

Symptoms and Recovery from Concussion

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- Speaker honorariums and travel expenses for conferences and meetings
- Independent practice in forensic neuropsychology, including athletes

Topics

- Pathophysiology
- Acute Symptoms
- Assessment
- Rest
- Return to Sports
- Active Rehabilitation

By definition, a sport-related concussion is
a mild traumatic brain injury.

Pathophysiology

- Complex interwoven cellular and vascular changes
- **Multilayered Neurometabolic Cascade**
- Under certain circumstances, cells degenerate and die

Primary Mechanisms

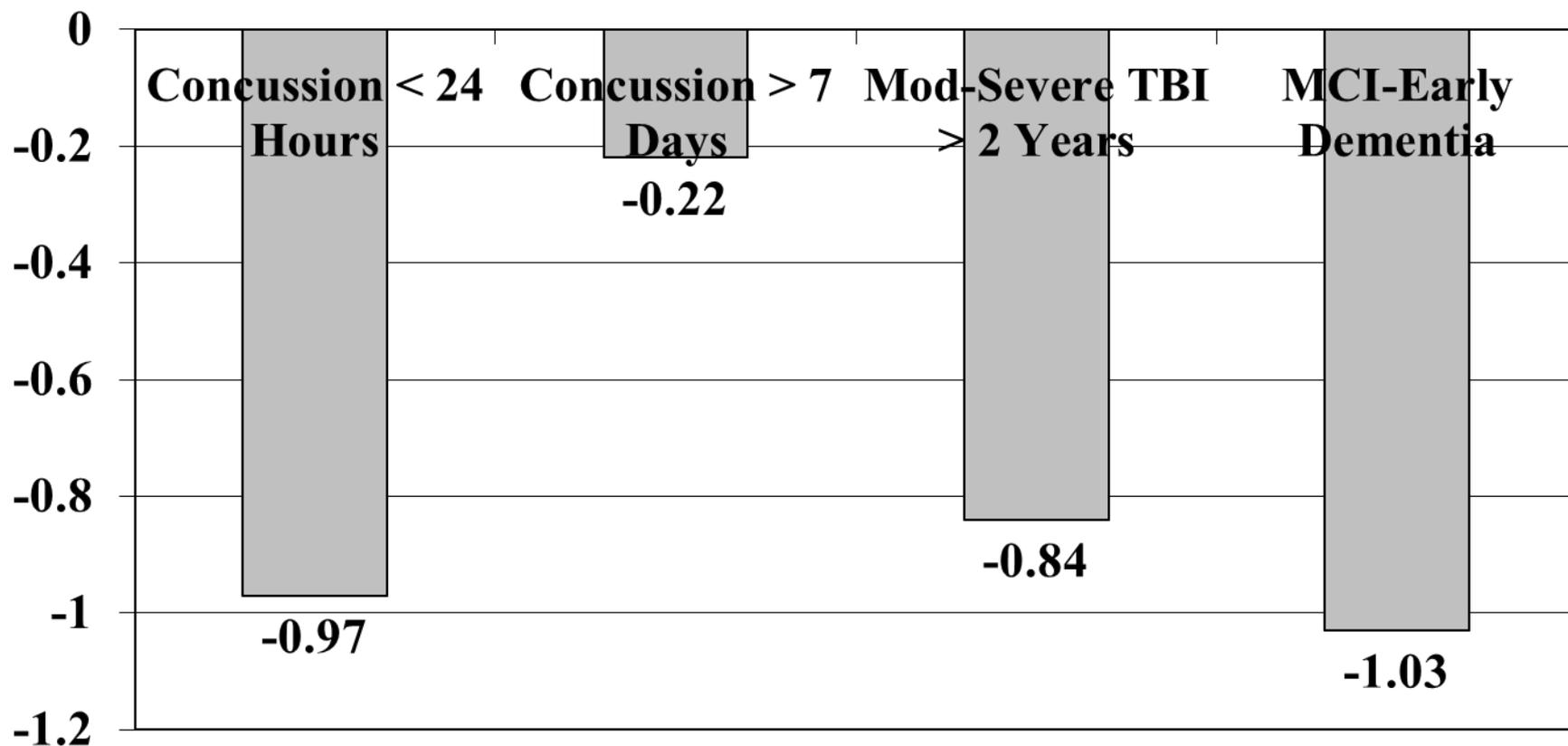
- Ionic shifts
- Abnormal energy metabolism
- Diminished cerebral blood flow
- Impaired neurotransmission

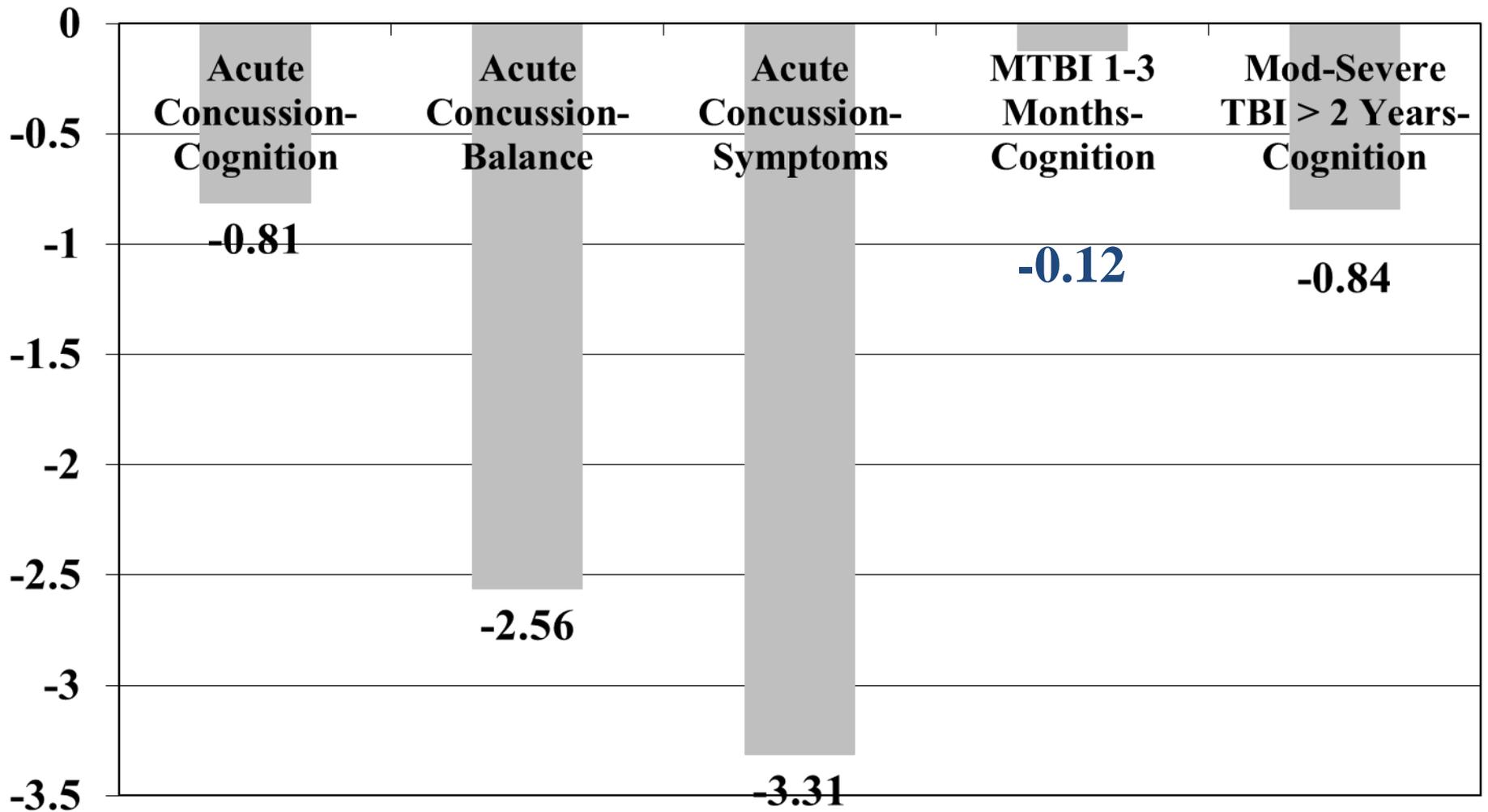
Fortunately, the brain undergoes
dynamic restoration

Is sport-related concussion a benign injury?

Results from meta-analyses

Adverse Effects of Sport Concussion on Cognition





Basic Principles

- Concussion is a clinical diagnosis
- Tests do not diagnose concussion, they measure certain aspects of how a concussion affects a person
- There are tremendous individual differences in how people are affected by a concussion

Assessment Timeline

Sideline

Post-
Game

24
Hours

First
Week

Second
Week

Third
Week

At
Risk!

Sideline and Post-Game

Observation and Examination

Observable Features

- Loss of Consciousness (uncommon)
- Balance Disturbance (e.g., “Bambi legs” on the ice)
- Amnesia (retrograde and/or anterograde; often very brief)
- Disorientation
- Confusion/Attentional Disturbance
 - Slowness to answer questions or follow directions
 - Easily distracted
 - Poor concentration
- Vacant Stare / “Glassy-Eyed”
- Inappropriate/confused Playing Behavior

Common Initially Reported Sideline Symptoms

- Headache
- Dizziness
- Some form of mental status disturbance, such as mental clouding, confusion, or feeling slowed down

SCAT3™



FIFA®



FEI

Sport Concussion Assessment Tool – 3rd Edition

For use by medical professionals only

- Glasgow Coma Scale
- Maddocks Questions: Amnesia
- Symptom Scale
- Balance Testing (M-BESS or BESS)
- Timed Tandem Gait
- Neck Exam
- Simple Coordination Exam (finger-to-nose)
- Cognitive Screening (SAC)

SCAT3

- Good News
 - Standardized
 - Objective
 - Multimodal
 - Relatively Brief
- Bad News
 - Unclear how best to define decrements/impairments
 - Unclear how best to interpret serial test results

Post-Concussion Scale: Symptoms Endorsed Acutely

- 260 acutely concussed high school and college athletes
- All assessed within 5 days
- Mean = 2.0 days; SD = 1.2 days
- 88% assessed within 3 days

(Lovell et al., 2006)

Most Common Symptoms

- Headaches (78.5%)
- Fatigue (69.2%)
- Feeling slowed down (66.9%)
- Drowsiness (64.2%)
- Difficulty concentrating (65.8%)
- Feeling mentally foggy (62.3%)
- Dizziness (61.2%)

(Lovell et al., 2006)

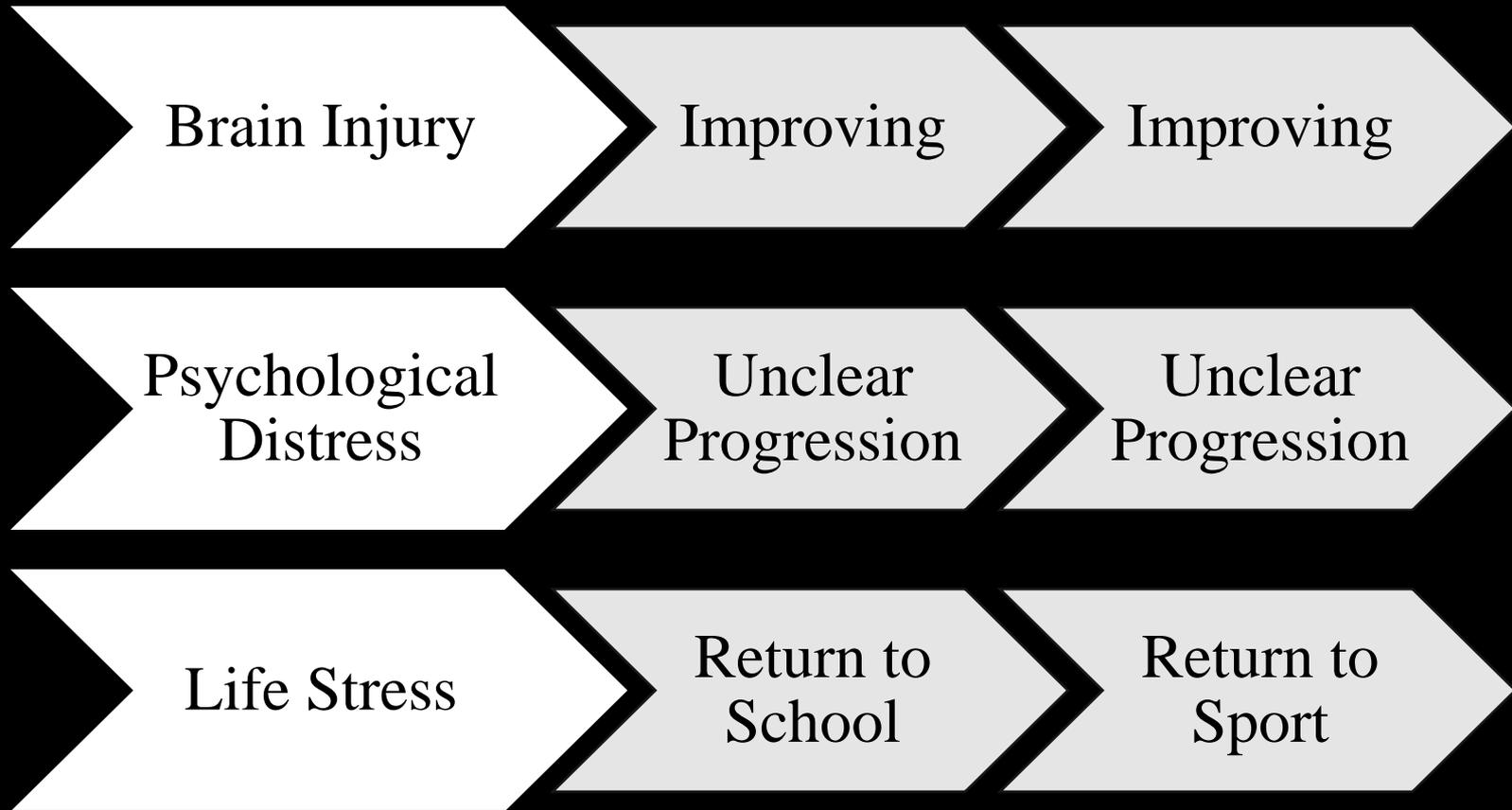
Least Common Symptoms

- Nervousness (21.2%)
- Feeling more emotional (17.7%)
- Sadness (15.0%)
- Numbness or tingling (14.6%)
- Vomiting (8.8%)

(Lovell et al., 2006)

Conceptualizing Symptoms Over Time

(individual differences in how symptoms change over time)



Acute and Subacute Concussion Symptoms

Remember:

Symptoms in the first two weeks following a concussion can be worsened by other factors, such as a neck injury, psychological distress, and life stress.

Slow Recovery: Some Risk Factors

- Vestibular + Anxiety
- Stress, Worry, Depression
- Chronic Headaches
- Multiple Prior Concussions

Rest Following Injury

How much and for how long?

Critical Questions

- How do we define “rest”?
- How long should an athlete rest?
- How do we define gradual resumption of activities?
- How much rest is too much rest?
- When should we begin active rehabilitation?

What is the rationale for rest?

- The injured brain might be in a state of neurometabolic crisis.
- Assuming that neurometabolic crisis involves an “energy crisis,” then vigorous activity might compound or magnify the energy crisis.
- Passing another mechanical force through the injured brain, while it is in a state of neurometabolic crisis, might result in magnified pathophysiology.

"Playing Through It": Delayed Reporting and Removal From Athletic Activity After Concussion Predicts Prolonged Recovery (Asken et al., 2016)

- Ninety-seven collegiate athletes who sustained a sport-related concussion between 2008 and 2015. Athletes were grouped as immediate removal from activity or delayed removal from activity.
- The Delayed Return athletes averaged 4.9 more days missed than the Immediate Return athletes. The Delayed Return athletes were approximately 2.2 times more likely to have a prolonged recovery (8 or more days) compared with the Immediate Return athletes.

Playing Injured and Recovery Time

(Elbin et al., 2016; Pediatrics)

Methods

- A prospective, repeated measures design.
- 35 youth removed from play following concussion vs. 35 who continued to play
- Neurocognitive and symptom data were obtained at baseline and at 1 to 7 days and 8 to 30 days after injury.

Results

The PLAYED group took longer to recover than the REMOVED group (44.4 ± 36.0 vs 22.0 ± 18.7 days; $P = .003$) and were 8.80 times more likely to demonstrate protracted recovery (≥ 21 days) ($P < .001$). The PLAYED group exhibited significantly worse neurocognitive and greater symptoms than the REMOVED group.

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

- Silverberg and Iverson (2012) concluded that bed rest exceeding three days is not recommended and gradual resumption of pre-injury activities should begin as soon as tolerated.

Is rest in the initial days following concussion a good idea?

In my opinion, yes.

Possible Harms of Prolonged Rest

- Falling behind in school with increased associated stress
- Physical deconditioning and evolving exercise intolerance
- Nocebo effects (expectation of sickness as a cause of sickness)
- Somatic preoccupation and Cognitive Hypochondriasis
- Depression

Factors Related to Depression in Adolescents

(Lewinsohn et al., 1997)

- The authors examined a wide range of psychosocial variables in the following 3 groups of adolescents:
 - depressed cases (n = 48),
 - nonaffective disorder cases (n = 92), and
 - healthy controls (n = 1,079)
- The authors found 3 of the 44 variables assessed in this study to be strongly specific to depression:
 - self-consciousness
 - low self-esteem
 - a reduction in activities because of physical illness or injury.

What does the Sport Concussion Group 2012 Zurich Consensus Statement say?

- “In the absence of evidence-based recommendations, a sensible approach involves the gradual return to school and social activities (prior to contact sports) in a manner that does not result in a significant exacerbation of symptoms”

(McCrorry et al., 2013)

Gradual Return to Sports Following Injury

Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012

Paul McCrory,¹ Willem H Meeuwisse,^{2,3} Mark Aubry,^{4,5,6} Bob Cantu,^{7,8}
Jiří Dvořák,^{9,10,11} Ruben J Echemendia,^{12,13} Lars Engebretsen,^{14,15,16}
Karen Johnston,^{17,18} Jeffrey S Kutcher,¹⁹ Martin Raftery,²⁰ Allen Sills,²¹
Brian W Benson,^{22,23,24} Gavin A Davis,²⁵ Richard G Ellenbogen,^{26,27}
Kevin Guskiewicz,²⁸ Stanley A Herring,^{29,30} Grant L Iverson,³¹ Barry D Jordan,^{32,33,34}
James Kissick,^{6,35,36,37} Michael McCrea,³⁸ Andrew S McIntosh,^{39,40,41}
David Maddocks,⁴² Michael Makdissi,^{43,44} Laura Purcell,^{45,46} Margot Putukian,^{47,48}
Kathryn Schneider,⁴⁹ Charles H Tator,^{50,51,52,53} Michael Turner⁵⁴



Consensus Statement on Concussion in Sport: the 3rd International Conference on Concussion in Sport held in Zurich, November 2008

P McCrory, W Meeuwisse, K Johnston, J Dvorak, M Aubry, M Molloy and R Cantu

Br. J. Sports Med. 2009;43:i76-i84
doi:10.1136/bjism.2009.058248

Management Protocol: Stepwise

- No activity / Rest
- Light aerobic exercise
- Sport-specific exercise
- Non-contact training drills
- Full contact practice
- Return to play

Recovery from Concussion in Sports



Recovery Time in Athletes

NCAA Football Cohort

- 1,631 players
- 94 concussions
- Balance problems resolved in 3-5 days
- Symptoms gradually resolved by 7 days
- Cognition resolved by 5-7 days
- 91% appeared recovered by 7 days

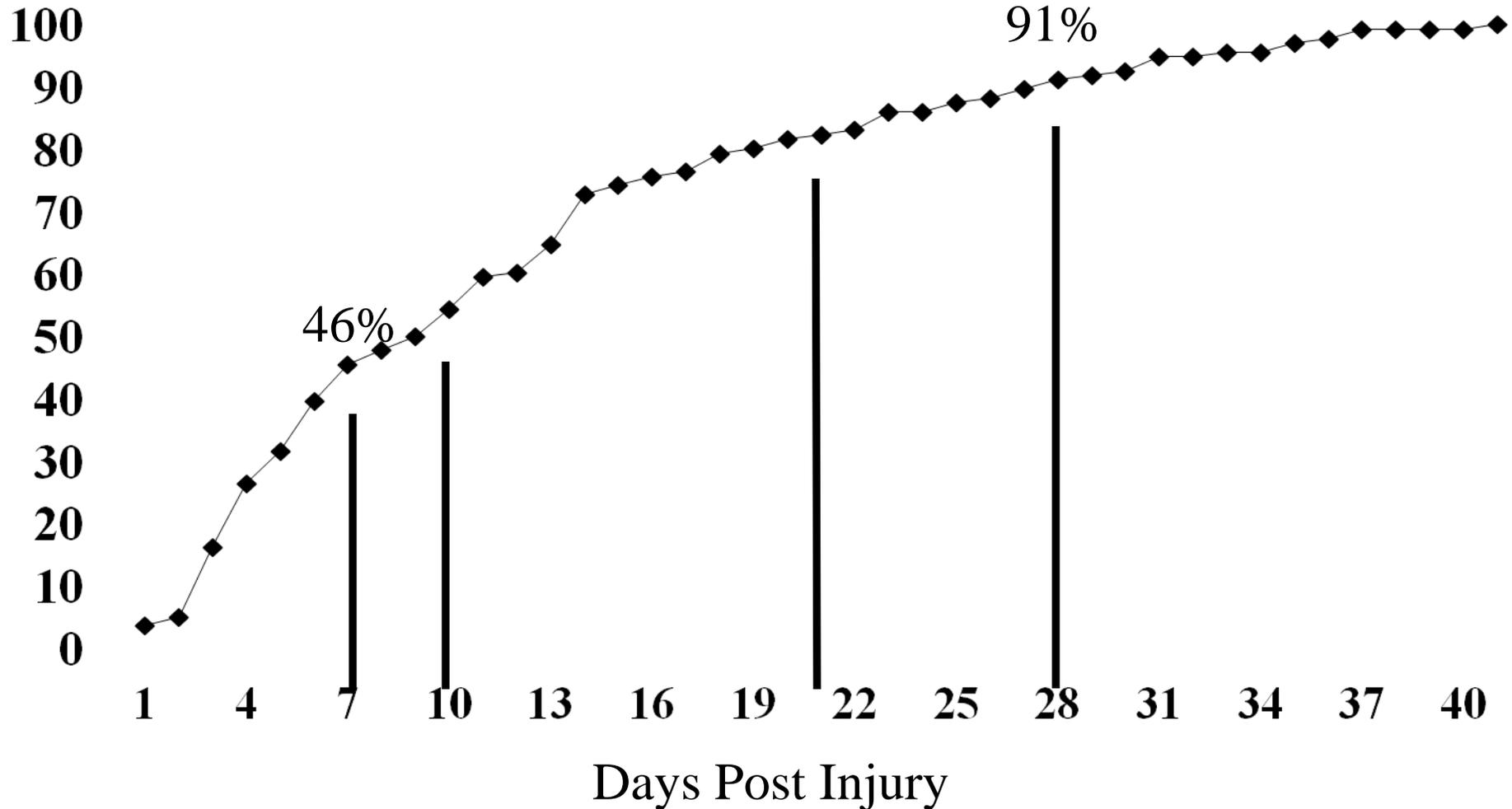
McCrea et al. (2003)

Pennsylvania High School Football Cohort

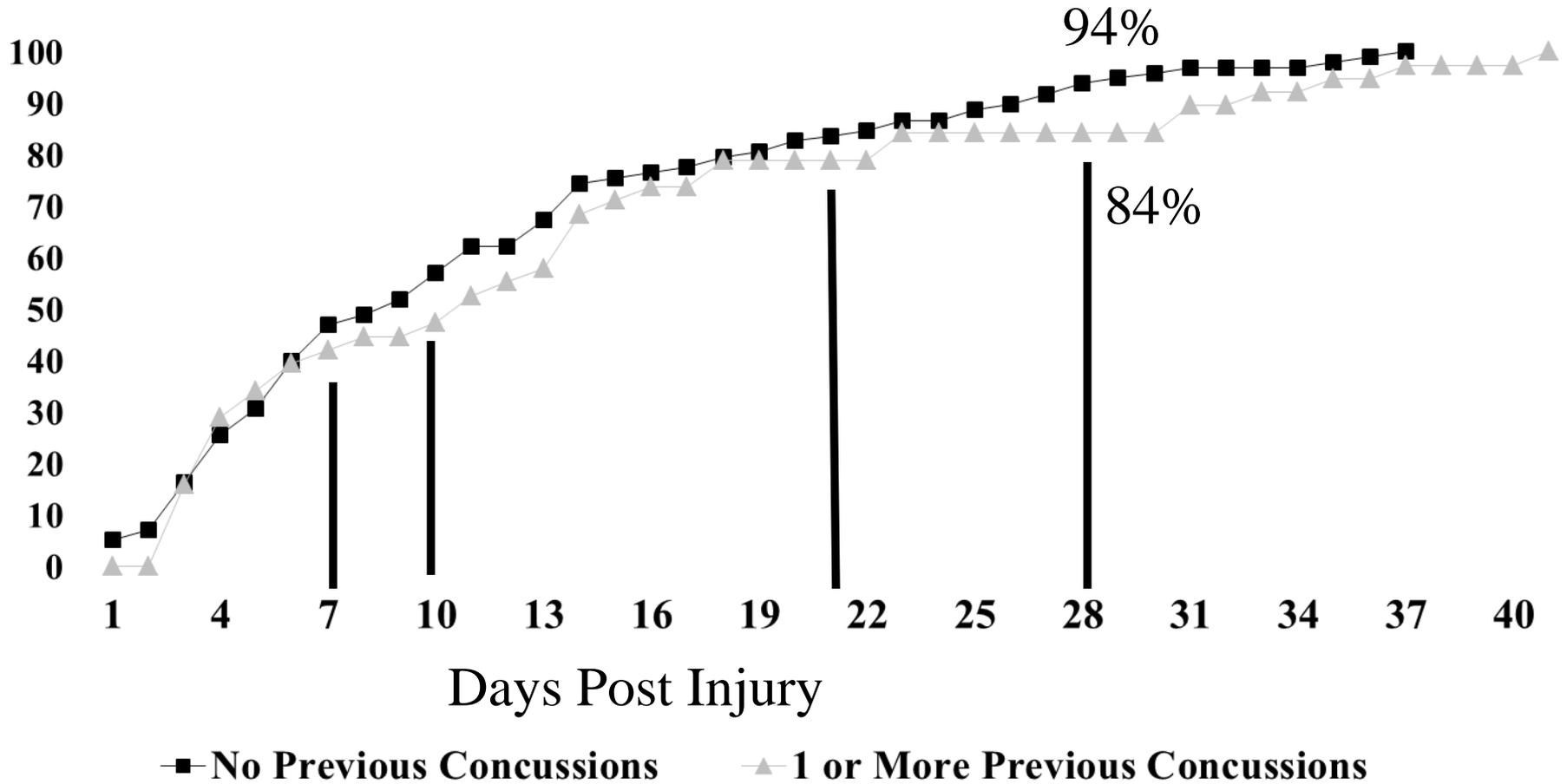
- 2,141 players
- 3-year prospective cohort study
- 134 concussions
- Players followed until recovered

Collins, Lovell, Iverson, Ide, Maroon (2006)

Recovery Curve (N = 134)



Recovery Curves (N = 134)



Possible Predictors of Worse Outcome

Age

- There is some, but not definitive, support for a gradient age and level of play effect with clinical recovery being fastest in professional athletes, followed by college athletes, followed by high school athletes.
- No age effects in several studies, including some large scale studies (Nelson, Guskiewicz, et al., 2016; Nelson, Tarima, et al., 2016).
- In the large multicenter Canadian study (Zemek et al., 2016), children presenting to the ED following injury, the rates of those having persistent symptoms > 4 weeks:
 - Ages 5-7=17.9%, ages 8-12=26.3%, ages 13-17=39.9%.

Sex

- Comparable number of studies show positive and negative findings that worse outcomes are associated with female sex
- Some large-scale and epidemiological studies indicate that girls and young women are at greater risk for having symptoms that persist for more than a month (e.g., Wasserman et al., 2016; Zemek, et al., 2016; Kostyun et al., 2016).
- The extent to which recovery is slower/outcomes are worse for females is still unclear.

Prior Concussions

- Many studies find an association between prior concussions and worse clinical outcomes.
- A greater number of studies **have not** found that prior concussions are associated with worse outcomes.
- Still likely a significant modifier because:
 - Prior history of concussion is a risk factor for future **concussions** (Abrahams et al., 2012)
 - Prior concussions are associated with greater pre-injury symptom reporting in some athletes (Abrahams et al., 2012; Iverson et al., 2015)
 - Some large-scale studies show an association between concussion history and increased risk for symptoms lasting **more than four weeks** (e.g., Castile et al., 2012; Miller et al., 2016; Wasserman et al., 2016)

Health History

- **Mental Health History**
 - Almost all studies suggest worse outcome.
- **ADHD History**
 - Almost all studies **do not** suggest worse outcome.
- **Learning Disability History**
 - Almost all studies **do not** suggest worse outcome.
- **Personal Migraine History**
 - Almost all studies **do not** suggest worse outcome.
 - One large well-designed study reported that a personal history of migraine is associated with risk for symptoms lasting more than four weeks (Zemek et al., 2016).

Injury Severity

- **Loss of consciousness**
 - Some studies report positive findings that LOC is associated with worse outcomes, but most do not find an association with LOC.
- **Post-traumatic amnesia/“amnesia”**
 - Mixed, but more studies do not find association with worse outcomes.
- **Retrograde amnesia**
 - Less frequently studied.
 - Consistently associated with worse outcome.

Acute Clinical Findings

- **Acute/sub-acute symptom burden**
 - Associated with worse outcome
 - Of all possible modifiers, it was the most consistently associated with worse outcome.
- **Acute/Subacute Post-injury Headaches**
 - Almost all studies suggest worse outcome.

Treatment & Rehabilitation

For those with persistent symptoms

Guidelines for Concussion / Mild Traumatic Brain Injury & Persistent Symptoms

Second Edition

For adults (18+ years of age)



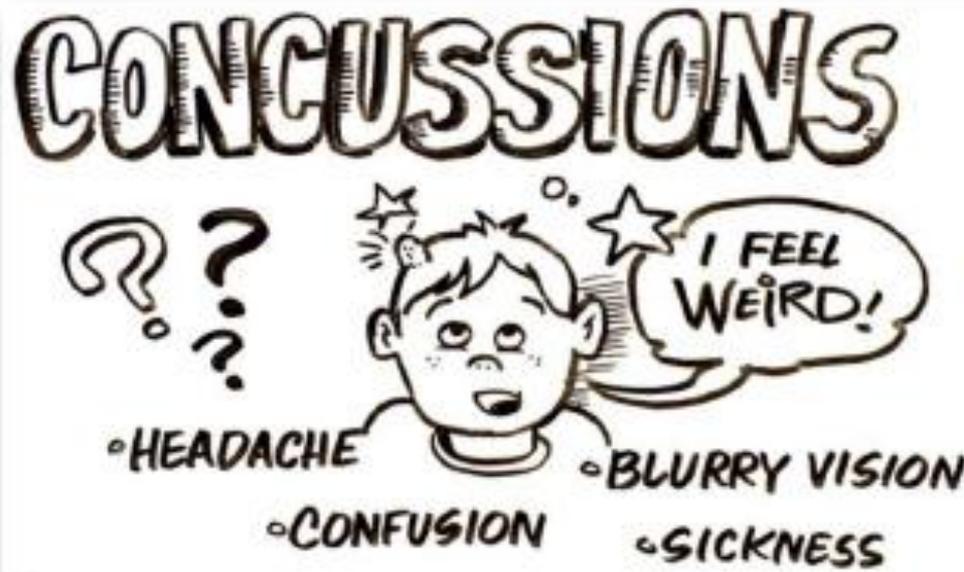
Complete Version



Ontario Neurotrauma Foundation
Fondation ontarienne de neurotraumatologie

Guidelines for Diagnosing and Managing Pediatric Concussion

First edition, June 2014



Basic Principles: Initial Weeks Following Injury

(and sometimes months following injury)

- Focused, Evidence-Based Treatment for Specific Symptoms and Problems
 - Medications
 - Physical Therapy
 - Vestibular Rehabilitation
 - Exercise
 - Psychological Treatment

Exercise as Treatment

- Exercise facilitates molecular markers of neuroplasticity and promotes neurogenesis in the healthy rodent brain and the injured brain.
- Associated with changes in neurotransmitter systems (Chaouloff, 1989; Molteni, Ying, & Gomez-Pinilla, 2002).

Exercise

- Improved mood and lower stress
(Callaghan, 2004; Conn, 2010)
- Improved sleep quality (Youngstedt, 2005)
- Positive effects on self-esteem
(Ekeland, Heian, Hagen, Abbott, & Nordheim, 2004)

Exercise

- Effective treatment, or adjunctive treatment, for mild forms of anxiety and depression (Daley, 2008; Mead et al., 2009; Rethorst, Wipfli, & Landers, 2009)
- Associated with reduced pain and disability in patients with chronic low back pain (Bell & Burnett, 2009; Henchoz & Kai-Lik So, 2008)
- Regular long-term aerobic exercise reduces migraine frequency, severity, and duration (Koseoglu, Akboyraz, Soyuer, & Ersoy, 2003; Lockett & Campbell, 1992)

Research on Exercise for MTBI

- Several small studies suggest exercise training is helpful for persistent symptoms in adolescents and adults

When should we stop resting and begin active rehabilitation?

From Mild Traumatic Brain Injury in Children and Adolescents: From Basic Science to Clinical Management.
Edited by Michael W. Kirkwood and Keith Owen Yeates. Copyright 2012 by The Guilford Press. All rights reserved.



Active Rehabilitation for Slow-to-Recover Children

Grant L. Iverson, Isabelle Gagnon, and Grace S. Griesbach

Active rehabilitation for children who are slow to recover following sport-related concussion

ISABELLE GAGNON^{1,2}, CARLO GALLI¹, DEBBIE FRIEDMAN¹, LISA GRILLI¹, & GRANT L. IVERSON³

¹*Montreal Children's Hospital, Montreal, Canada,* ²*McGill University, Montreal, Canada,* and ³*University of British Columbia and British Columbia Mental Health & Addiction Services, Vancouver, Canada*

Active Rehab for Slow-to-Recover Children

- Montreal Children's Hospital (since 2007)
- Implemented after one month post injury
- For this group, significant lifestyle restrictions, including avoiding physical activity, can actually contribute to symptom maintenance over time.
- The longer a child (or adult) has symptoms, the more likely it is that other factors that are separate from or only partially related to the neurobiology of the original injury are causing or maintaining the symptoms.

Gagnon, Galli, Friedman, and Iverson (2009)

Submaximal Aerobic Exercises

60% max capacity

Treadmill or stationary bicycle

Up to 15 min or stop if symptoms increase

Home Program

Same Activities,

Same intensity

For 1 week

Coordination exercises

Sport related, footwork or ball activities

Up to 10 min or stop if symptoms increase

(Later stages: anaerobic activities)

First Study

- All 16 of the children and adolescents who participated in the program experienced a relatively rapid recovery and returned to their normal lifestyles and sport participation.

Gagnon et al. 2009

Second Study

Scand J Med Sci Sports 2015; **••**: ••–••
doi: 10.1111/sms.12441

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MEDICINE & SCIENCE
IN SPORTS

A pilot study of active rehabilitation for adolescents who are slow to recover from sport-related concussion

I. Gagnon^{1,2,3}, L. Grilli², D. Friedman^{2,3,4}, G. L. Iverson^{5,6,7,8}

Second Study: Slow to Recover Adolescents (sport-related concussions)

- Gagnon et al. (2015)
- 10 adolescents who were symptomatic for more than 1 month post injury
- Duration of rehab: 2-15 weeks
- All 10 experienced improvement in symptoms and functioning during the course of treatment, achieved asymptomatic status, and returned to full activity participation (including sports).

Recently Published Small Randomized Clinical Trial (Kurowski et al., 2016)

- Participants: 30 adolescents with persistent symptoms from between 4 and 16 weeks.
- Design: Partially blinded, pilot RCT of subsymptom exacerbation aerobic training compared with a full-body stretching program. At least 6 weeks of treatment.
- Results: There was a greater rate of improvement in the subsymptom exacerbation aerobic training group than in the full-body stretching group.
- Conclusion: Subsymptom exacerbation aerobic training is potentially beneficial for adolescents with persistent symptoms after an MTBI.

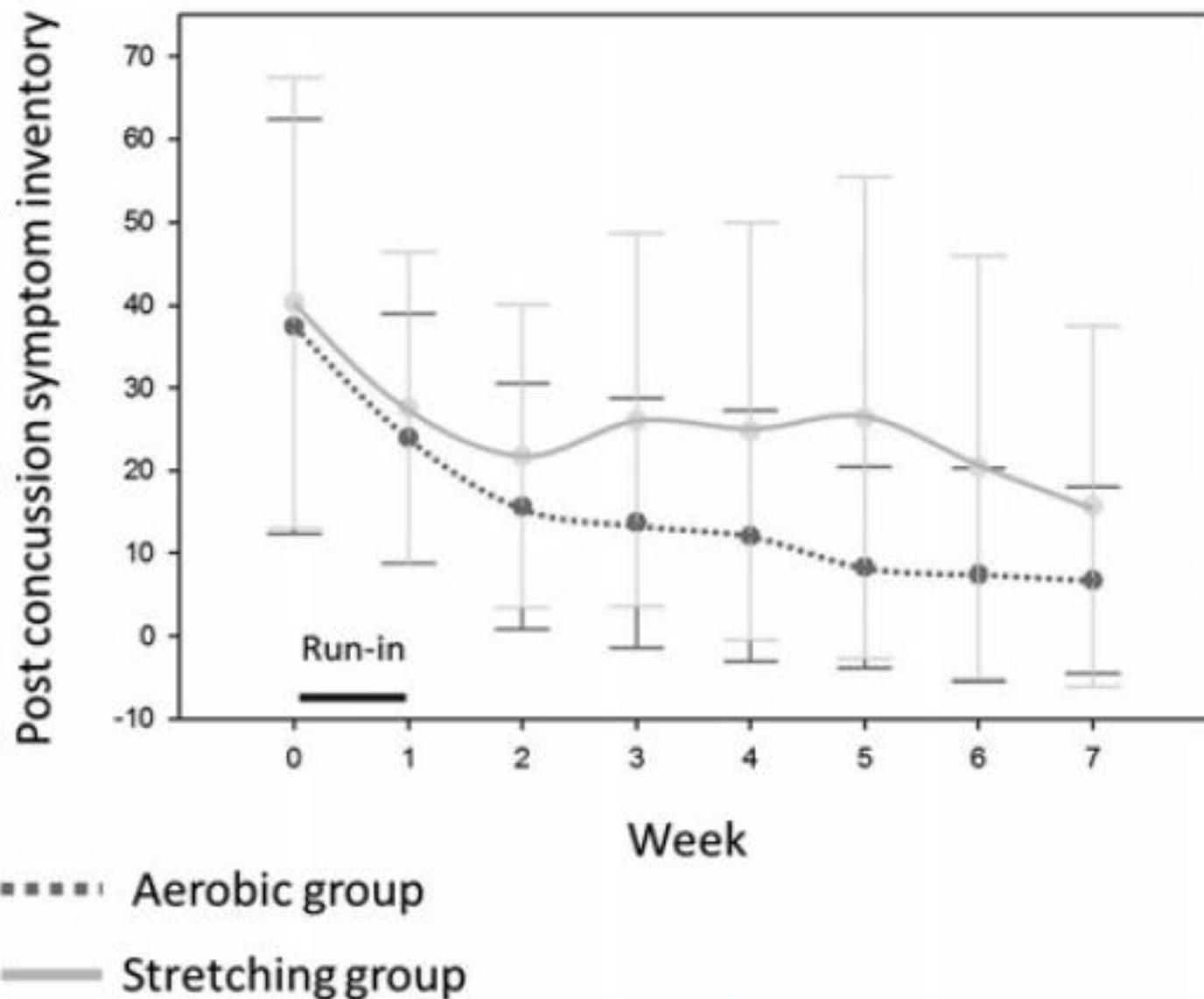


Figure 3. Trajectory of self-reported Post-Concussion Symptom Inventory ratings. Means and standard deviations (represented by error bars) are reported for each weekly visit.

What does the 2012 Zurich Consensus Statement say?

- “Low-level exercise for those who are slow to recover may be of benefit, although the optimal timing following injury for initiation of this treatment is currently unknown” (McCrory et al., 2013)

Conclusions

- Acute Symptoms: can be mild, moderate, or severe
- Recovery Time: 1-30 Days
- Time-Limited Rest (avoid prolonged rest and activity restrictions)
- Concussion-like symptoms can be influenced by a variety of factors
- Consider Active Rehabilitation for those with Persistent Symptoms