The Physiology of Concussion

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First Consensus Conference on Concussion (Vienna 2001)
Guidelines for return to play
1. No activity
2. Light aerobic exercise
3. Sport-specific exercise
4. Non-contact training drills
5. Full contact practice
6. Return to play

Definition of concussion:
A complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces

Consensus Guidelines
If there is symptom exacerbation at any step return to the previous step.

Return to play when the athlete can exercise fully without exacerbation of symptoms
Established An Evidence Based Concussion Clinic

- Systematize the return to play process (using a treadmill and careful monitoring of symptoms)
- Proposed exercise below the level of symptom exacerbation... even before athlete is asymptomatic

Management of Concussion and Post-Concussion Syndrome

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

From Systematic Assessment to Treatment

- Pilot study used subjects as their own controls
- But why would exercise help recovery?

Neurometabolic Cascade Following Cerebral Concussion/MTBI

A Preliminary Study of Subthreshold Threshold Exercise Training for Reducing Post-Concussion Syndrome

Cerebral Blood Flow

The Neurometabolic Cascade of Concussion

K+

Glutamate

Glucose

Calcium

% of normal

0 10 200 300 400 500

0 2 6 12 20 30 45 60 120

minutes hours days
Physiological Findings in Humans with Concussion

- Decreased CBF at rest
- Higher resting HR at rest
- Decreased HRV at rest

Suggests "sympathetic overdrive"

Cardiovascular performance during exercise

PCS versus Resolved

Heart Rate

Perceived Exertion

Autonomic Nervous System Dysfunction

Difficulty isn’t being locked in sympathetic drive or parasympathetic drive but rather, difficulty switching from one drive to the other.

Thus, HR is elevated during rest but decreased during exercise.

What the patient experiences is fatigue and sleep difficulty.
Altered cerebral blood flow during exercise

CBF during exercise is increased (and associated with symptom exacerbation)
CO₂ Sensitivity reduced

END RESULT IS EXERCISE INTOLERANCE

Functional Imaging Study

- Purpose: To compare subjects with PCS and normal Ss on brain activation patterns during a simple math test
- To compare Ss with PCS who received an exercise based program for recovery and a sham (stretching program)

fMRI
PCS vs Normal (Recovered)

(Patton et al 2013)
Does Exercise Treatment Work For Everyone?

- 4/4 exercise treated subjects had symptom resolution v. stretching placebo control (Leddy et al. 2013)
- 77% of P-PCD (n=65) treated with aerobic exercise returned to full sport or work (Baker et al. Rehabilitation Research and Practice 2012)
- *5 of 6 who refused to exercise did not return to full function

Diffusion Tensor Imaging

- When we compared the PCS group with the control group using DTI, the PCS group had more issues with white matter at the beginning and after treatment.

Diagnosis using SIGNS

- Patients who have exercise intolerance (and orthostatic imbalance) have PCS
- Patients who do not have exacerbation of symptoms may have one or more other conditions but not PCS (mTBI)
Diagnosis of Concussion and PCS

- Concussion: 60%
- PCS: 20%
- CVA: 55%
- Anxiety: 5%
- Migraine: 5%

Diagnoses

Safety Study
- Assessed 54 adolescents with 27 randomly assigned to receive the BCIT acutely (~ 4 days)
- Tested 2 weeks later
- No negative effect of early (acute) testing
- 48/54 of Ss recovered within 5 weeks

Treadmill Test Results Predict Recovery Rate

- 13
- 98