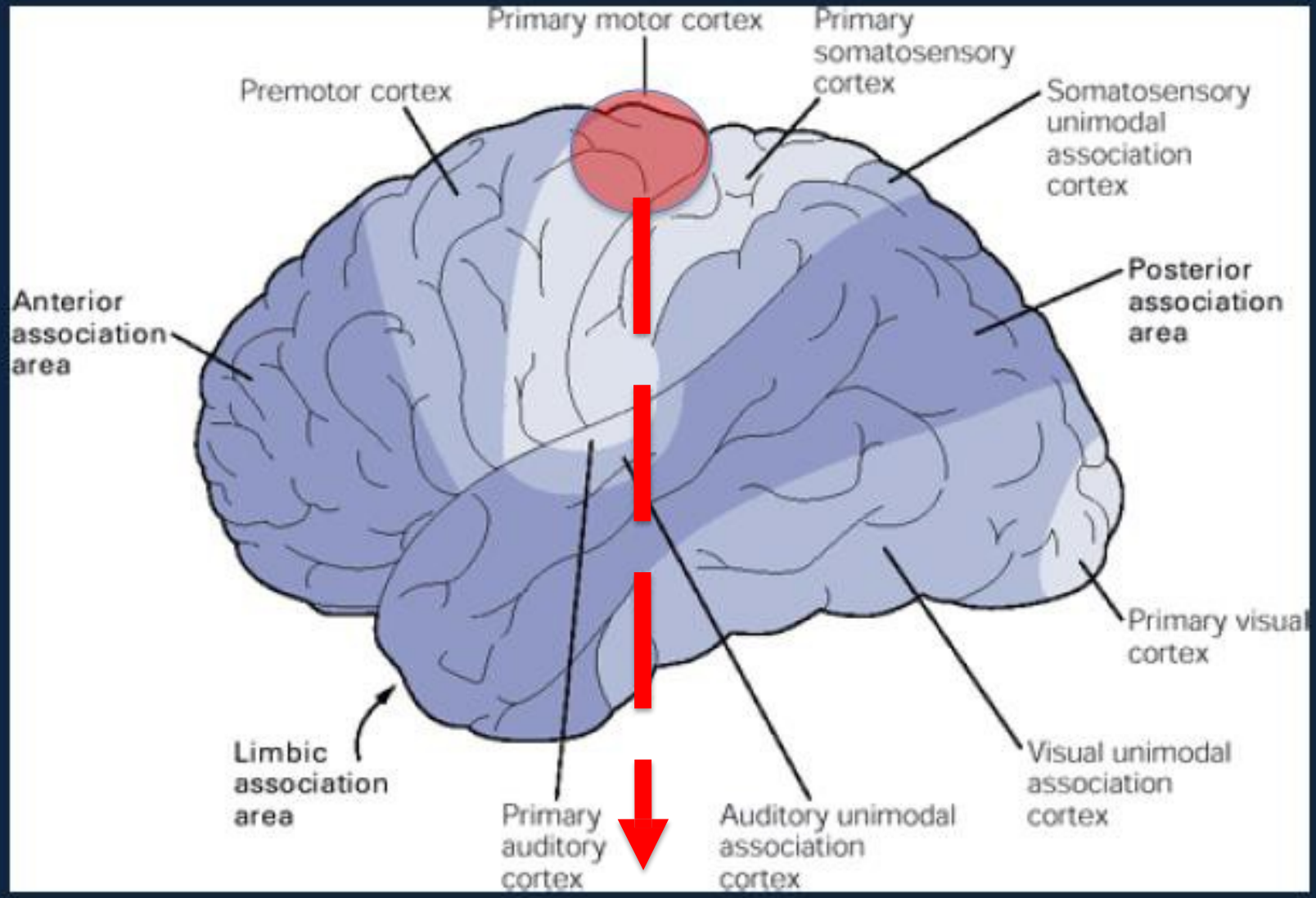
Slide Courtesy of Brain Pietrosimone NATA 2014

Creating a Motor Program



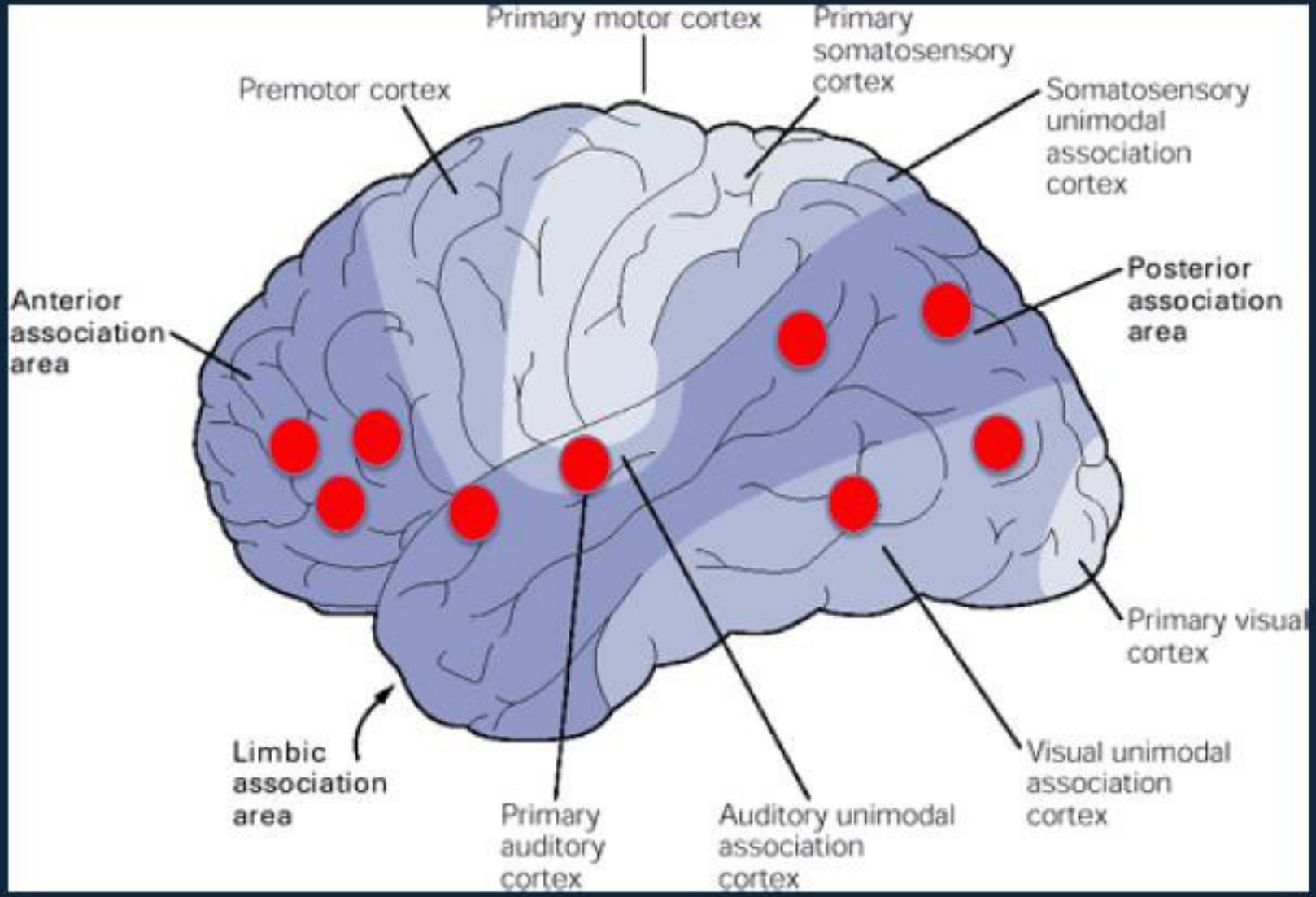
Slide Courtesy of Brain Pietrosimone NATA 2014

Creating a Motor Program



Slide Courtesy of Brain Pietrosimone NATA 2014

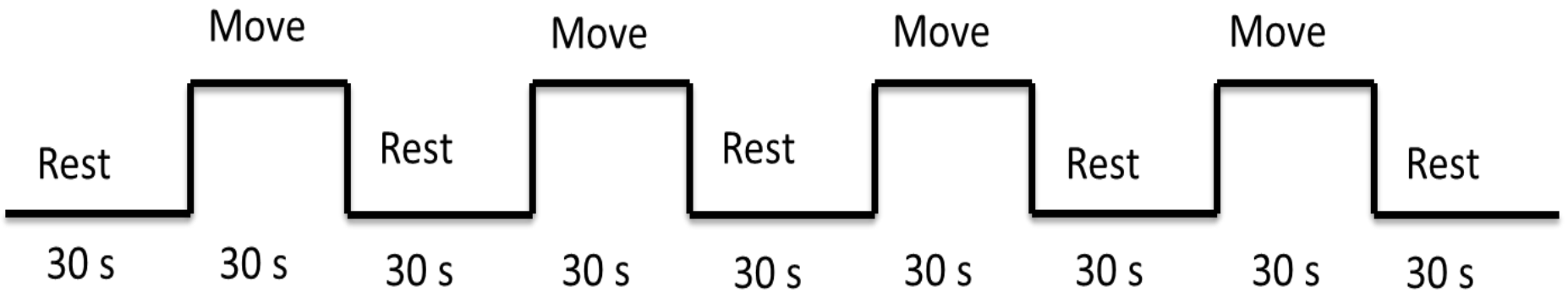
Creating a Motor Program



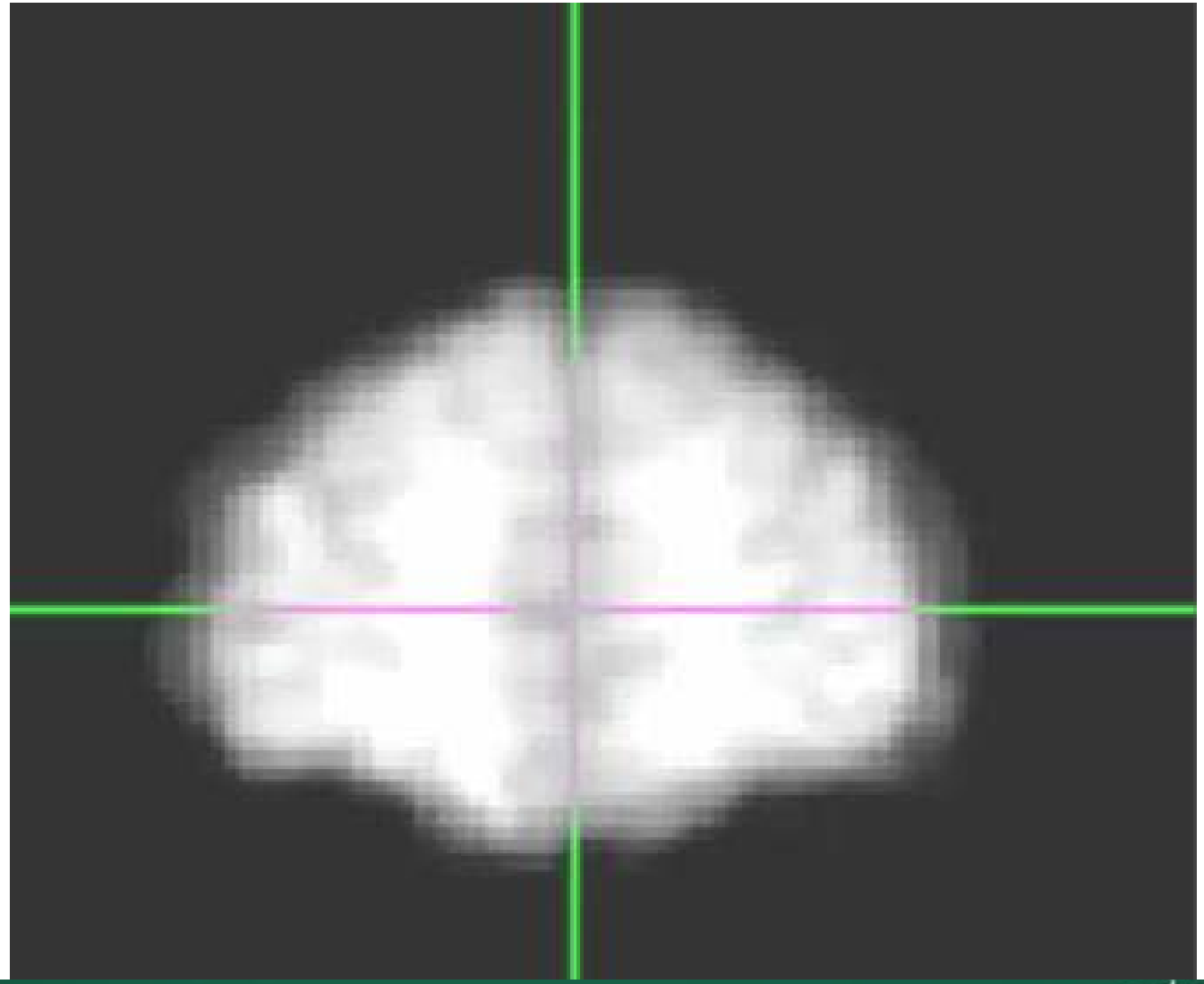
Slide Courtesy of Brain Pietrosimone NATA 2014

Measuring the Brain

- Movement paradigm – 4 sets – Block Design
  - F
  - k

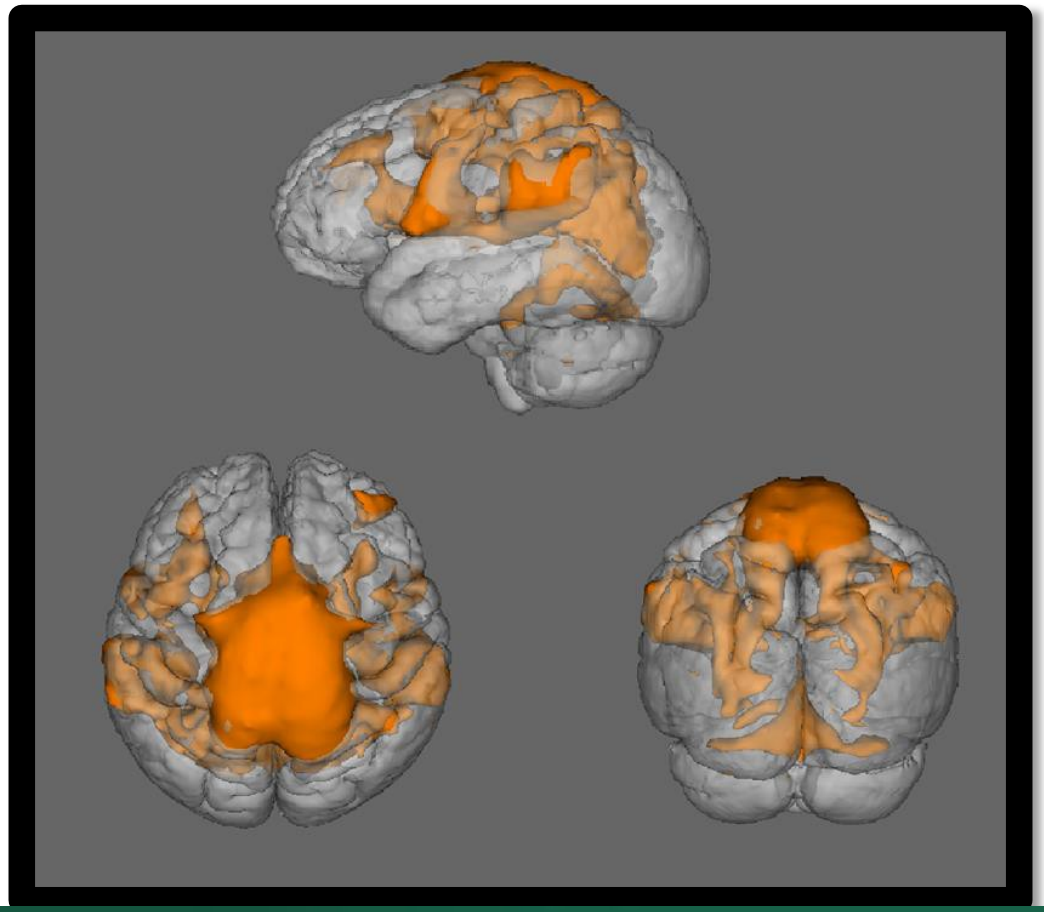


Measuring the Brain

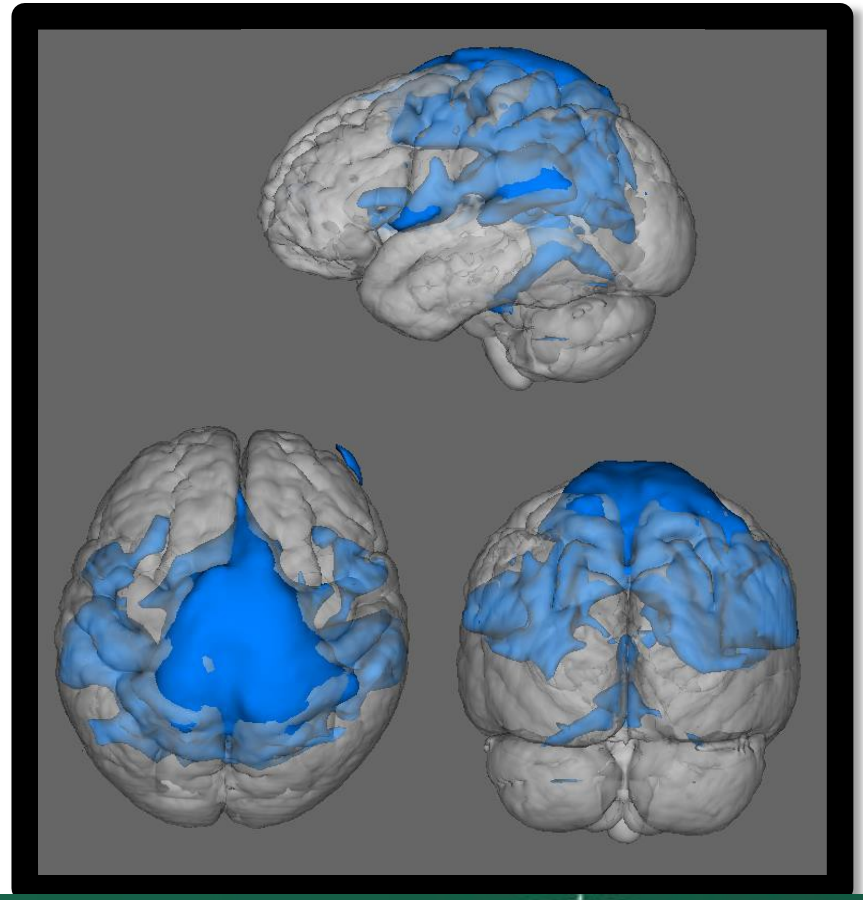


Brain-Outcomes

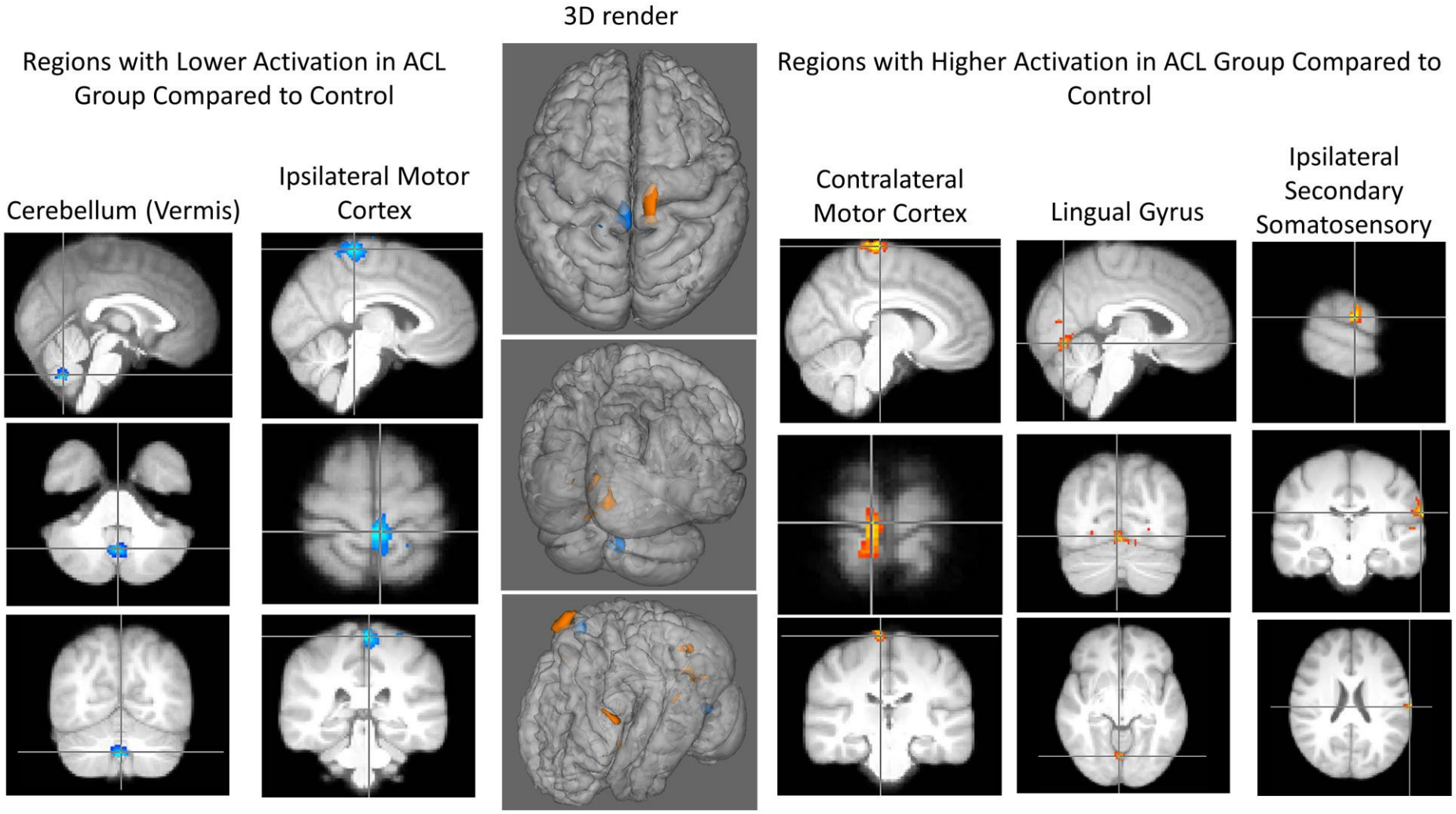
ACL

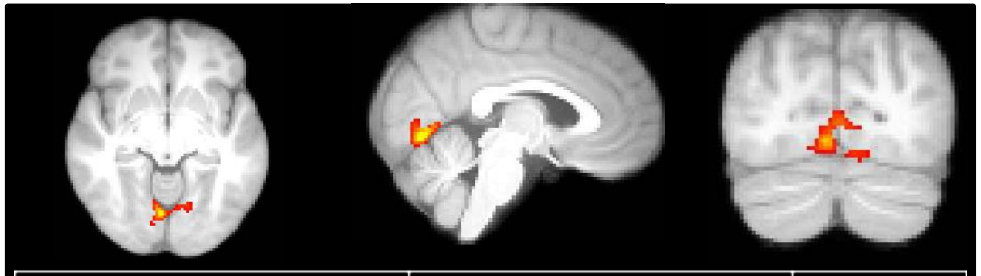


Control



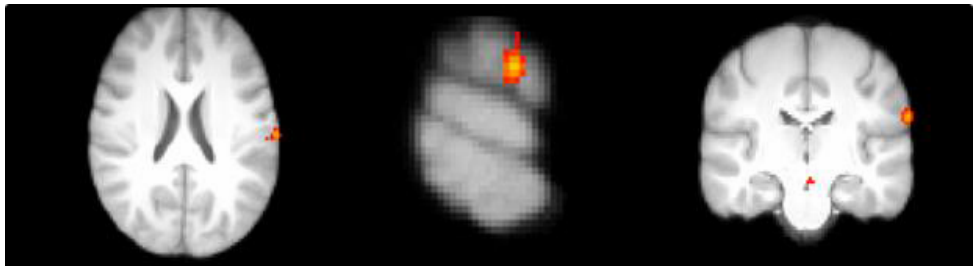
Knee Motor Control





Area	MNI Coordinates			Z Value
	X	Y	Z	
Left Lingual Gyrus	4	-70	-8	8.315

- Lingual gyrus[23]
  - Visual processing
  - Spatial memory



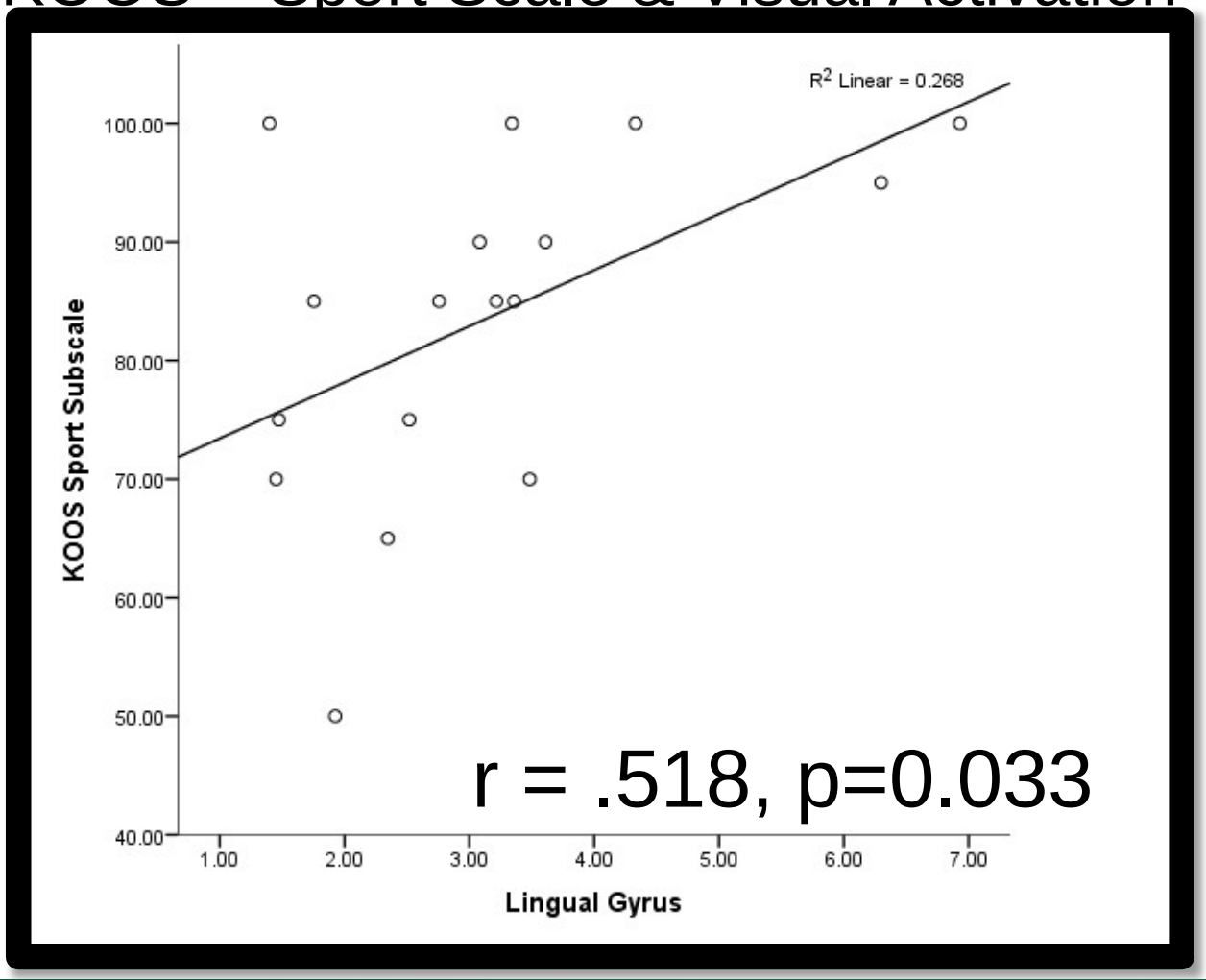
Area	MNI Coordinates			Z Value
	X	Y	Z	
Left Secondary Somatosensory	--68	-18	24	11.27

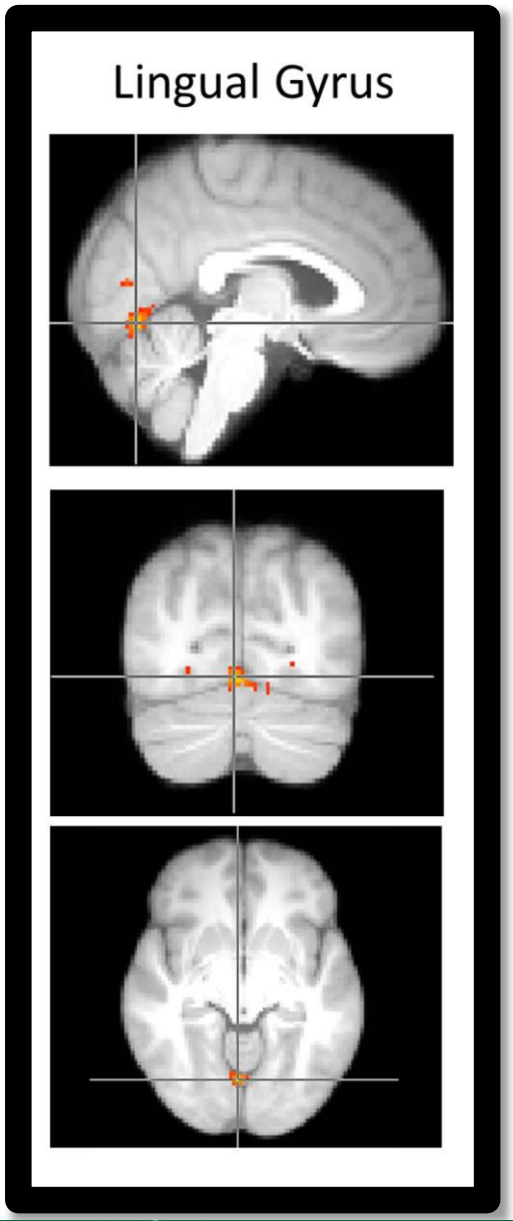
- Secondary somatosensory[24]
  - Sensory processing
  - Pain memory

23)Servos CC 2002; 24)Torquati NI 2005; 25) Kapreli NI 2006

ACL Brain-Outcomes

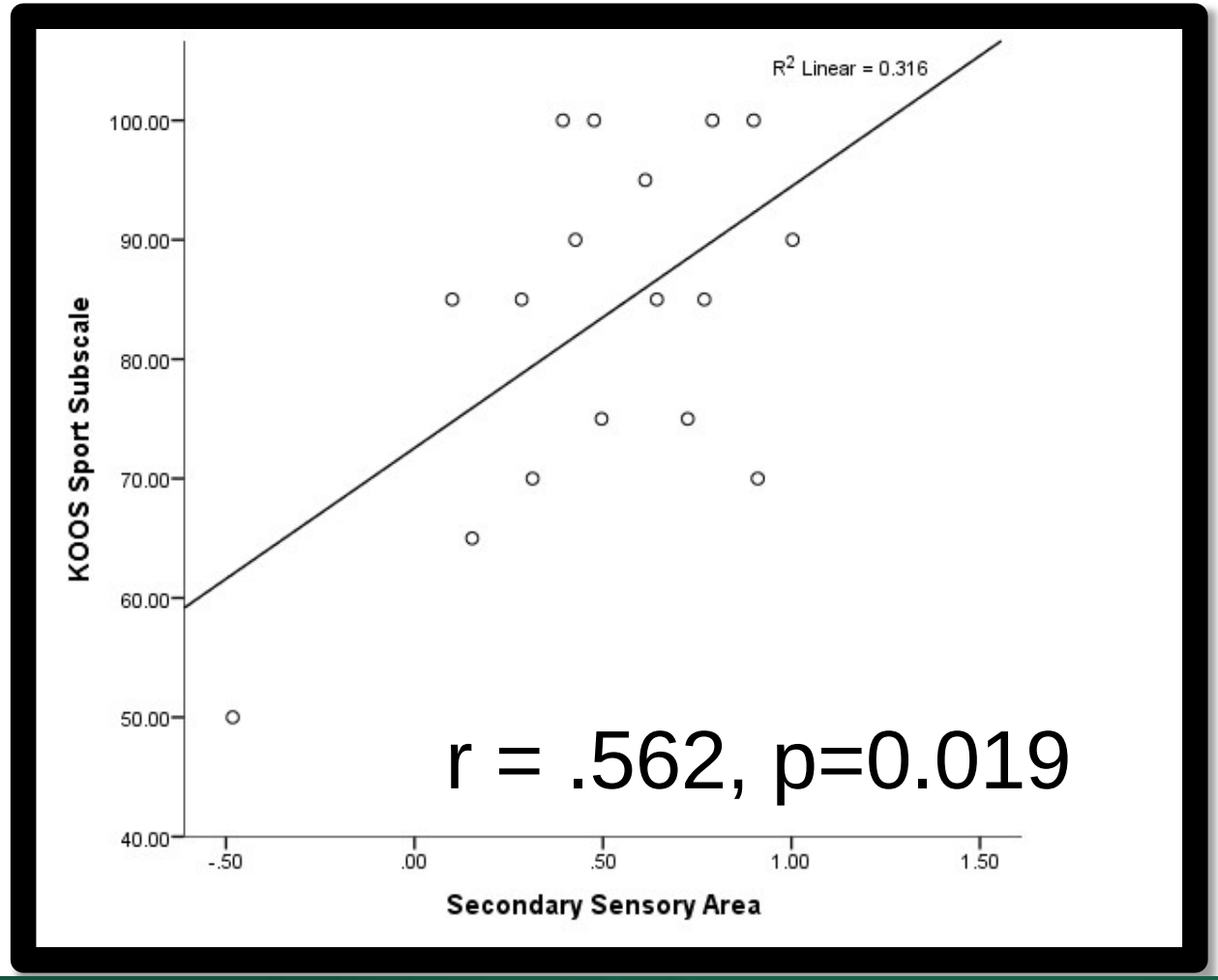
- KOOS – Sport Scale & Visual Activation

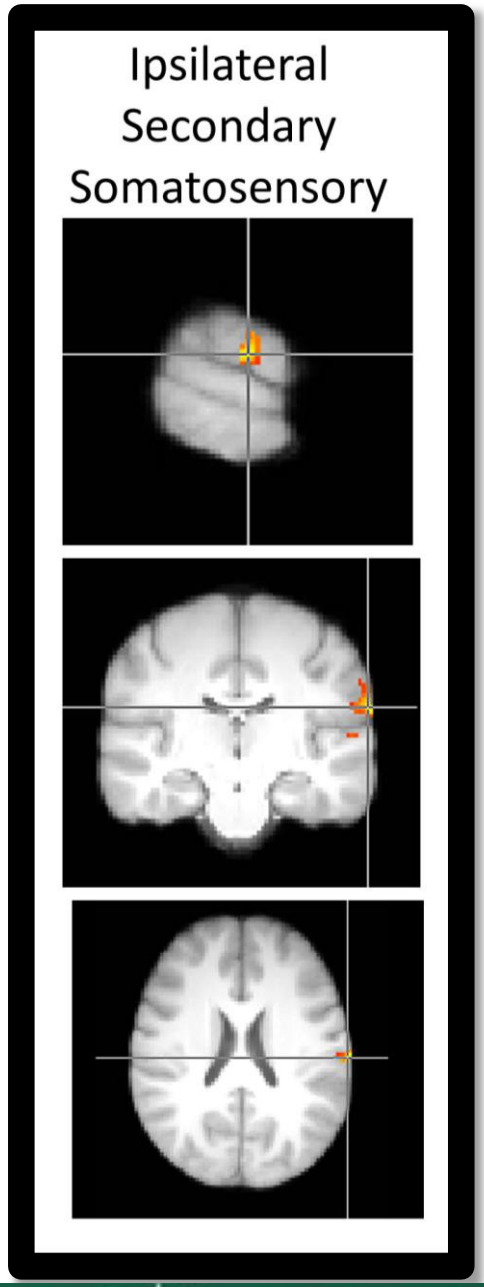




ACL Brain-Outcomes

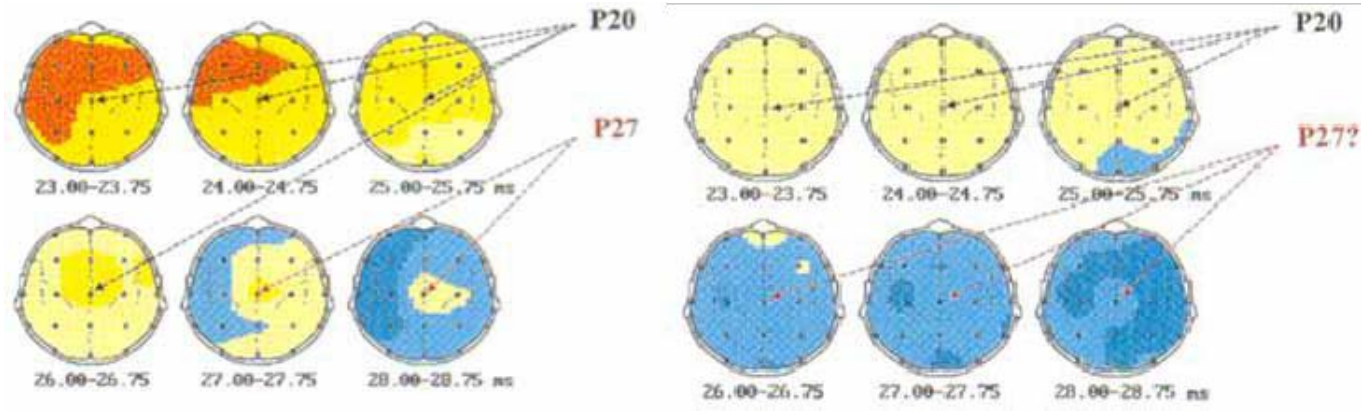
- KOOS – Sport Scale & Sensory Activation

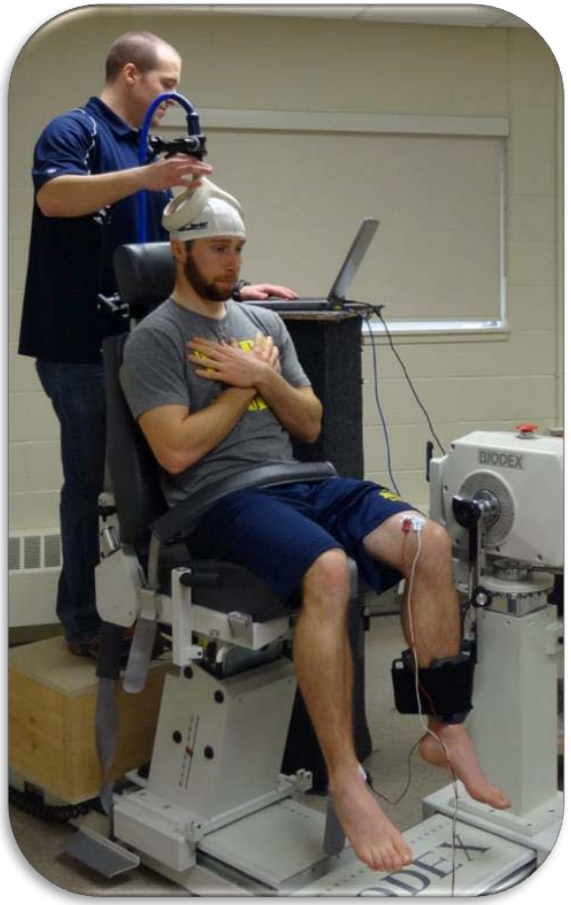




Implications

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





30) Courtney G&P 20105 31) Courtney G&P 2006 32) Lepley SJMSS 2015 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[21,22]
    - Allows complex action
    - Improves visual processing and action anticipation

19) Destaso IES 1997 20) Horita EJAP 1996 21) Appelbaum 2011 *JSS* 22) Appelbaum 2012 *BJSM*

Virtual Reality

Environment & Anticipation

IJSPT

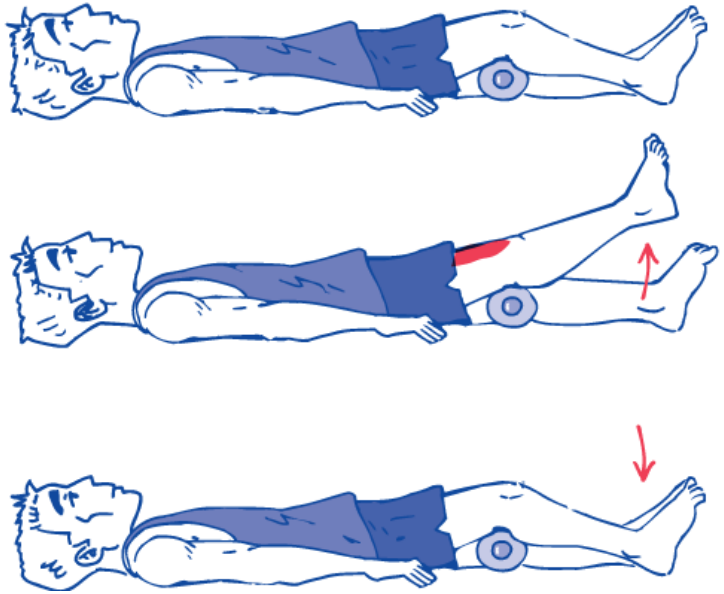
CASE REPORT

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

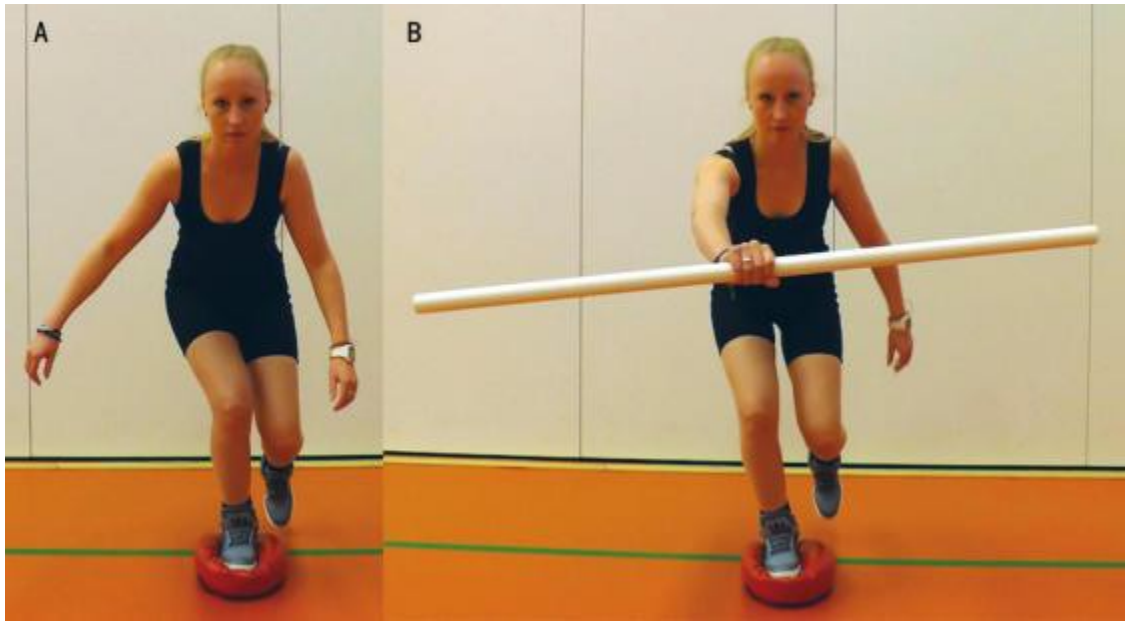
John Faltus, DPT, MS, SCS, LAT, ATC, CSCS[1]

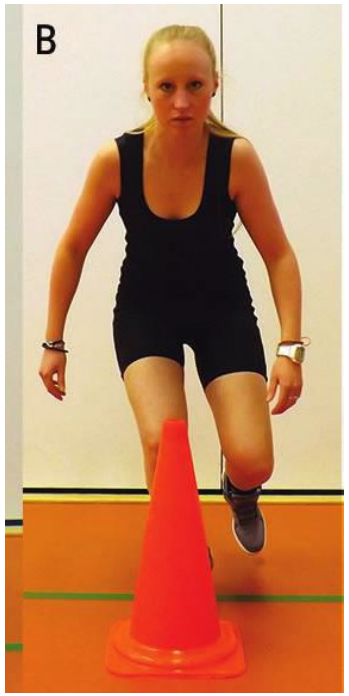
Modifying Performance

- 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

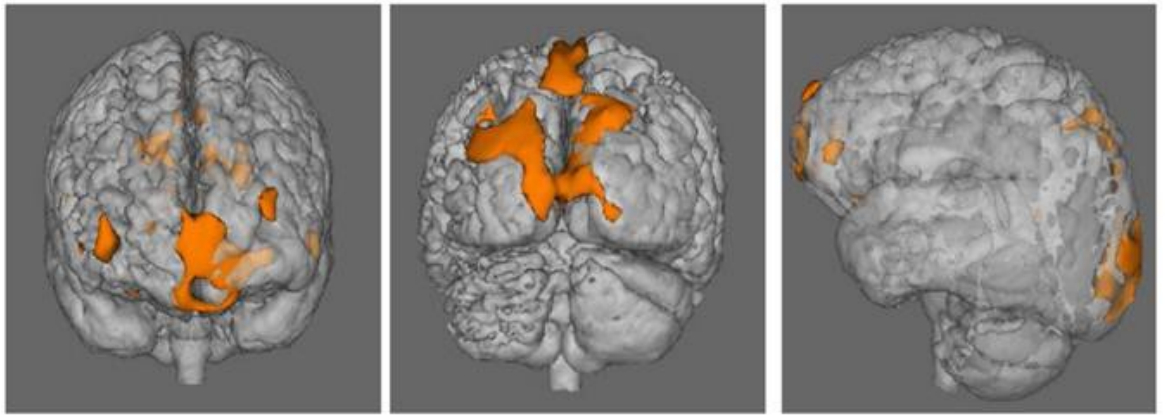


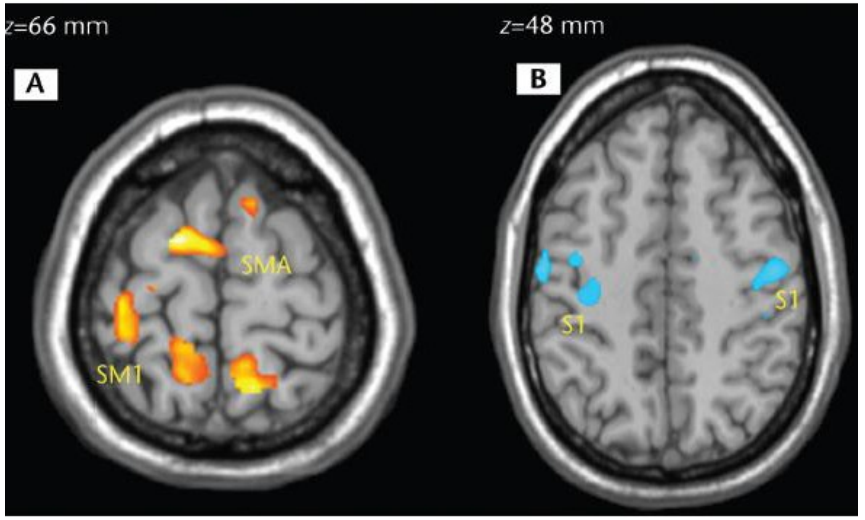
Figure 1: Areas of brain activation when participants used an external focus of attention compared to an internal focus of attention, all $p < .001$.

What if I just throw some tape on it?

Neuroplasticity of Tape

Effects of Patellar Taping on Brain Activity During Knee Joint Proprioception Tests Using Functional Magnetic Resonance Imaging

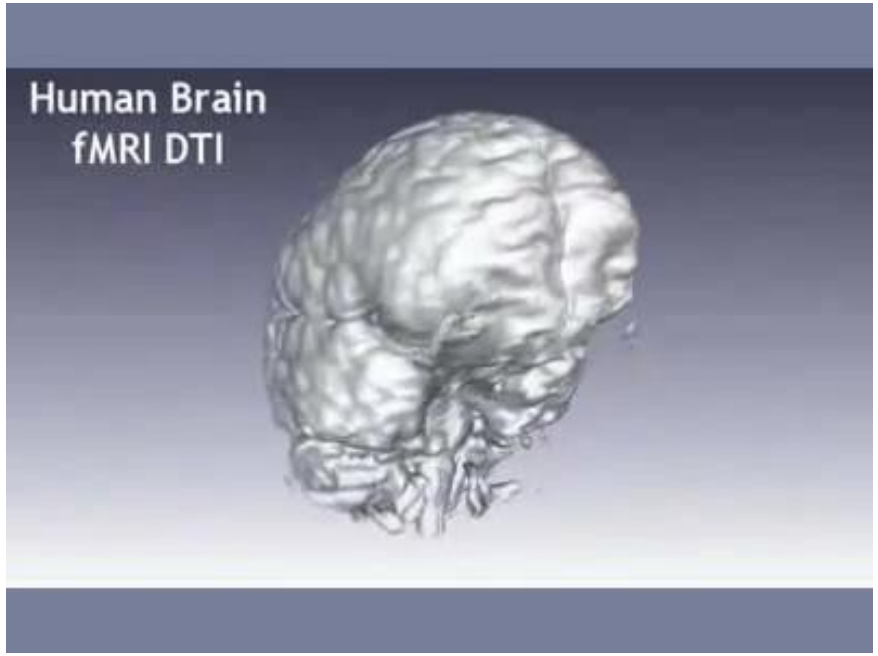
Michael J. Callaghan, Shane McKie, Paul Richardson, Jacqueline A. Oldham



- **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**



Acknowledgments-Dustin Grooms

OSU Mentors
- James Onate PhD AT
- Stephen Page PhD OT
- Deborah Larsen PhD PT
- Ajit Chaudhari PhD
- Susan White PhD

CCBBI Staff
- Francisco Aguila
- Deborah Hardesty
- Zhong-Lin Lu PhD
- Xiangrui Li PhD
- Jinghua Wang PhD
- Julie Golomb PhD

Lab Mates
- Mike McNally MS CSCS
- Meghan Miller MS AT
- Eric Schussler PT AT
- Jarred Bowman BS
- Cambrie Starkel BS
- Dan Clifton MEd AT
- Jay Young BS
- Gabrielle Colucci BS
- Jack Cerne BS

Other Lab Mates
- Louise Thoma PT
- Matt Ithurburn PT
- Greg Freisinger PhD
- Steve Jamison PhD
- Chris Nagelli MS
- Jackie Lewis PhD
- Scott Monfort MS
- Margaret Raabe MS
- Laura Schmitt PhD PT

Other Great People
- Nonie Finlayson PhD
- Andrew Persch PhD OT
- Alexandra Borstad PhD PT
- Matthew Schroeder PhD
- Shawn Flanagan MS

OU Collaborators
- Chad Starkey PhD AT
- Janet Simon PhD AT
- Jae Yom PhD
- Jeff Russell PhD AT
- Brian Clark PhD
- Robert Wayner PhD PT

Other Collaborators
- Lindsey Leply PhD AT UConn
- Adam Lepley PhD AT UConn
- Alan Needle PhD AT AppState
- Randy Schmitz PhD AT UNCG
- Greg Myer PhD Cincinnati
- Kyung Min Kim PhD Miami

NATA RESEARCH & EDUCATION FOUNDATION

NSCA NATIONAL STRENGTH AND CONDITIONING ASSOCIATION

NIH National Institute of Arthritis and Musculoskeletal and Skin Diseases

OHIO STATE Wexner Medical Center

Acknowledgments-Janet Simon

IU Mentors

- Carrie Docherty PhD AT
- John Schrader HSD AT
- Katie Grove PhD AT
- Jackie Kingma MS AT PA PT

Motor Control Lab IU

- David Koceja PhD
- Hannah Block PhD
- Koichi Kitano PhD
- Rachel Ryder PhD

Lab Mates

- Matt Donahue PhD AT
- Emily Hall PhD AT

Former Masters Students

- Leah Tanen MS AT
- Ashley Allen MS AT
- Sarah LoCicero MS AT
- Alyssa McPherson MS AT
- Tim Newell MS AT
- Mark Forbing MS AT
- Sam Scott MS AT
- Kristen Tetuan MS AT
- John Bigouette MS AT
- Mike Uzelac MS AT
- Ashley Gray MS AT
- Kevin Morris MS AT

OU Collaborators

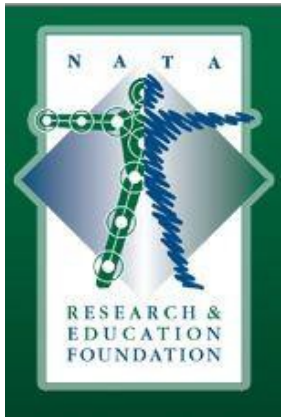
- Chad Starkey PhD AT
- Dustin Grooms PhD AT
- Jae Yom PhD
- Jeff Russell PhD AT
- Brian Clark PhD
- Robert Wayner PhD PT

Other Collaborators

- Alison Valier PhD AT A.T. Still
- Luke Donovan PhD AT UNC-Charlotte
- Abbey Thomas PhD AT UNC-Charlotte
- Zack Kerr PhD MPH UNC-Chapel Hill
- Erik Wikstrom PhD AT UNC-Chapel Hill
- Phillip Gribble PhD AT Kentucky

Other Mentors

- Gary Morin Southern PhD AT Connecticut
- Brent Arnold PhD AT IUPUI



References

Hootman, J. M., R. Dick, et al. (2007). "Epidemiology of collegiate injuries for 15 sports: Summary and recommendations for injury prevention initiatives." J Athl Train **42**(2): 311-319.

Majewski, M., H. Susanne, et al. (2006). "Epidemiology of athletic knee injuries: A 10-year study." Knee 13(3): 184-188.

Ferretti A, Papandrea P, ConteducaF, Mariani PP. Knee ligament injuries in volleyball players.Am J Sports Med. 1992;20(2):203-207.

Gerberich SG, Luhmann S, FinkeC, Priest JD, Beard BJ. Analysis of severe injuries associated with volleyball activities. PhysSportsmed. 1987; 15(8):75-79.

Chandy TA ,Grana WA. Secondary school athletic injury in boys and girls: a three-year comparison. *Phys Sportsmed*. 1985; 13(3):106-111.

Griffin, L. Y., J. Agel, et al. (2000). "Noncontact anterior cruciate ligament injuries: risk factors and prevention strategies." J Am Acad Orthop Surg 8(3): 141-150.

McNair, P. J., R. N. Marshall, et al. (1990). "Important features associated with acute anterior cruciate ligament injury." N Z Med J 103(901): 537-539.

Nordenvall, R., S. Bahmanyar, et al. (2012). "A population-based nationwide study of cruciate ligament injury in Sweden, 2001-2009: incidence, treatment, and sex differences." Am J Sports Med 40(8): 1808-1813.

. "Charging and Cost for ICD-9-D-844.2, 2004-2008: Sprain/strain of cruciate ligament in the knee. Pearl Diver, Inc." Retrieved May 1, 2011, from http://pearldiverinc.com/pdi/code_results.jsp?code=844.2&x=33&y=13.

Wojtys, E. M. and A. M. Brower (2010). "Anterior cruciate ligament injuries in the prepubescent and adolescent athlete: clinical and research considerations." J Athl Train 45(5): 509-512.

Lohmander, L. S., A. Ostenberg, et al. (2004). "High prevalence of knee osteoarthritis, pain, and functional limitations in female soccer players twelve years after anterior cruciate ligament injury." Arthritis Rheum 50(10): 3145-3152.

von Porat A, Roos EM, Roos H. High prevalence of osteoarthritis 14 years after an anterior cruciate ligament tear in male soccer players: a study of radiographic and patient relevant outcomes. Annals of the rheumatic diseases. Mar 2004;63(3):269-273.

References

Salmon, L., V. Russell, et al. (2005). "Incidence and risk factors for graft rupture and contralateral rupture after anterior cruciate ligament reconstruction." Arthroscopy **21**(8): 948-957.

Ernst, G. P., E. Saliba, et al. (2000). "Lower extremity compensations following anterior cruciate ligament reconstruction." Phys Ther 80(3): 251-260.

Knoll, Z., R. M. Kiss, et al. (2004). "Gait adaptation in ACL deficient patients before and after anterior cruciate ligament reconstruction surgery." J Electromyogr Kinesiol 14(3): 287-294.

Paterno, M. V., K. R. Ford, et al. (2007). "Limb asymmetries in landing and jumping 2 years following anterior cruciate ligament reconstruction." Clin J Sport Med 17(4): 258-262.

Scanlan, S. F., A. M. Chaudhari, et al. (2010). "Differences in tibial rotation during walking in ACL reconstructed and healthy contralateral knees." J Biomech 43(9): 1817-1822.

Valeriani, M., D. Restuccia, et al. (1996). "Central nervous system modifications in patients with lesion of the anterior cruciate ligament of the knee." Brain 119 (Pt 5): 1751-1762.

Valeriani, M., D. Restuccia, et al. (1999). "Clinical and neurophysiological abnormalities before and after reconstruction of the anterior cruciate ligament of the knee." Acta Neurol Scand 99(5): 303-307.

Kapreli, E. and S. Athanasopoulos (2006). "The anterior cruciate ligament deficiency as a model of brain plasticity." Med Hypotheses 67(3): 645-650.

Myer, G. D., K. R. Ford, et al. (2007). "Differential neuromuscular training effects on ACL injury risk factors in"high-risk" versus "low-risk" athletes." BMC Musculoskelet Disord 8: 39.

Hewett, T. E., G. D. Myer, et al. (2005). "Reducing knee and anterior cruciate ligament injuries among female athletes: a systematic review of neuromuscular training interventions." J Knee Surg 18(1): 82-88.