

# Behavioral & Clinical Strategies in Concussion Management: Active Strategies to Improve Outcomes



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Matthew Gfeller Sport-Related TBI Research Center  
Injury Prevention Research Center



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## Disclosures

- Research grant funding past 3 years
  - National Operating Committee for Standards on Athletic Equipment
  - University of North Carolina at Chapel Hill
  - National Football League
  - Centers for Disease Control
  - National Collegiate Athletic Association & Department of Defense Mind Matters Challenge
- Other Disclosures
  - Education content developer: Allied Health Education
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## Agenda

- Review the current evidence concerning exercise and rehabilitation post-concussion – 30 minutes
- Discuss concussion rehabilitation strategies- 45 minutes
- Describe the role behavior change and policy may play in implementing current evidence concerning exercise and rehabilitation post-concussion – 30 minutes
- Questions/Discussion- 15 minutes

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## Objectives

- Evaluate the current state of evidence concerning exercise and rehabilitation acutely and sub-acutely following concussion and its benefits over strict rest.
- Describe effective concussion rehabilitation strategies.
- Describe the role behavior change and policy may play in implementing current evidence concerning exercise and rehabilitation post-concussion.

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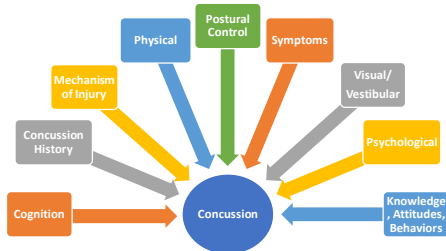
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## Concussion: A Multifaceted Condition

*...especially true for student-athletes*



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## For Many Years ....Consensus Driving Best Practice...



Previous Gold Standard:  
Rest Followed by Graded Exertion

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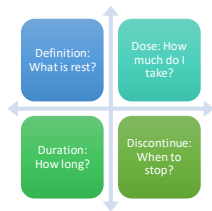
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*J Head Trauma Rehabil*  
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## Is Rest After Concussion “The Best Medicine?”: Recommendations for Activity Resumption Following Concussion in Athletes, Civilians, and Military Service Members

Noah D. Silverberg, PhD; Grant L. Iverson, PhD




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## Changing Landscape Adolescent and young adult settings

- Increased awareness
- Societal interest
- Policy changes
- Organizational investment
- Passive to active
  - Educational strategies
  - Management and treatment strategies
- Surge in scientific evidence




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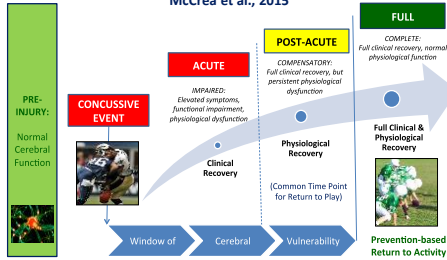
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## Integrated Recovery Model

McCrea et al., 2015



Science Driving Evidence-based Management

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## Current Return to Sport Strategy




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### Short Term Issues

- Worsening of post-concussive signs and symptoms
- Repeat concussion with post concussion syndrome
- School-related issues in student athletes
- Second Impact Syndrome (younger athletes)

### Long Term Issues

- Prolonged concussion symptoms (daily basis)
- Depression, cognitive impairment, dementia
- Long-term academic issues in student athletes
- Decreased Quality of Life

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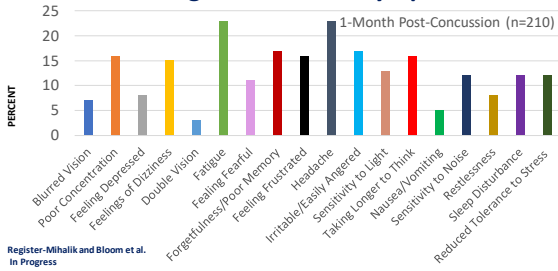
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## Supporting Need for Intervention: Prolonged/Persistent Symptoms




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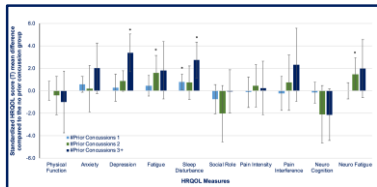
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## Supporting Need for Intervention: Prior Concussion & HRQL Effects



Adjusted mean difference estimates (colored bars) and associated 95% confidence intervals (error bars) for HRQL outcomes standardized scores comparing prior concussion groups to the no prior concussions group; An asterisk indicates significant difference compared to the no prior concussions group

Register-Mihalik et al., ACSM 2019

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2.2x greater risk in previously concussed players



Nordstrom et al. 2014

60% higher injury risk for previously concussed players



Cross et al. 2015

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Odds of injury 2.5x ↑ within 90 days after concussion

Brooks et al. 2016



Concussion associated with injury in retired NFL players

3+ concussions = 73-165% higher odds of sustaining lower extremity injury

Pietrosimone et al. 2015




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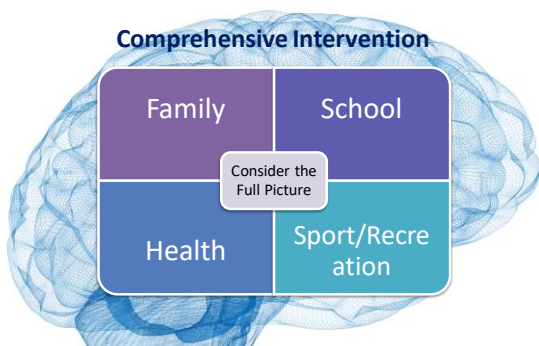
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### Comprehensive Intervention




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Biopsychosocial Consideration in Evaluation and Treatment of concussion (Register-Mihalik, 2020)	
<b>Biopsychosocial Model*</b>	<b>Key Considerations</b>
<b>Biological</b>	<ul style="list-style-type: none"> <li>• Physiologic Considerations</li> <li>• Neuroendocrine cascade post-concussion</li> <li>• Autonomic nervous system function</li> <li>• Early exercise may provide physiologic adaptations to improve outcomes</li> <li>• Clinical manifestations and considerations for evaluation</li> <li>• Symptoms</li> <li>• Cognitive function</li> <li>• Motor/Balance</li> <li>• Visual and Vestibular</li> <li>• Medication/pharmacologic considerations</li> <li>• Sex and age may influence outcomes and treatment considerations</li> </ul>
<b>Psychological</b>	<ul style="list-style-type: none"> <li>• Anxiety and depression should be considered in evaluation and treatment</li> <li>• General mood considerations</li> <li>• Integration back into social activities that do not exacerbate symptoms may improve athlete perceptions</li> <li>• Exercise and rehabilitation effects on psychosocial outcomes (e.g., quality of life)</li> <li>• Comprehensive approach/care team may improve outcomes</li> <li>• Peer-support and Cognitive Behavioral Therapy, especially in those with persistent symptoms (e.g., headache)</li> </ul>
<b>Social</b>	<ul style="list-style-type: none"> <li>• Peer/teammate interaction</li> <li>• Engagement in daily social activities without symptom exacerbation early in the process</li> <li>• Rehabilitation as a means for social interaction</li> <li>• Social support systems consideration</li> <li>• Work and school interactions</li> </ul>

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**Vestibular Rehabilitation**

## We Can

- Actively manage and treat concussion.
- Develop strategies within the context of our current best practices and return-to-play strategies.
  - What can we do from the very beginning?

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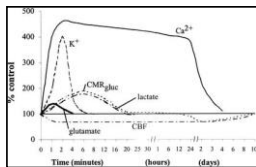
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## Treatment Assumptions

- Too much symptom exacerbation following physical or cognitive activity is a sign that the brain's dysfunctional neurometabolism is being pushed beyond tolerable limits.
- In guiding recovery, management of neurometabolic demands on the brain is central.



Giza 2001 & 2014

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**Activity**  
(When Done Right)

**Outdoors Rest**



**Benefits of Strict Rest After Acute Concussion: A Randomized Controlled Trial**

Sam George Thomas, MD, MPH, Jennifer A. Aho, PhD, Spencer C. Wilbur, PhD, Michael W. Cole, PhD, Thomas Hornsby, PhD

**OBJECTIVE:** To determine if increasing strict rest improved concussion recovery and reduced time to discharge from the pediatric emergency department (ED).

**DESIGN:** Patients aged 11 to 22 years presenting to pediatric ED within 10 hours of concussion were enrolled. Postconcussion symptoms, neurocognitive, balance, and cognitive assessment in the ED and were randomized to strict rest for 3 days versus usual care (1-2 days rest). Measures to improve return to school. Patients completed a diary used to record physical and mental activity level, calculate energy exertion, and record daily postconcussion symptoms.

**MEASUREMENTS AND MAIN RESULTS:** Concussion severity was predicted at 3 and 10 days postinjury. Energy use calculations were performed to detect clinically meaningful differences in postconcussion symptoms, neurocognitive, and balance scores between treatment groups. Linear mixed modeling was used to detect contributions of group assignment to individual recovery trajectory.

**CONCLUSIONS:** Strict rest patients were enrolled. ED completed all study procedures. ED assessment, ED control, discharge, and group reported 20% decrease in energy exertion and physical activity levels. As expected, the intervention group reported less school and behavioral difficulties (for days 3 to 7) postconcussion (10% vs 6% lower total,  $P < .05$ ). There was no clinically significant difference in neurocognitive or balance outcomes. However, the intervention group reported more daily postconcussion symptoms (total symptom score over 10 days, 10% vs 15%,  $P < .05$ ) and showed improved resolution.

**CONCLUSIONS:** Return to school was not for adolescents immediately after concussion. Effect on school levels over the next few adolescents' symptom reporting was influenced by increasing strict rest.

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## Growing Body of Research



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## Modes of Intervention



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Brief (24-48h) rest is appropriate for most patients

Following brief rest, patients should gradually increase activity

Cervical and vestibular rehabilitation

Multifaceted care

Submaximal, monitored, sub-symptom threshold exercise may also benefit

Rest and treatment/rehabilitation following sport-related concussion: a systematic review  
Kathryn J Schneider,<sup>1</sup> John Luskley,<sup>2</sup> Kevin M Guskiewicz,<sup>3</sup> Just Taylor,<sup>4</sup> Michael McCrea,<sup>5</sup> Noah D Swearingen,<sup>6</sup> Nina Indemmermann-Demant,<sup>7</sup> Grant L Hanson,<sup>8</sup> Alex Hayden,<sup>9</sup> Michael Madsen,<sup>10</sup> CP

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Schneider et al, 2017



Overview of key recent exertion, exercise, and rehabilitation studies				
Study	Design	Participants	Intervention and Comparison	Key Findings
Leddy et al. 2019	Multicenter RCT	203 adolescent athletes (ages 13-18 years); 52 aerobic exercise group, 51 stretching group	Progressive sub-symptom threshold aerobic exercise vs. progressive placebo stretching	Exercise participants recovered in median 13 days (IQR 10-18) vs. stretching participants recovery in 17 days (IQR 13-23)
Popovich et al. 2019	Retrospective Cohort	126 patients presenting to a university sports-related concussion clinic; 28 with supervised exercise; 100 without	Record of supervised activity in patients still symptomatic initiated within 16 days of injury vs. no record of supervised activity	No serious adverse events, early supervised exercise group faster clearance to return to sport compared to those with no record of supervised exercise (mean days=26.5 (SD=11.2) vs. mean days=35.1 (SD=26.5))
Orkman et al. 2019	Pilot RCT	32 youth, 30 completing the study; 19 with intervention, 11 with stretching control (ages 12-18 years)	Sub-symptom threshold exercise program (only 2 in person visits) vs. active stretching control	Concussion symptoms declined more rapidly in the exercise group compared to the control (p=0.02); health-related quality of life improved over time, but was not different between groups
Gauvin-Lepage et al. 2018	Multicenter Prospective Quasi-Experimental Control Group Design	49 youth reporting to tertiary care center or community care providers who were slow to recover after concussion; 36 experimental; 13 control	Active rehabilitation intervention vs. standard of care alone	Both groups reported decreased symptoms over time (no group differences); children in the intervention group had a higher quality of life (p<0.04) and less anger (p<0.02)

Silverberg et al. 2019	Case-Control	146 patients from two Canadian concussion clinics; 82.9% recommended more than 2 days rest	Patients recommended more than 2 days of rest post-concussion vs. those recommended 2 or less days	Exposure to prolonged rest advice was predictive of productivity status; 64.5% of those prescribed prolonged rest vs. 40.0% of those not were on leave from work or school at time of intake when the exposure question was asked
Remigio-Baker et al. 2019a	Prospective Cohort	62 service members enrolled within 72 hours post-concussion	Activity levels acutely post-injury and association with symptoms at 1, 3, and 6 months post-injury	Greater baseline activity levels significantly related to greater vestibular symptoms at 1, 3, and 6 months post-injury (β = 0.61, 0.63, and 0.59, respectively)
Remigio-Baker et al. 2019b	Prospective Cohort	39 service members enrolled within 72 hours post-concussion	Activity levels at 1 and 3 months post-concussion and association with subsequent symptoms at 1 and 6 months	Greater physical and vestibular/balance activity at 1-month was correlated with lower symptoms at 3 months post-concussion (but not 6 months); acute symptoms did not affect these relationships
Kjellgaard et al. 2019	Single-Blind RCT	65 patients presenting to a university hospital; 33 vestibular therapy; 32 control	Group-based vestibular therapy vs. control	The intervention group had improved dizziness handicap (4.7; 95% confidence interval (CI): -16.6 to -0.9) and better High Level Mobility assessment scores (1.7 points; 95% CI: 1.4-6.0)
Hammerk et al. 2019	Retrospective Chart Review	Active-duty military patients who received standard Law vestibular rehabilitation therapy (VRT) or cervical spine proprioceptive retraining (CSPR); 22 VRT, 26 CSPR	CSPR vs. VRT	Patients who received CSPR were more likely to report improvements in dizziness than those with VRT, but the confidence interval was large (adjusted odds ratio 30.12; 95% confidence interval 4.44-204.26, P < .001)

# Evidence Supporting Exercise & Rehabilitation: Aerobic Exercise

Leddy, 2019

- 103 concussed participants (~46% female)
- Randomly signed aerobic exercise vs. stretching treatment
  - Supervised aerobic exercise ~20 min sessions daily at a **prescribed** heart rate on a treadmill or bike
  - No Ix administered prior to 48 hours post-injury
- Mean time to visit 4.8/4.9 days from injury
- Aerobic exercise recovered in median 13 (IQR 10-18.5 days)
- Stretching recovered in median 17 (IQR 13-23 days)

**New Release** | [View Article](#) | [Citation](#) | [Abstract](#) | [Share](#)

**Original Investigation**

February 4, 2019

**Early Subthreshold Aerobic Exercise for Sport-Related Concussion: A Randomized Clinical Trial**

Leddy, MJ; Mahomed, S; Hodge, MP; et al. | [DOI: 10.1001/jama.2018.10877](#)

[View Article](#)

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## Graded Exercise Testing...

COMPETITIVE SPORTS

### Use of Graded Exercise Testing in Concussion and Return-to-Activity Management

John J. Leddy, MD, FRCPC FACP<sup>1</sup> and Barry Willer, PhD<sup>2</sup>



Figure 2: Use of the BCTT and exercise prescription for RTA in physiologic PCO. APMHR, age predicted maximum HR. \*After 3 wk of symptoms. \*\*15 bpm for nonathletes; 10 bpm for athletes. To obtain a more precise target HR, consider repeating the BCTT every 2 wk.

LEADING ARTICLE

Journal of Orthopaedic & Sports Physical Therapy  
© 2008 American Physical Therapy Association

Armstrong, 2008  
*Sports Med*

### Head and Neck Position Sense

Bridget Armstrong, Peter McNair and Denise Taylor

Health and Rehabilitation Research Centre, Auckland University of Technology, Auckland, New Zealand

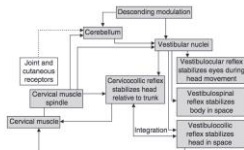
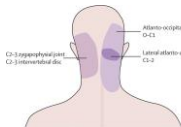


Fig. 1. Simplified schematic of the neural connections described in the text for head and neck position sense. Note: the clear box and dotted line indicate a secondary role.

## Cervicogenic Dysfunction



• Common concussion symptoms that could have a cervicogenic basis include neck pain or stiffness, and headache

• "cervicogenic post-concussion disorder" - patients could present with symptoms such as dizziness and postural instability

• Cervical spine has complex proprioceptive system

• "Impairments in sensorimotor features such as eye movement control, cervical joint position sense and postural stability, affecting balance have been found in association with persistent neck pain of both insidious and traumatic origins" (Treleaven, Clamaron Cheers, & Jull, 2011, p. 636).

## Cervicogenic Options



- Cervical manipulation has been shown to be more effective as compared to mobilization. (Dunning, 2016)
- Therapeutic exercise and manipulation/mobilization were equally effective and that both were more effective than no treatment in the management of chronic cervicogenic headaches. (Jull, 2002)

Examples: Neck ROM, strengthening, proprioceptive targeting

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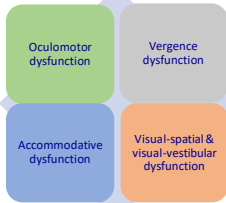
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## Visual Therapy

- Strobe training even in healthy people improves cognitive outcomes and performance (Applebaum 2011 & 2012; Smith 2012)
- Studies in acquired and TBI patients show improvements in oculomotor function following training (Kapoor, 2018)
- Oculomotor training improves reading and visual attention in mild TBI patients (Thiagarajan, 2014)



- Retrospective analysis of patients with mild TBI who underwent vision therapy for oculomotor signs and symptoms found that 90% had complete or marked improvement in their primary symptoms. (Cuffreda, 2008)

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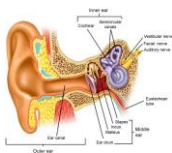
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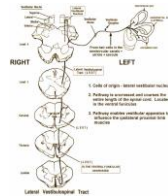
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### Vestibulo-Ocular



Maintains visual stability during head movements

### Vestibulospinal



Responsible for postural control

*The primary role of the vestibular system is to maintain head and eye coordination, upright posture and balance, and conscious realization of spatial orientation and motion.*

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# Vestibular Therapy

Accepted 2 December 2016  
DOI: 10.1111/otn.12327

ORIGINAL ARTICLE

WILEY

## Feasibility of early physical therapy for dizziness after a sports-related concussion: A randomized clinical trial

J. C. Rensker<sup>1</sup> | A. Hassen<sup>2</sup> | R. S. Phillips<sup>2</sup> | M. C. Moughiman<sup>3</sup> | M. Donaldson<sup>2</sup> | J. Moughiman<sup>3</sup>

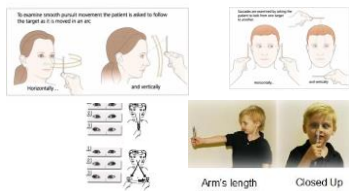
### Outcomes Following a Vestibular Rehabilitation and Aerobic Training Program to Address Persistent Post-Concussion Symptoms

An Exploratory Study

Brian M. Moore, PT, DPT<sup>1,3</sup>  
Joseph T. Adams, PT, DPT<sup>2</sup>  
Edward Barakatt, PT, PhD<sup>1</sup>

## Examples Visual-Vestibular

- Smooth pursuits, saccades, gaze stability, and convergence, habituation, VOR, Convergence



## Video Examples in the Real World *VOR and Convergence*

## Cervicovestibular Therapy

Schneider et al, 2014 - BJSM

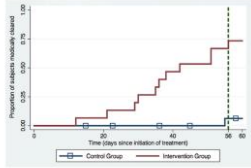


Figure 1 Proportion of patients medically cleared over time.

- 31 concussion patients ages 12-30 with symptoms > 10 days and with dizziness, neck pain, and/or headaches
  - Vestibular or cervical spine involvement
  - 15 Intervention Group
- Both groups weekly sessions and GRTP; treatment also received cervical spine and vestibular rehabilitation
- Of those who completed the intervention, patients in the treatment group >10x more likely to be cleared to return to sport by 8 weeks post-injury

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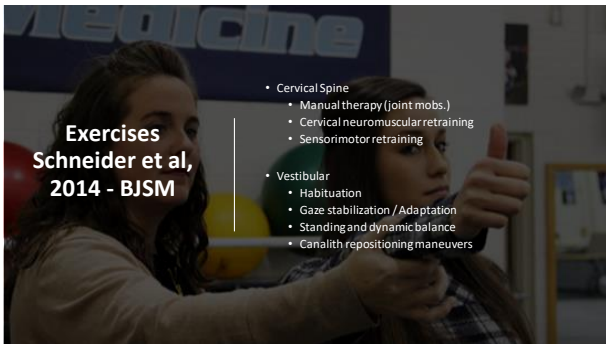
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## Evidence Supporting Exercise & Rehabilitation: Dual-Task

- Motor and cognitive tasks
- Low-level to more intense progressions
- Fun, engaging, move to sport-specific



### Pilot work

- Improvements in balance and coordination after 4 weeks

Ingreselli et al, 2014

Contents lists available at ScienceDirect

Journal of Science and Medicine in Sport

journal homepage: [www.elsevier.com/locate/jasm](http://www.elsevier.com/locate/jasm)

Original research

Outcomes, utility, and feasibility of single task and dual task intervention programs: Preliminary implications for post-concussion rehabilitation

Joseph M. Ingreselli<sup>a,\*</sup>, Joshua K. Reigister-Mihalik<sup>a,b,c</sup>, Julianne D. Schmidt<sup>c</sup>, Jason P. Mihalik<sup>a,b</sup>, Benjamin M. Goerger<sup>d</sup>, Kevin M. Guskiewicz<sup>a,b</sup>

<sup>a</sup>Department of Biomedical Engineering, Virginia Tech, Blacksburg, VA, USA; <sup>b</sup>Department of Exercise Science, Virginia Tech, Blacksburg, VA, USA; <sup>c</sup>Department of Health, Behavior, and Society, Johns Hopkins University, Baltimore, MD, USA; <sup>d</sup>Department of Health, Behavior, and Society, Johns Hopkins University, Baltimore, MD, USA

\*Corresponding author. E-mail address: [jm2@vt.edu](mailto:jm2@vt.edu) (J.M. Ingreselli).

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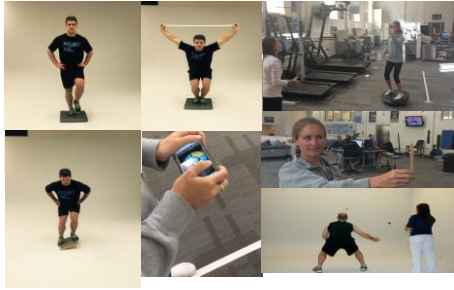
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## Some examples




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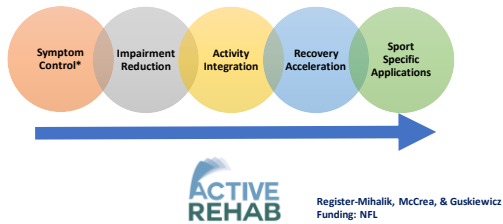
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## A Paradigm Shift




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## Current Active Rehabilitation Study

Role of Active Rehabilitation in Concussion Management:  
A Randomized, Controlled Trial

Specific Aim 1

Compare the effects of a multidimensional rehabilitation protocol versus enhanced graded exertion on clinical recovery, return to play, and patient outcomes after SRC.

Specific Aim 2

Demonstrate the safety and feasibility of active intervention protocols when introduced during the sub-acute recovery period after SRC, as part of a multidimensional rehabilitation protocol.

	School/Team Randomization	
	Enhanced Graded Exertion Arm	Multidimensional Rehabilitation Arm
Pre-Season Baseline Testing	✓	✓
Immediate Concussion Assessment	✓	✓
24-48 Hour Assessment + Education	✓	✓
Intervention Activities	Guided Activity	Guided Activity + Multidimensional Rehab
Asymptomatic Assessment	✓	✓
Enhanced RTP Strategy Begins (Stage 2)	✓	✓
Fall RTP	✓	✓
1-month Assessment	✓	✓

RTP = return to play

Register-Mihalik et al, 2019

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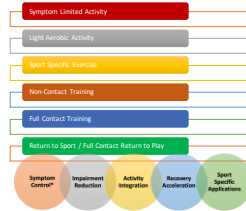
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# Current Active Rehabilitation Study

Role of Active Rehabilitation in Concussion Management:  
A Randomized, Controlled Trial




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## MDR General Progression Overview

- Guided by symptom presentation and activities of concern for return to sport
- Symptom severity primary marker for progression
- Easy/hands-on activity progressed to divided attention and sport-specific activities
- Integrated with return to sport progression once asymptomatic




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## Other treatments for consideration....




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<b>Biological</b>	<ul style="list-style-type: none"> <li>• Physiologic Considerations</li> <li>• Neuroendocrine cascade post-concussion</li> <li>• Autonomic nervous system function</li> <li>• Early exercise may provide physiologic adaptations to improve outcomes</li> <li>• Clinical manifestations and considerations for evaluation</li> <li>• Symptoms</li> <li>• Cognitive function</li> <li>• Motor/Balance</li> <li>• Visual and Vestibular</li> <li>• Medication/pharmacologic considerations</li> <li>• Sex and age may influence outcomes and treatment considerations</li> </ul>
<b>Psychological</b>	<ul style="list-style-type: none"> <li>• Anxiety and depression should be considered in evaluation and treatment</li> <li>• General mood considerations</li> <li>• Integration back into social activities that do not exacerbate symptoms may improve athlete perceptions</li> <li>• Exercise and rehabilitation effects on psychosocial outcomes (e.g., quality of life)</li> <li>• Comprehensive approach/care team may improve outcomes</li> <li>• Peer-support and Cognitive Behavioral Therapy, especially in those with persistent symptoms (e.g., headache)</li> </ul>
<b>Social</b>	<ul style="list-style-type: none"> <li>• Peer/teammate interaction</li> <li>• Engagement in daily social activities without symptom exacerbation early in the process</li> <li>• Rehabilitation as a means for social interaction</li> <li>• Social support systems consideration</li> <li>• Work and school interactions</li> </ul>

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## Considerations from Current Evidence

-  Assessment of deficits & current state of patient
-  Clinical supervision & direction
-  Tracking & monitoring of progress
-  Appropriate skills to conduct activity / refer when needed
-  Dose, timing, intensity...

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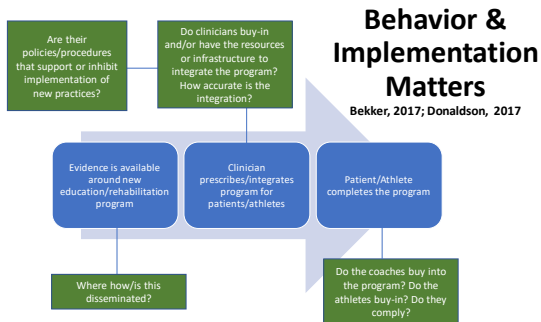
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## Behavior Change at Multiple Levels of the Sport Environment is Necessary to:

Improve Primary, Secondary, and Tertiary Prevention

Improve Clinical Management

Improve Clinical & Patient Outcomes

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## Clinical Experiences Tie into Disclosure

Previous experience with concussion is associated with lower attitudes and worse reporting outcomes

(Baugh, 2019, Register-Mihalik, 2017)

Student-athletes and cadets weigh

*Cost vs. Benefit*

(Weber, 2019 In Press)

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## What does this mean in the context of current “rules” and guidelines?

- It’s rehabilitation, make sure it’s in your standing orders and protocols
- You are not entering the “RTP” process (Stage 2) when starting activities like this, you are conducting rehabilitation activities as you would with any other injury
  - Best practice is not to begin **Stage 2** of the return-to-play strategy until asymptomatic
- Complete continuing education to be trained in any new skills/activities
- Clinician directed and supervised activity appears safe, even in close proximity post-concussion

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# Changes in Clinical Practice

## Pragmatic Considerations

General awareness of new evidence	Alignment of policies with current evidence	Clinician change practice towards the new evidence	Participants engage in intervention
<ul style="list-style-type: none"> <li>• Current return to sport strategy</li> <li>• New evidence around rest / activity post-concussion</li> </ul>	<ul style="list-style-type: none"> <li>• State laws</li> <li>• Athletic association policies</li> <li>• Current concussion protocols</li> </ul>	<ul style="list-style-type: none"> <li>• Buy-in</li> <li>• Resources</li> <li>• Local strategies for their current practice and model of care</li> </ul>	<ul style="list-style-type: none"> <li>• Buy-in to new strategies</li> <li>• Coach/team buy in to changes in practice</li> <li>• Time to complete intervention</li> </ul>

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While we are concerned with patient-level interventions, there are other “interventions” to consider.



Kerr, 2014; Register-Mihalik, 2017; Lininger, 2019

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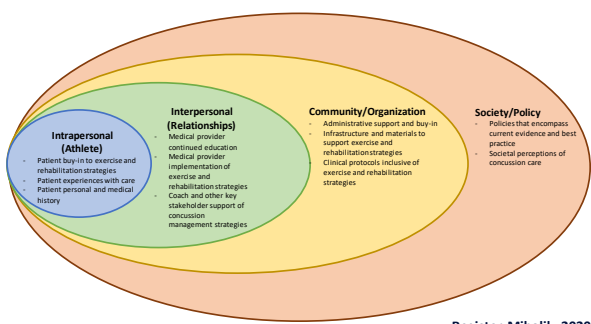
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Register-Mihalik, 2020

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***Clinically directed sub-threshold exercise and rehabilitation acutely and sub-acutely post-concussion appears to be effective and safe. Key behaviors of many involved in the concussion management process as well as policies should be considered in order to effectively implement current best practices in a timely manner across various clinical settings.***

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## Thank You



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