Internal Vs. External Focus of Attention in Rehabilitation of Athletes

Mark Weigand MS, DPT, CSCS

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Objectives

- Understand the neurophysiological consequences seen following ACL injury and p/o ACL-r.
- Learn the difference between Internal and External Focus of Attention and their use in the rehabilitation process.
- Understand common motor patterns associated with ACL injuries during sport
- Review examples of literature and rehabilitation techniques for effective transition of athletes back to field.

What happens immediately following injury?

Disrupted CNS afferent input

↓

1. Loss in somatosensory signaling

2. Increased nociceptor activity

Pain — Inflammation

↓

Motor control adaptations

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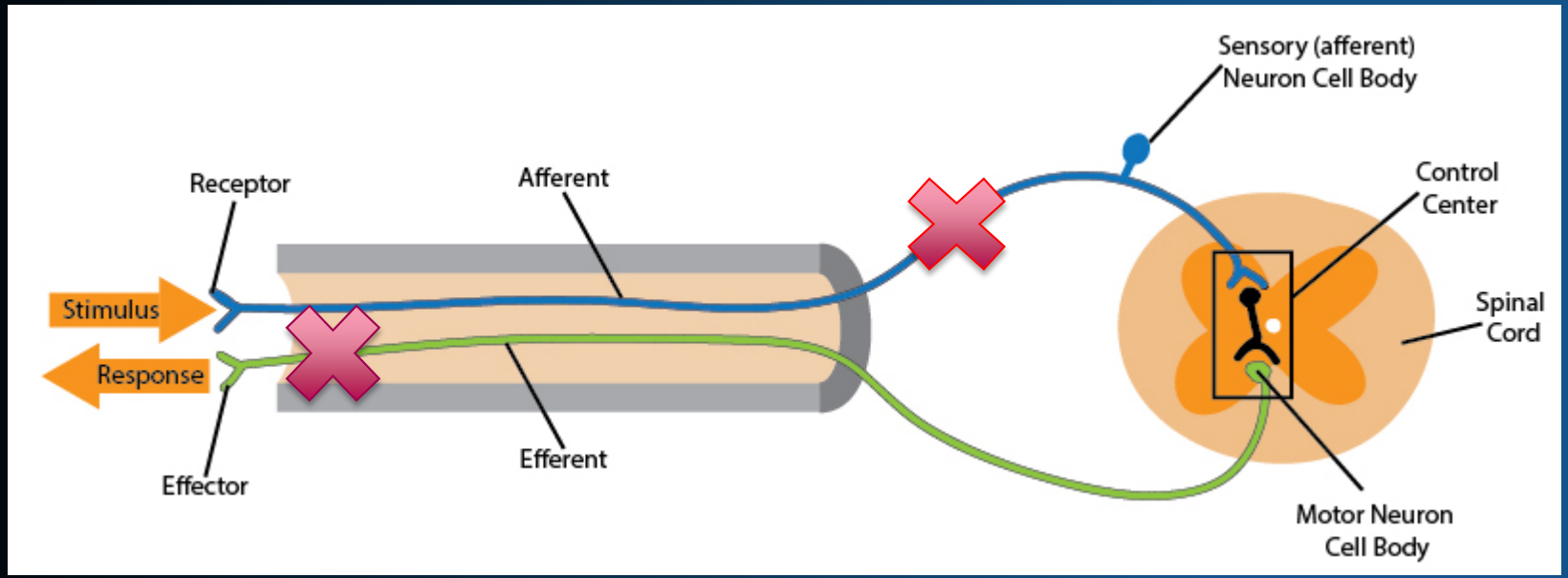
Disrupted input → maladaptive output



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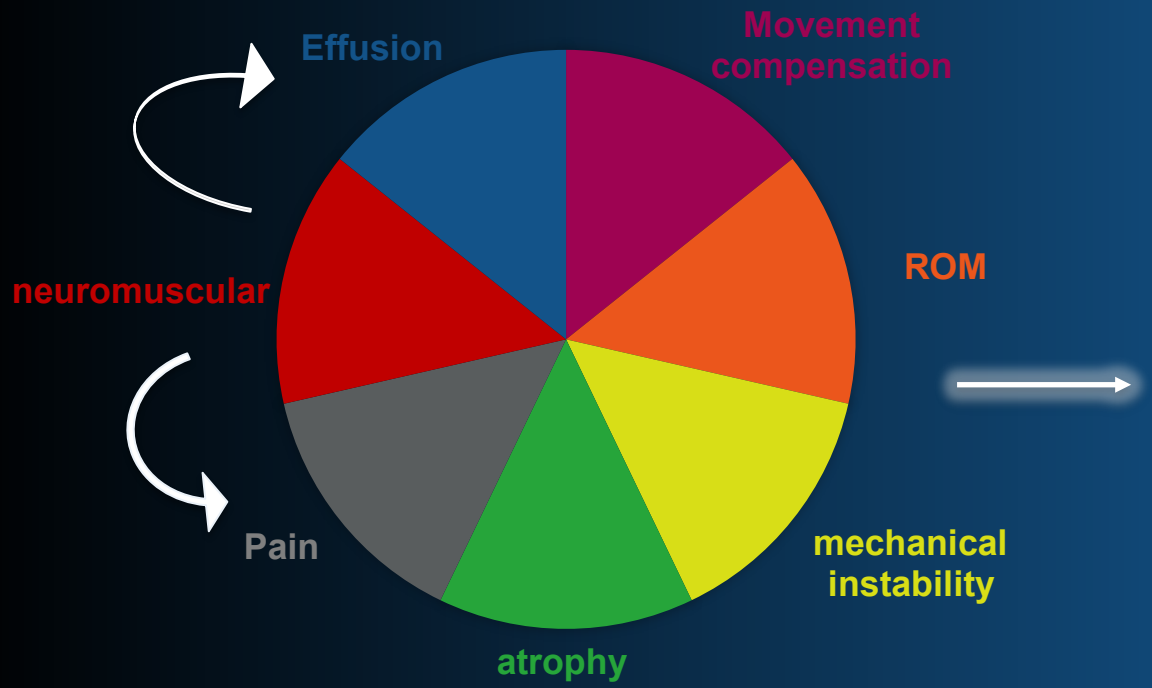
Post Injury Factors



MOTOR CONTOL ADAPTATIONS!!!

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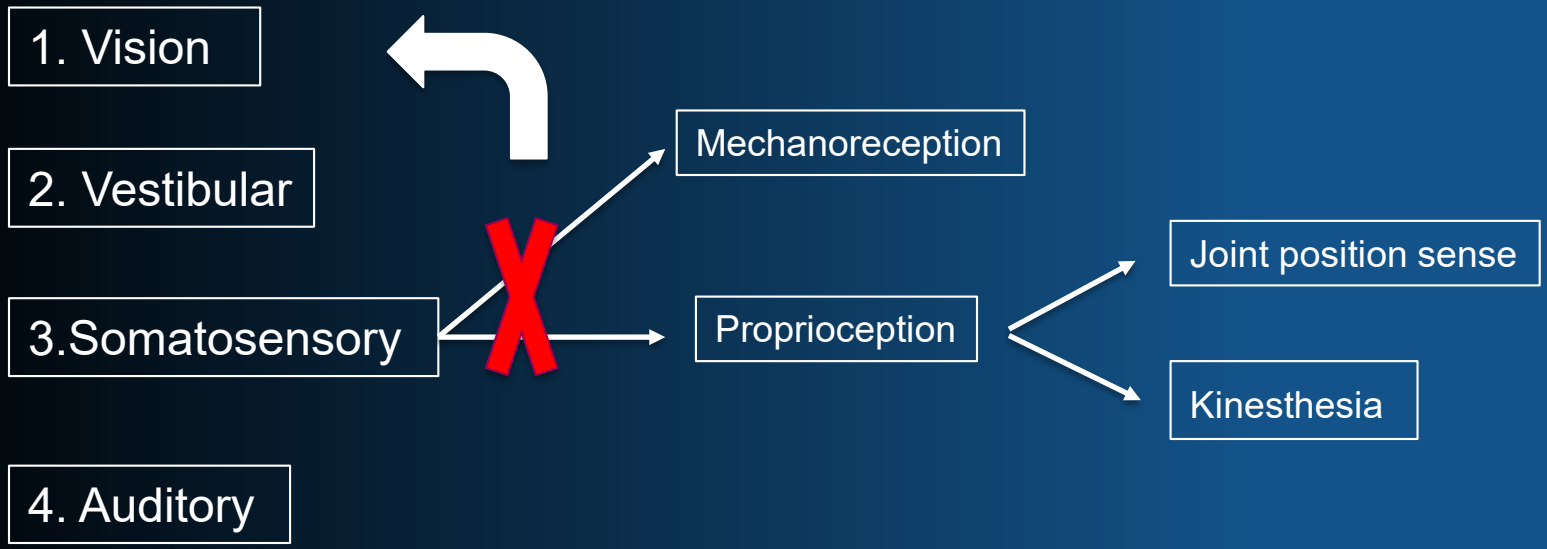
Multi-model sensory system



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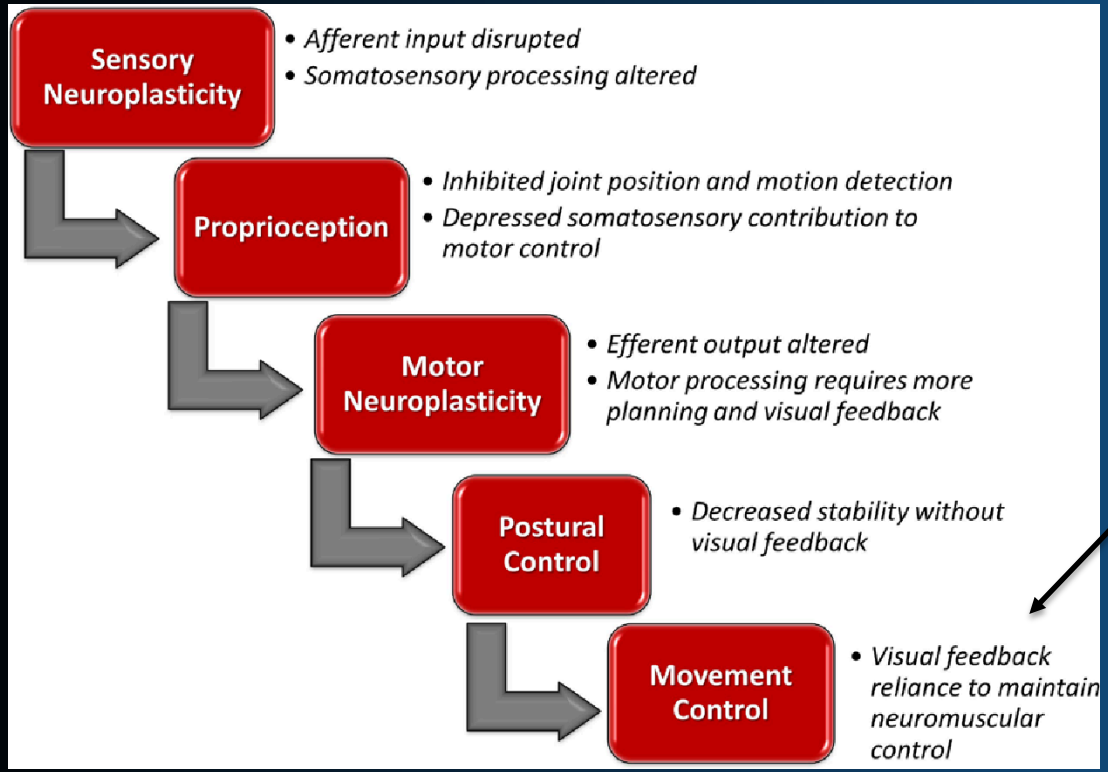

Increased reliance on visual feedback for motor planning execution!!

= sensory reweighting

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Motor Planning and Sensory Neuroplasticity after ACL Reconstruction

Dustin R. Grooms, Stephen J. Page, Deborah S. Nichols-Larsen, Ajit M.W. Chaudhari, James A. Onate

The Ohio State University
School of Health and Rehabilitation Sciences

School of Health and Rehabilitation Sciences, The Ohio State University, Columbus, OH

Background

ACL (anterior cruciate ligament) injury and reconstruction may induce brain motor control adaptations[1]

Typical neuromuscular control assessment may not adequately address this neuroplasticity[2]

Assessing brain function with fMRI (functional magnetic resonance imaging) provides a means to address this gap in knowledge

Purpose

To investigate the degree of unilateral sensory-motor brain activation during knee extension-flexion between a group with knee ACLR (ACL reconstruction) and a healthy matched control group

Methods

Six left ACL reconstructed participants and six controls were recruited and matched on height, mass, extremity dominance, history, and current physical activity level

- ACL: (25.5±1.37 years, 1.70±0.13 m, 83.0±19.8 kg, Tegner activity level 6.0 ± 1.5, 23±18 months post-surgery)
- Control: (23.6±3.14 years, 1.75±0.05 m, 73.5±12.24 kg, Tegner activity level 6.0 ± 1.5)

The brain fMRI paradigm consisted of 4 cycles of 30 second unilateral knee extension at a metronome controlled 1.2 Hz(fig. 1)

A within subject analysis between sides followed by a group analysis was compared with a general linear model second level fixed-effects analysis, ***a priori*** p<0.01 cluster corrected threshold

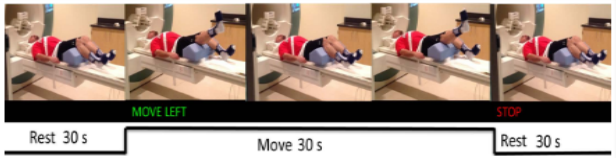

Figure 1: fMRI test position

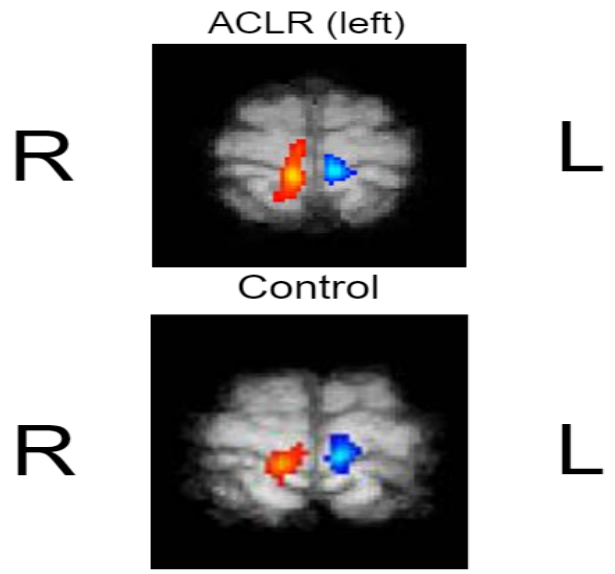

Figure 2: fMRI results for region of interest analysis (right and left supplementary motor, motor and sensory cortices); Red indicates activation during left knee movement, blue indicates activation during right knee movement

Results

ACL reconstructed individuals demonstrated(fig. 2) :

- Increased (red) primary somatosensory cortex activation, z=4.72±1.58, p<.001
- Increased (red) supplementary motor region activation, z=3.29±1.06, p<.001
- No difference in motor cortex activation

Conclusions

Brain motor region activation during knee movement is different in those with ACL reconstruction compared to matched healthy controls

Increased sensory cortex activation may be due to the increased sensory processing due to the disrupted afferent signals from the ACLR[3]

Increased motor planning activation may be in response to the adapted sensory integration and feed-forward compensations[4]

Acknowledgements

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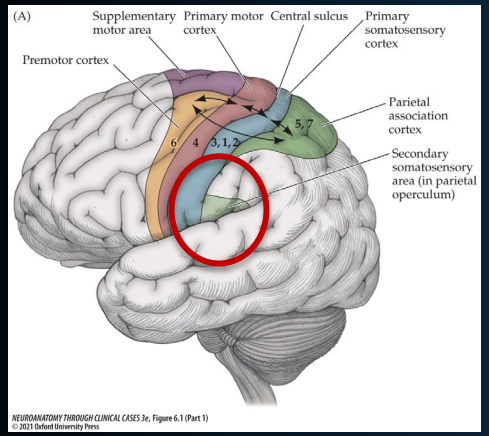
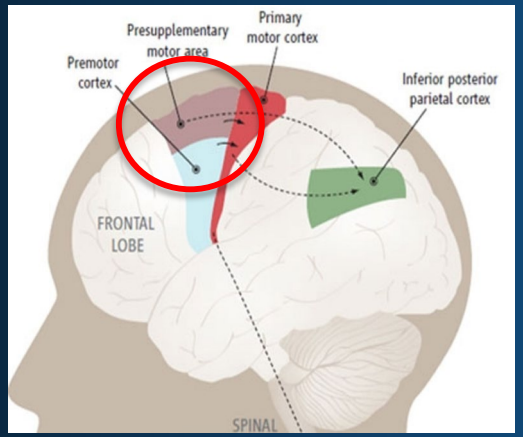
Brain activation following ACL-r





<u>Secondary somatosensory area</u> - Somatosensory processing – sensory stimuli and pain

Motor cortex: Complex motor planning

Lingual gyrus - Visual processing of movement

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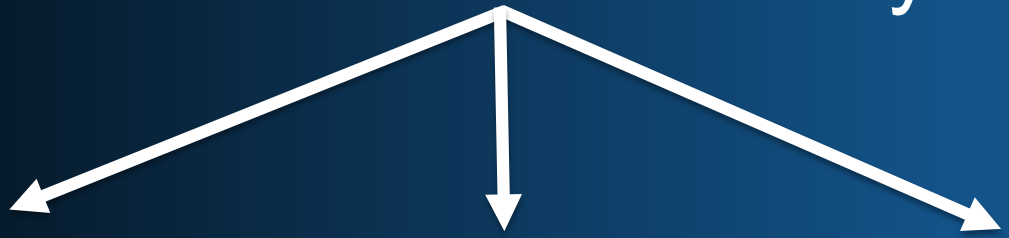
Decreased somatosensory input



Increased motor planning adaptations

Increased cortical involvement and cognitive processing

Increased visual reliance

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So how do we translate this framework to a rehab setting?

Interval vs. External Focus of Attention

Motor Learning Principles

The athlete is more focused on his/her own body's movements and has a conscious awareness of the injured joint.

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Internal focus of Attention (IFA)

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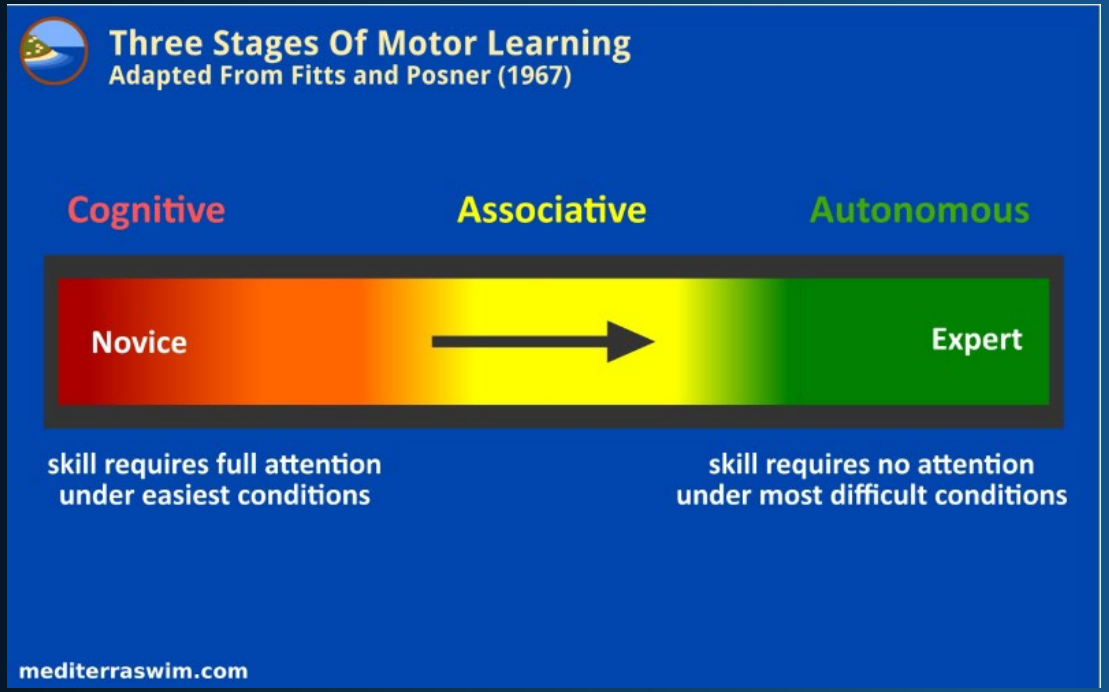
Is there is a time and place for IFA…



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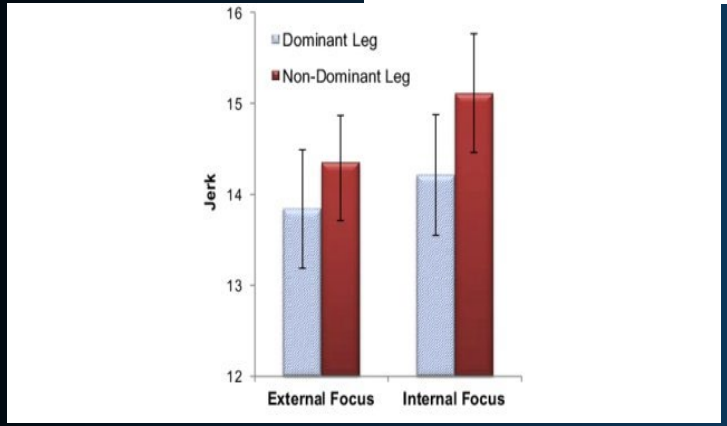
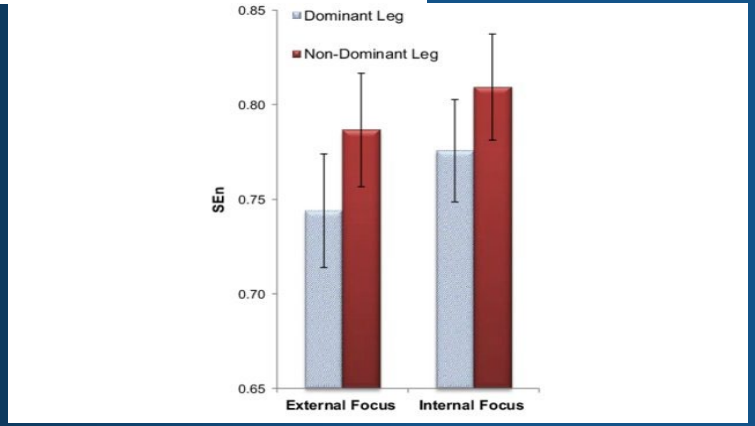
Constrained Action Hypothesis





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What does CAH mean for sport?

Contents lists available at ScienceDirect

Human Movement Science

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Increased jump height and reduced EMG activity with an external focus

Gabriele Wulf *, Janet S. Dufek, Leonardo Lozano, Christina Pettigrew

Department of Kinesiology and Nutrition Sciences, University of Nevada, 4505 Maryland Parkway, Las Vegas, NV 89154-3034, United States

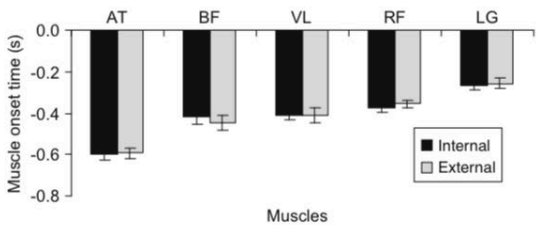


Fig. 4. Muscle onset times before takeoff for the various muscles as a function of internal versus external focus (AT = m. tibialis anterior; BF = m. biceps femoris; VL = m. vastus lateralis; RF = m. rectus femoris; LG = lateral m. gastrocnemius).

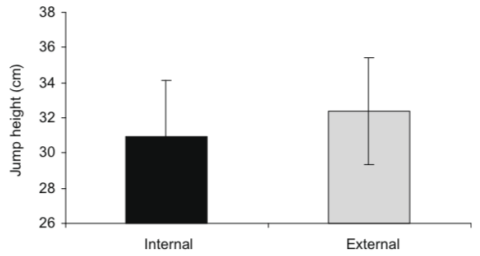
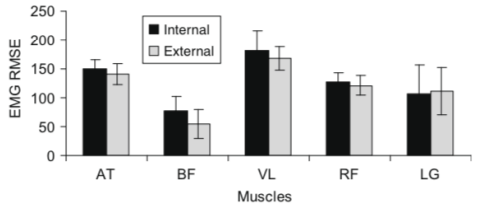


Fig. 1. Jump-and-reach height as a function of internal versus external focus.



EMG root-mean-square error (RMSE), from muscle onset to takeoff, for the various muscles as a function of in external focus (AT = tibialis anterior; BF = biceps femoris; VL = vastus lateralis; RF = rectus femoris; LG = l nemius).

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Key Takeaways

1. No significant difference in muscle onset times before take-off (inter-muscular coordination)

2. Significant difference in amount of muscular activity between focus conditions – why less in the external focus group? = increased coordination with the muscle

3. Movement production becomes more efficient with practice/external focus of attention = neural adaptations

So how do we get back to the field?

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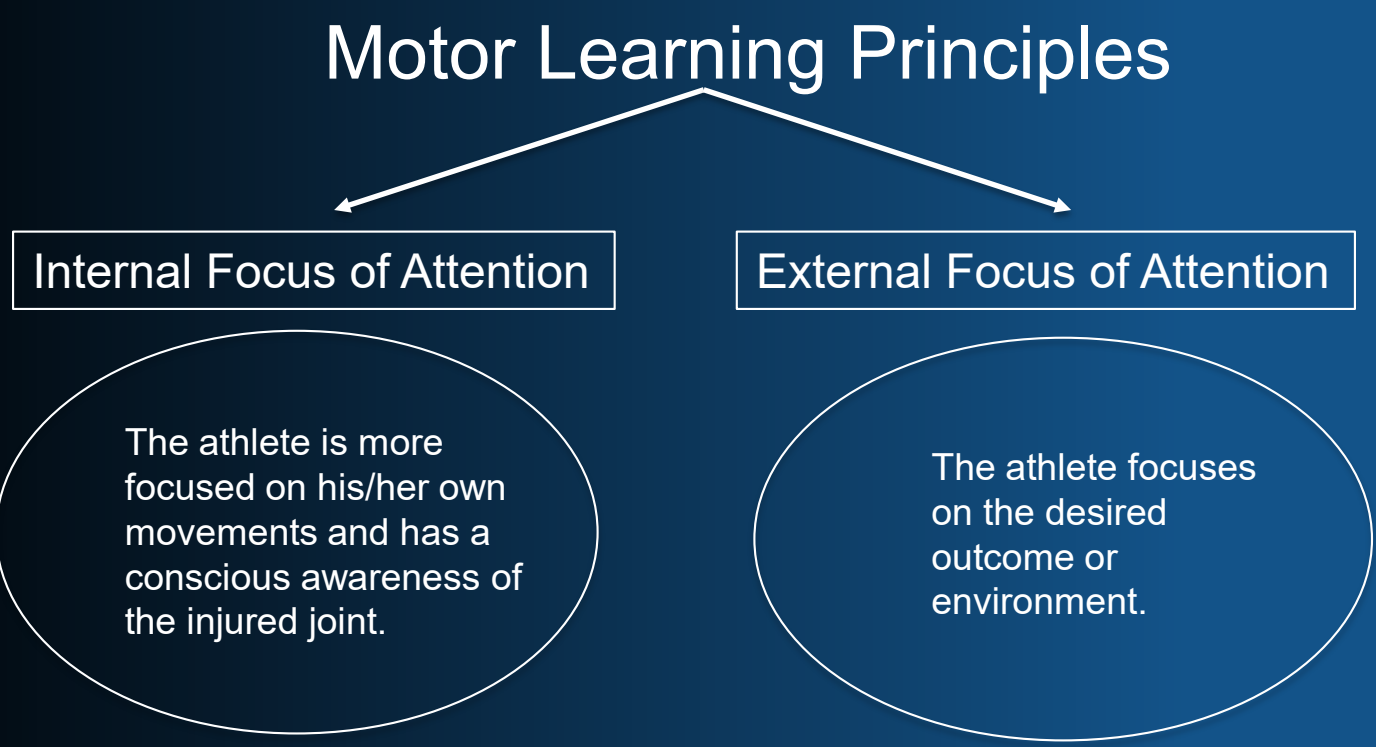
External Focus of Attention



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Types of ER

1. implicit learning
2. visual external cues & modified visual feedback
3. auditory external cues

Implicit Learning

Exercise	Internal Focus	External Focus
Double Leg Squat	Bend your knee while keeping knees over toes.	While bending your knees, point your knees toward the cones and pretend you are sitting back into a chair
Single Leg squat	Bend your knee while keeping your knee over your foot	Standing on 1 leg and reach slowly toward the cone while bending your knee
Countermovement jump (vertec)	Jump and reach your fingers up as high as possible	Jump as high as you can and touch the marker
Single leg hop for distance	Jump as far as you can and while doing so reach your heel as far as you can	Attempt to jump passed the line
Drop landing	Jump down, land with your feet shoulder width, and bend your knees keeping knees over toes	-Jump down, landing on markers on floor, and point toes toward the cones -Land Softly

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Visual External Cues

“Keep the bar horizontal” : “Try to keep the bars on the balance board as steady as possible”

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Visual External Cues

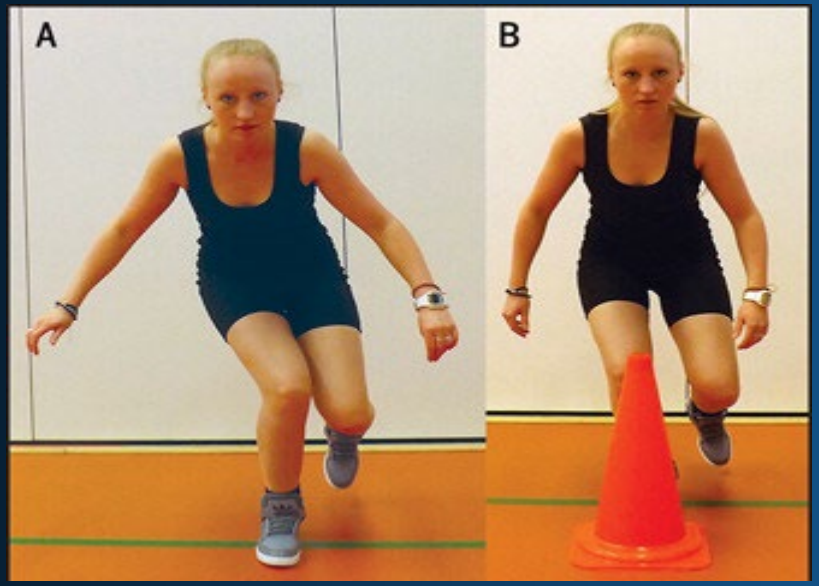

FIGURE 2. Comparison of instructions to reduce knee valgus motion during a single-leg squat, with (A) an internal focus (“Keep your knee over your foot”) and (B) an external focus (“Reach toward the cone with your knee”).

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Visual External Cues

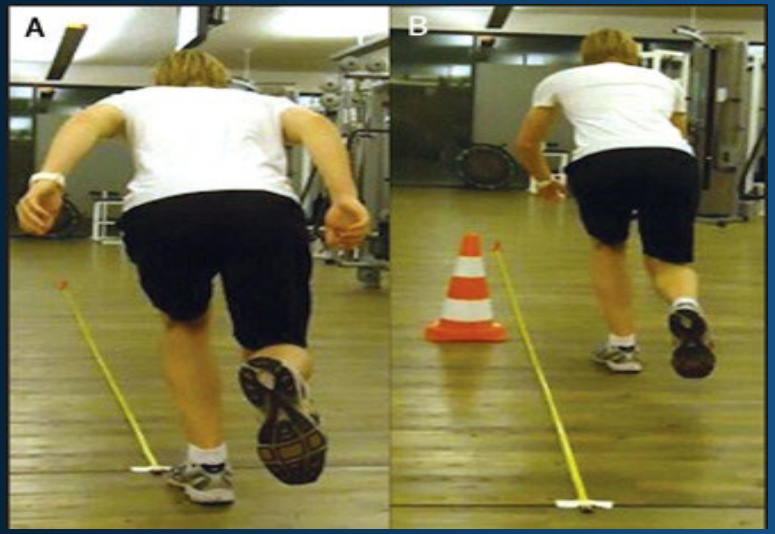

FIGURE 3. Comparison of instructions to reduce knee valgus and increase knee and hip flexion motion during a single-leg hop for distance, with (A) an internal focus ("Jump as far as you can; while jumping, focus on extending your knees as rapidly as possible") and (B) an external focus ("Jump as far as you can; while jumping, focus on jumping as close to the cone as possible").

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Visual External Cues

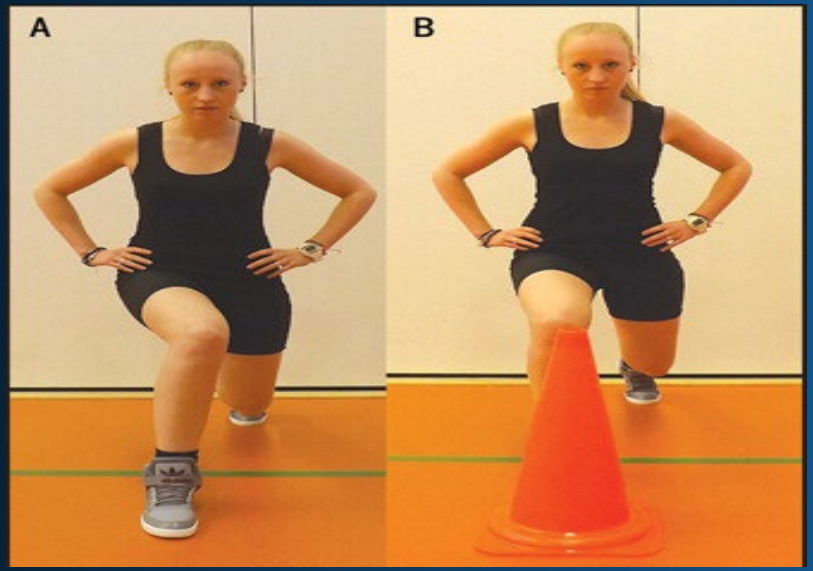

FIGURE 4. Comparison of instruction to reduce knee valgus motion during lunge with (A) an internal focus (“Keep your knee over your foot”) and (B) an external focus (“Reach towards the cone with your knee”).

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Visual External Cues

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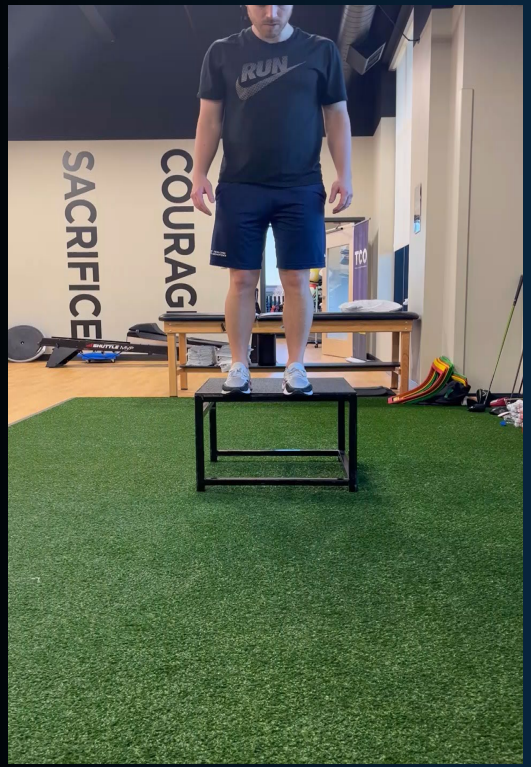
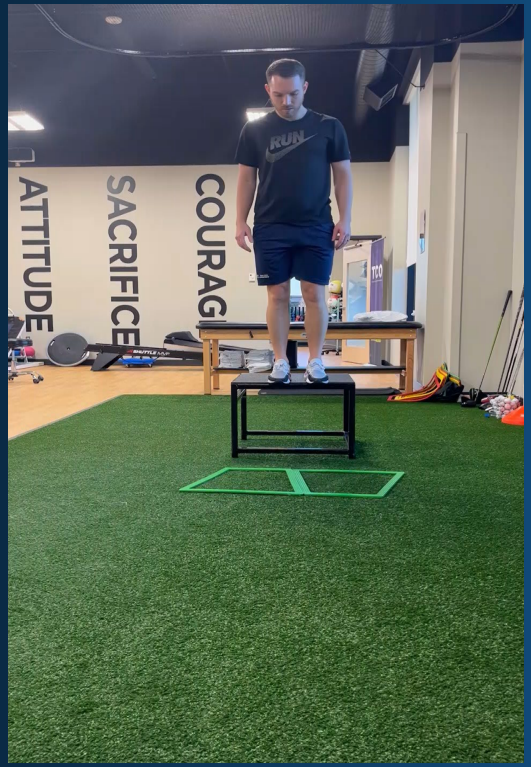
Visual External Cues





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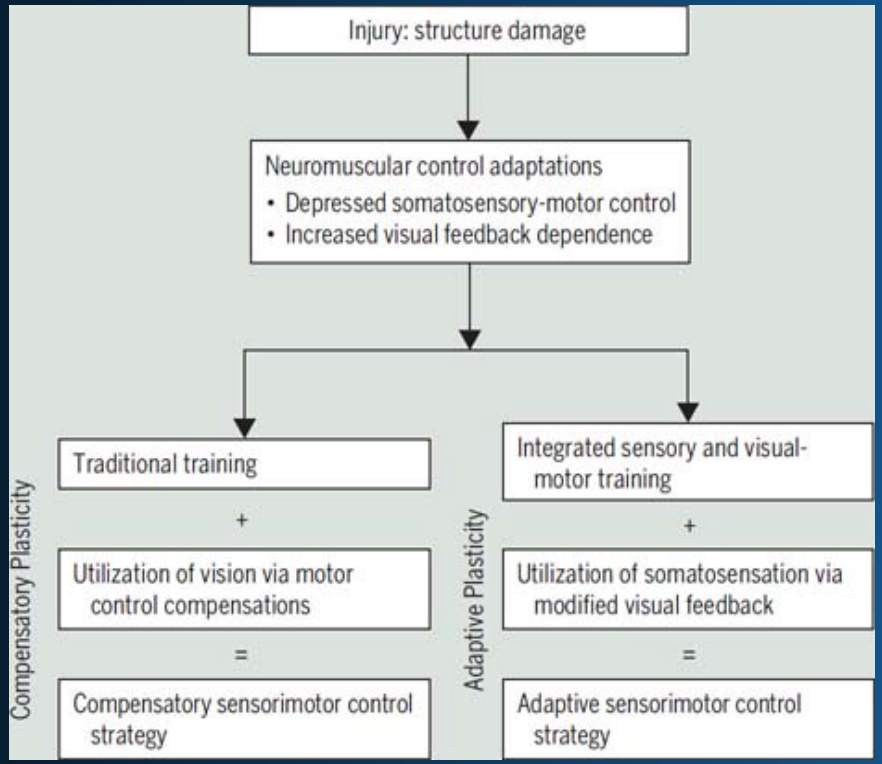
Modified visual feedback



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Ways to modify visual feedback

1. Modifying vision (lights/blindfold)
2. Direct visual disruption (Stroboscopic eyeware)
3. Visual motor training (cognisens, dynavision, SPARQ sensory training station, Blazepod)
4. Indirect visual distraction (dual task)

1. Modifying Vision

-SL balance eyes closed/blindfolded

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2. Direct Visual disruption

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3. Visual-motor training

- CogniSens
- Dynavison
- SPARQ sensory training

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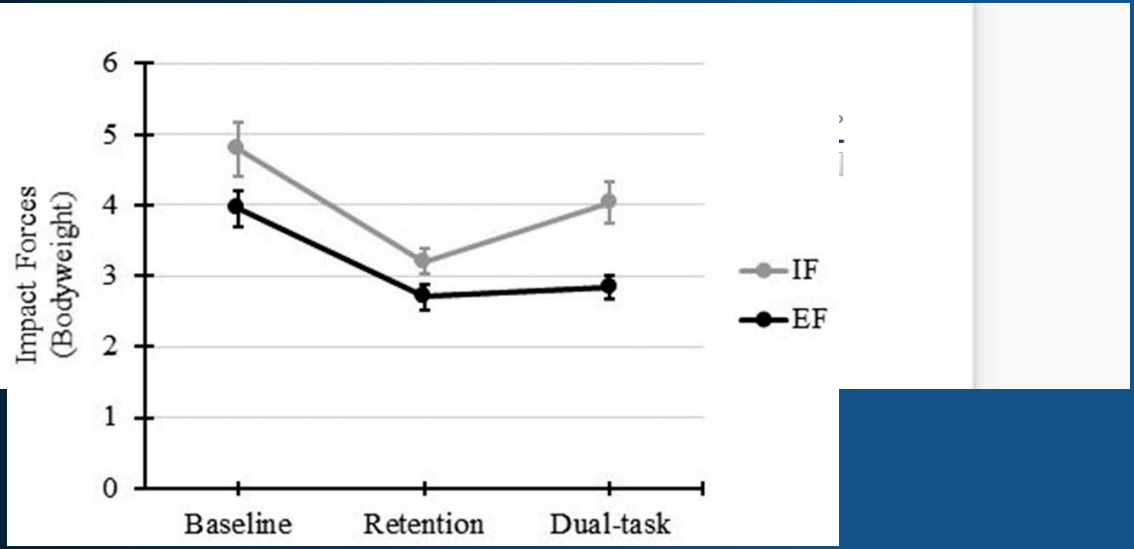
Dual Tasks Training In Athletes w/ EFA



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4. Indirect Visual distraction (Dual Task)

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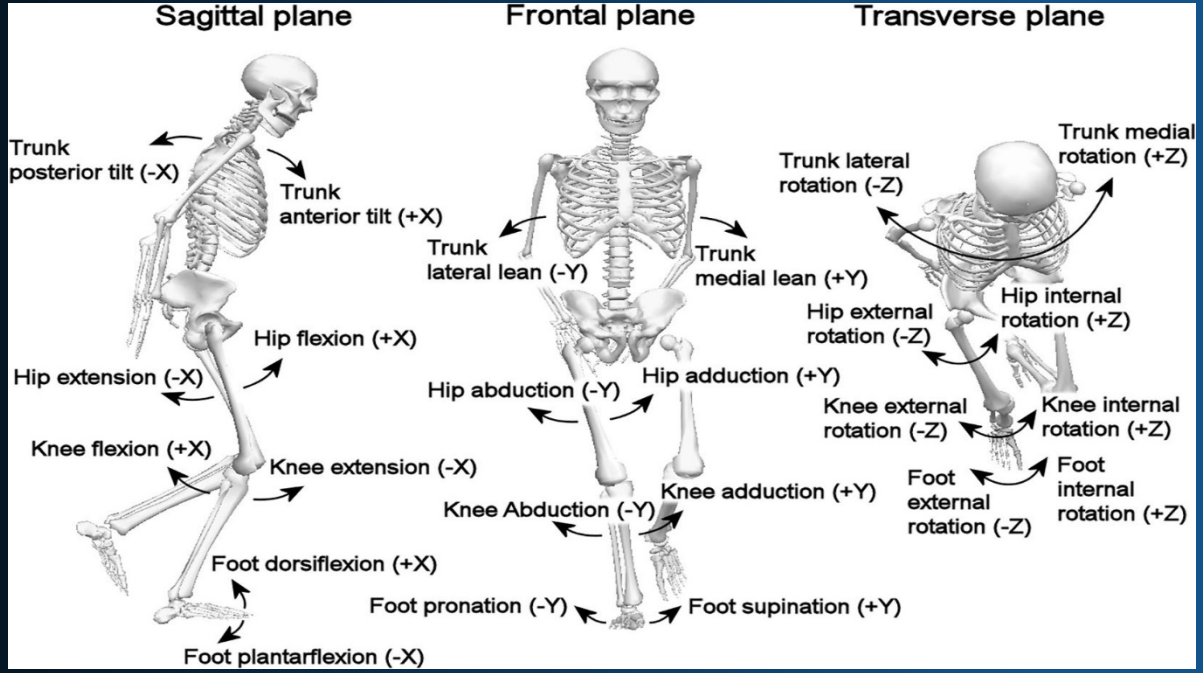
Movement Assessment



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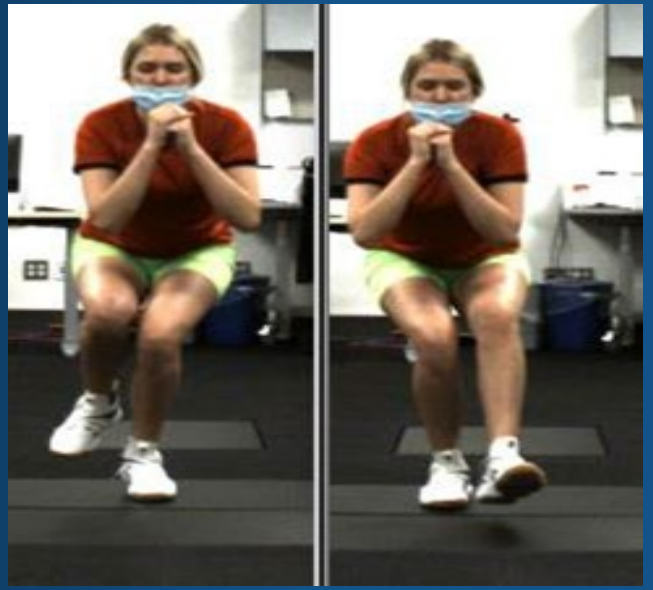

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Mechanism of injury for ACL pathology

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Dosing of EFA/NM Training Thru Rehab

1. Acute Phase
2. Post Acute Phase
3. Plyometric/RTR/agility
4. Return to Sport

Stage 1 (Acute):

1. managing effusion
2. restoring ROM
3. facilitating active quadriceps contraction

<u>quad set</u>:
“push back of knee into table”

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Stage 2 (Post-acute stage)

1. Muscle strength and hypertrophy
2. Motor planning
3. Dynamic loading progression

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Stage 3:

1. plyometric/RFD
2. running/agility/cutting
3. sport specific training

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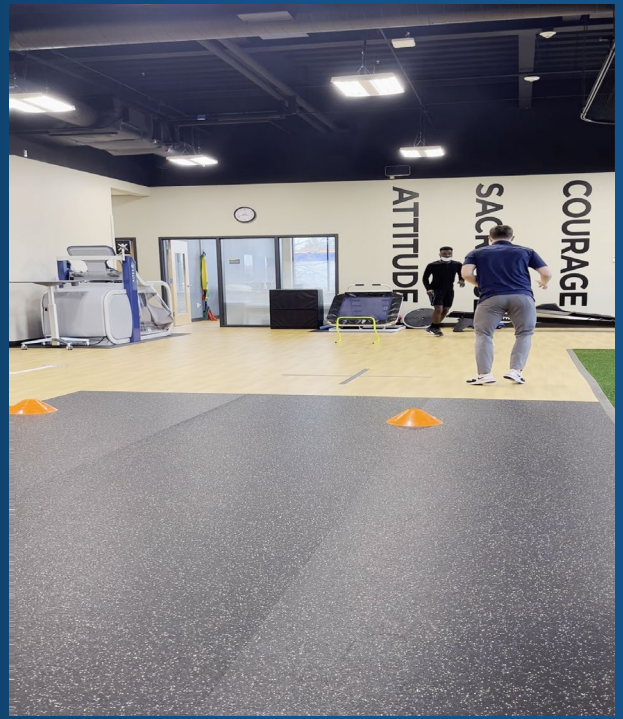
Stage 4 (RTS): Sport specific mvmt

1. high intensity running/cutting
2. Open field decision making
3. Position specific training



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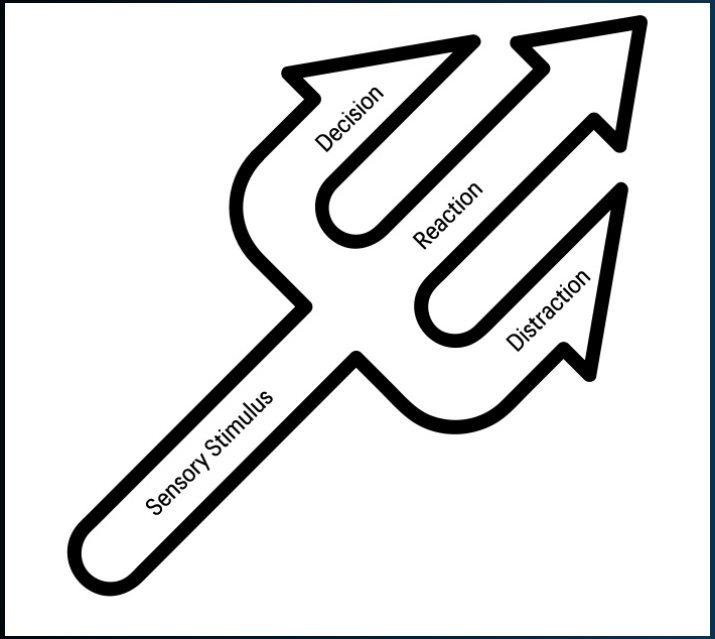
Motor learning Models (Trident Model)



Low Complexity & Contextual Interference. Consider Sensory Manipulation with:		
Decision	Reaction	Distraction
Moderate Complexity & Contextual Interference. Consider Sensory Manipulation with:		
Decision + Reaction	Decision + Distraction	Reaction + Distraction
High Complexity & Contextual Interference. Consider Sensory Manipulation with:		
Decision + Reaction + Distraction		

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Conclusion

- An internal focus of attention promotes a top-down cortical and visual feedback for control of movement with an increased conscious awareness of the injured joint = NOT autonomous movement.
- External focus of attention promotes automatic movements by use of subcortical regions which begins to free cortical space for programming more complex motor actions.

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