Module Overview

• Initial Management
  – Education & Reassurance!!
  – Rest? Exercise? Medications?

• Return-to-Learn/Work

• Return-to-Play (Athletes ONLY)
Disclaimer

This protocol is to be used as a **guideline**. This protocol is based on the research that has been done by CCMI, however clinical judgment will prevail and individual practitioners are ultimately responsible for ensuring the best possible management for your patients. CCMI is not responsible for the decisions you make.

Be conservative & **always** err on the side of caution!

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Download Acute Management Algorithm
Diagnosis has been made & Red Flags ruled out

• EDUCATION & REASSURANCE!!
  – One of the best ways to reduce the incidence of persistent symptoms (ONF, 2013)
    • What is a concussion? Your brain is not damaged – temporary
    • What are you likely to experience?
    • What things can you do to improve your outcomes? Sense of control
  – Prognostic Variables:
    • High symptom severity score (also related to anxiety & poor coping skills – increased education & reassurance for these people)
    • Pre-existing mental health status (anxiety & depression)
    • Early removal from play
    • Sex
    • Time from injury to assessment (CCMI data; De la Cour et al., 2019)

Predictors for return to work

• Goal was to predict who would return to work in those that were ‘sick-listed’ at 6 to 8 weeks following injury
• Prospective cohort – 151 patients (median age was 32 years & 61% were men)
  – Injury characteristics were obtained from medical records
  – Sick leave data was obtained from 1 year prior and 1 year after concussion injury
• Logistic regression found the following 4 items to be the strongest negative predictors of returning to work within 1 year:
  – Having been on sick leave in the year preceding the injury (OR=8.48, 95% CI: 2.6-27.9, p<0.001)
  – Being on sick leave at 2 months post-injury (OR= 10.16, 95% CI: 2.6 – 40, p<0.001)
  – Severe or moderate disability at 2 months (Glasgow Outcome Scale Extended (GOSE)) (OR = 1.17)
  – Psychological Distress (Hospital Anxiety & Depression (HAD) score) (OR = 1.16)
• Injury-specific data such as intracranial injury, symptom severity, etc., were not strong predictors!
Return to Learn/Work

- Consensus didn’t discuss RTL much but they included this table

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Graduated return-to-school strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage</td>
<td>Aim</td>
</tr>
<tr>
<td>1</td>
<td>Daily activities at home that do not give the child symptoms</td>
</tr>
<tr>
<td>2</td>
<td>School activities</td>
</tr>
<tr>
<td>3</td>
<td>Return to school part-time</td>
</tr>
<tr>
<td>4</td>
<td>Return to school full time</td>
</tr>
</tbody>
</table>
Return to Play

- Note – removal of absolute rest!

**Table 1** Graduated return-to-sport (RTS) strategy

<table>
<thead>
<tr>
<th>Stage</th>
<th>Aim</th>
<th>Activity</th>
<th>Goal of each step</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Symptom-limited activity</td>
<td>Daily activities that do not provoke symptoms</td>
<td>Gradual reintroduction of work/school activities</td>
</tr>
<tr>
<td>2</td>
<td>Light aerobic exercise</td>
<td>Walking or stationary cycling at slow to medium pace. No resistance training</td>
<td>Increase heart rate</td>
</tr>
<tr>
<td>3</td>
<td>Sport-specific exercise</td>
<td>Running or skating drills. No head impact activities</td>
<td>Add movement</td>
</tr>
<tr>
<td>4</td>
<td>Non-contact training drills</td>
<td>Harder training drills, eg, passing drills. May start progressive resistance training</td>
<td>Exercise, coordination and increased thinking</td>
</tr>
<tr>
<td>5</td>
<td>Full contact practice</td>
<td>Following medical clearance, participate in normal training activities</td>
<td>Restore confidence and assess functional skills by coaching staff</td>
</tr>
<tr>
<td>6</td>
<td>Return to sport</td>
<td>Normal game play</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** An initial period of 24–48 hours of both relative physical rest and cognitive rest is recommended before beginning the RTS progression. There should be at least 24 hours (or longer) for each step of the progression. If any symptoms worsen during exercise, the athlete should go back to the previous step. Resistance training should be added only in the later stages (stage 3 or 4 at the earliest). If symptoms are persistent (eg, more than 10–14 days in adults or more than 1 month in children), the athlete should be referred to a healthcare professional who is an expert in the management of concussion.

“Children and adolescents should not return to sport until they have successfully returned to school...” – Davis et al., 2017
CCMI Return to Learn/Work/Sport Protocols

<table>
<thead>
<tr>
<th>Stage</th>
<th>Return to Learn/Work</th>
<th>Stage</th>
<th>Return to Sport/Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Symptom-limited Cognitive activity (eg., light reading, TV, etc. – provided no increase in symptoms) – also encourage plenty of rest - “take it easy for a day or two – but don’t just lie in bed all day” – 2-3 days MAX</td>
<td>1.</td>
<td>Symptom-limited physical activity (eg., encourage light daily walks, and household chores that do not provoke symptoms to a significant degree or place you at risk for hitting your head)</td>
</tr>
<tr>
<td>2.</td>
<td>Light Cognitive Activity (increase cognitive load) – encourage homework and working from home – emails, phone calls, assignments, etc. – once able to tolerate 45 mins-1hr with minimal increase in symptoms, move on to stage 3</td>
<td>2.</td>
<td>Light Physical Activity – Buffalo Concussion Treadmill Test (BCTT) - if it’s been any more than 5 to 7 days since the injury – it’s time to find a threshold and start a subsymptom threshold exercise program – can speed recovery vs. rest alone – get them moving Pass = Move on to Stage 3, Fail = Subsymptom program, re-test in 1 wk</td>
</tr>
<tr>
<td>3.</td>
<td>% days of school/work – with restrictions: No tests, no gym, no recess, no (added) homework (or at least loose deadlines to reduce pressure)</td>
<td>3.</td>
<td>Sport-Specific activity – i.e., light, non-contact practice with the team or individually</td>
</tr>
<tr>
<td>4.</td>
<td>Full Days of School/work – with restrictions: same restrictions as above – once able to tolerate full days with no increase in symptoms, gradually lift restrictions</td>
<td>4.</td>
<td>Non-Contact Training drills – higher intensity, non-contact practice with team – can begin resistance training – start pushing yourself</td>
</tr>
<tr>
<td>5.</td>
<td>Full Days of School/work – no restrictions - (Discharge non-athletes)</td>
<td>5.</td>
<td>Medical Clearance – Once completely ASYMPTOMATIC and back to full time school/work with no issues, &amp; no increased symptoms with physical activity/practices – Blackhawks test (if a high-risk/contact athlete) &amp; comprehensive baseline re-test (if available) in exerted state</td>
</tr>
<tr>
<td>6.</td>
<td>Full Return to Contact/Discharge – should have at least 1 full contact practice prior to playing in a game</td>
<td></td>
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</tbody>
</table>

### Aren’t I supposed to REST?

- Rest is one of the most widely implemented interventions for concussion...STILL!
- Rationale for rest is 3 parts (DiFazio et al., 2015):
  - Brain is in a state of neurometabolic crisis
  - A second injury during recovery can result in magnified pathophysiological and behavioural deficits
  - Animals exercising too soon show down-regulation of neuroplasticity biomarkers (BDNF etc.)
- Limited evidence to support its effectiveness
  - Johnson et al., 2016 – critical appraisal
- Pediatric patients randomized to have 5 days rest following injury had worse outcome (higher symptom scores and prolonged recovery) than those only having 1-2 days rest
  - Thomas et al., 2015
- Adolescents who did not adhere to physician recommendations for “rest” recovered faster than patients who were adherent
  - Moor et al., 2015
- “Advice to rest for more than 2 days after mTBI is associated with delayed return to productivity” (Work/school)
  - Silverberg et al., 2019
  - “this study supports growing evidence that prolonged rest after mTBI is generally unhelpful”
Rest: more harm than good?

• Possible Harmful Effects of Rest:
  1. Anxiety, expectations, and the Nocebo Effect
     - being told to stay at home and that a text message can damage your brain is quite alarming to patients!
     - the “nocebo” effect (the causation of sickness by the expectations of sickness) – need to reassure patients that they will be ok.
  2. Depression and other psychological complications
     - removal from normal life after injury can have significant psychological effects (depression)
  3. Physical Deconditioning
     - bed rest results in physiologic alterations in as little as 2-3 days

DiFazio et al., 2015

Rest

“There is currently insufficient evidence that prescribing complete rest achieves these objectives. After a brief period of rest during the acute phase (24-48 hours) after injury, patients can be encouraged to become gradually and progressively more active while staying below their cognitive and physical symptom-exacerbation thresholds (ie, activity level should not bring on or worsen their symptoms).”

McCrory et al., 2017
OK…How about exercise?

- Grool et al., 2016
  - Found that early participation in physical activity (within 7 days of injury) was associated with lower risk of persistent concussion symptoms (>28 days), compared to those that engaged in no physical activity (n=3063 ages 5-18)
  - Limitation – self-selection (observational)
- Lawrence et al., 2018
  - “For each successive day in the delay to the initiation of aerobic exercise, individuals had a less favourable recovery trajectory”
    - Faster return to school and sports
    - Example: Compared to initiating exercise on day 1, exercise initiated on day 3 had a 36.4% reduced probability of faster return to sport; starting on day 5 had a 59.5% reduced probability and starting day 7 resulted in a 73.2% reduced probability, and starting at day 14 was associated with a 88.9% reduced probability of faster recovery!
  - Limitation – Self-selection (observational)

A preliminary study of the effect of early aerobic exercise treatment for sport-related concussion in males

- The purpose of the study was to compare early subthreshold aerobic exercise with prescribed rest on days to recovery from a concussion.
- The study compared two cohorts of adolescent males who sustained acute sport-related concussion:
  1. Rest group (n=24) - Instructed to rest (no participation in physical activities, sports or gym class) but instructed to advance daily cognitive activities according to symptom tolerance.
  2. Exercise group (n=30) - Provided an individualized subthreshold exercise prescription based on Buffalo Concussion Treadmill Test performance (i.e. 80% of HR achieved at symptom exacerbation on the BTT)
- Exercise group is from an ongoing RCT that began in 2016.
- All athletes presented to a University Concussion Management Clinic less than 10 days from injury and were diagnosed with a concussion by a sport medicine physician based on international guidelines.

<table>
<thead>
<tr>
<th>Exercise Group – days to recover</th>
<th>Rest Group – days to recover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recovery time since initial visit (d)</td>
<td>8.23 ± 3.85</td>
</tr>
<tr>
<td>Total recovery time (d)</td>
<td>13.04 ± 4.83</td>
</tr>
<tr>
<td>Total symptoms (% not recovered by 14 d)</td>
<td>8% (2/24)</td>
</tr>
<tr>
<td>Physical symptoms (% not recovered by 14 d)</td>
<td>8% (2/24)</td>
</tr>
<tr>
<td>Cognitive symptoms (% not recovered by 14 d)</td>
<td>4.2% (1/24)</td>
</tr>
<tr>
<td>Sleep symptoms (% not recovered by 14 d)</td>
<td>0% (0/24)</td>
</tr>
<tr>
<td>Affective symptoms (% not recovered by 14 d)</td>
<td>8% (2/24)</td>
</tr>
<tr>
<td>Delayed recovery (recovery &gt; 35 d)</td>
<td>0% (0/24)</td>
</tr>
</tbody>
</table>

More and more research is pointing towards early physical activity, prior to 10 days, to speed recovery.
Early subthreshold aerobic exercise for sport-related concussion: A randomized clinical trial

Leddy et al., 2019

First RCT published on the effect of sub-symptom threshold exercise in the ACUTE phase, compared to placebo, on recovery time.

Athletes (13-18 yoa) presented within 10 days of sustaining a sport-related concussion.

Initial assessment consisted of history, cognitive evaluation, symptom questionnaire, physical assessment, and exercise tolerance on the Buffalo Concussion Treadmill Test.

Participants who failed the BCTT were randomly divided into two treatment interventions:

1. **Group 1: Aerobic exercise group (n=52)** – Told to aerobically exercise for 20 minutes/day on bike, treadmill, or walking at 80% of HR achieved at symptom exacerbation on the BCTT at the first visit. They were provided with Polar H7 HR monitor to track HR. They were instructed to stop exercise if symptoms increased by 2 or more points (on a 10 point VAS) or at 20 minutes. A new target HR was determined by weekly BCTT retesting for as long as they were exercise intolerant or until 30 days post-injury.

2. **Group 2: Stretching Group (n=51)** – Instructed to follow a prescribed stretching program, which was advanced each week for 20 minutes per day, that would not considerably elevate HR. They were provided with Polar H7 HR monitor to ensure HR was low while performing the stretches. The stretching group performed repeat BCTT at each weekly clinic visit.

Both groups were given instructions to rest, when not doing exercise, which included limiting activities that exacerbate symptoms.

The primary outcome measure was days to recovery since date of injury:

- Recovery was defined as symptom resolution to normal (ie. normal physical exam including VOMS) and ability to exercise without exacerbation of symptoms on BCTT.
- Symptom resolution was defined as 7 points or fewer on the PCSS for 3 consecutive days (first of the 3 days was taken as date of recovery).
- Treating physicians were blinded to group allocation.

Results

Leddy et al., 2019

103 participants sustained a sport-related concussion and were included for the study.

- Exercise group (n=52) were seen a mean of 4.9 days following injury.
- Stretching group (n=51) were seen a mean of 4.8 days following injury.

The two groups did not differ significantly in age, sex, previous concussion hx, time since injury, initial symptom severity score, or initial BCTT results.

Aerobic exercise group recovered in a median of 13 days from injury, whereas the stretching group recovered in 17 days from injury, which was statistically significant.

Those with delayed recovery (<30 days) were higher in the stretching than exercise group, but was not significant.

The total symptom score decreased more rapidly in the exercise group, but was not significant.

There were no adverse effects of the early sub-symptom threshold exercise.

*This is the first study to show that individualized sub-symptom threshold aerobic exercise prescribed during the first week after a sport-related concussion safely speeds recovery.*
The effects of early physical activity compared to early physical rest on concussion symptoms – Systematic Review

- Five studies were included for review – one RCT, two prospective cohort and one retrospective cohort study.

Summary of best evidence
- During the first 10 days following a concussion, engaging in early physical activity was beneficial in reducing post-concussion symptom and those with strict rest resulted in significantly longer symptom duration.
- Strict physical rest demonstrated higher neurocognitive and balance assessments within 24 hours of injury but were non-significant at one week post injury. Normalization of neurocognitive and balance test occurred at 1-2 weeks post-injury regardless of cognitive or physical rest.

Clinical Bottom line

“The current literature suggests that early physical activity in the acute phase (0-7 days) following a concussion may decrease the time needed for a symptom resolution compared to strict rest”

- Level 3 evidence – not very strong

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The association between moderate and vigorous physical activity and time to medical clearance to return to play following sport-related concussion in youth ice-hockey players

**Lishchynsky et al., 2019**

**Objective**

The objective of this study was to determine if youth ice-hockey players who perform more moderate and vigorous physical activity (MVPA) during recovery take longer to achieve medical clearance to return to play (RTP).

**Design**

Cohort study.

**Setting**

Sport Medicine Centre, Alberta, Canada.

**Participants**

Thirty youth ice-hockey players (25 males, 5 females, median age 14 years [range 12-17]) presenting to a sport medicine clinic within 4 days (range 2-10 days) of sustaining a sport-related concussion diagnosed by a sport medicine physician. Exposure Participants MVPA during the first three days following their initial appointment was measured using a wrist-worn Actigraph accelerometer. MVPA was dichotomized into high (≥45 minutes) and low (<45 minutes) activity based on the median daily MVPA.

**Outcome**

The primary outcome was time to medical clearance to RTP.

**Results**

All thirty participants performed at least some MVPA over the first three days, despite physician instruction to initially rest following the concussion. Players performing low levels of MVPA reached medical clearance in a median of 15 days (range: 10–30 days). Players performing high levels of MVPA reached medical clearance in a median of 19 days (range: 12–55 days). The low level MVPA group reached medical clearance significantly sooner than the high activity group (log-rank chi²=5.27, p=0.02).

**Conclusions**

More time in MVPA during the first three days after initial assessment is significantly associated with greater time to medical clearance to RTP. Future research is needed to better understand the optimal amount and timing of MVPA for concussion recovery.
CCMI Recommendation on Exercise

- Encourage light to moderate physical activity each day in the very acute phase (Day 0-5), provided it:
  - Does not exacerbate symptoms
  - Does not put you at risk for hitting your head
- I tend to stick more towards the “light” at this point in time (walking vs. running)
- Emerging Trend: I think as the research evolves, we will soon be putting people on the BCTT on day one and starting them on a specific exercise program
  - BCTT results may serve as a prognostic indicator for recovery in early/acute stages too (Orr et al., 2018)

Ok...Can I drive?

- “Teen drivers with mTBI experience poorer driving performance especially in conditions of increased cognitive load” (Driving simulator)
  - Newton et al., 2018
- “There is evidence to suggest that restriction from driving for the first 24 to 48 hours after mTBI is reasonable.”
  - Christensen et al., 2019
- No established “return to driving” protocol
  - CCMI Thoughts:
    - Stage 1 – Riding in car as passenger (no dizziness) – for at least first 48hrs
    - Stage 2 – Driving around neighbourhood with a passenger
    - Stage 3 – Driving on highways with a passenger
    - Stage 4 – Driving around neighbourhood alone
    - Stage 5 – Full Driving alone
Medications?

- Current guidelines and evidence suggest that there is not sufficient evidence to support the use of pharmacotherapy for concussion symptoms. Furthermore, medications may mask the signs of a worsening condition and many contribute to rebound headaches and side-effects which appear very similar to concussion symptoms which may cloud the diagnostic picture.

Recovery Dashboard
Give athletes the best chance for a speedy recovery!

Athlete’s Personal Dashboard
- View recovery timeline
- Specific information provided at each stage of recovery
- Track symptoms
- Send progress updates
- View recovery diet plans
- Access recovery tips
- Communicate with treating healthcare providers

Symptom Tracking
Easy-to-use interface allows players and coaches to send symptom updates to treating healthcare providers
Track Recovery Progress

*Step-by-step recovery protocols help keep you informed and athletes safe!*

Track your players recovery every step of the way

- What stage of recovery are they on?
- Are they allowed to practice or compete?
- What are they allowed to do at practice?
  - Includes recommended drills and restrictions at each stage
- What to watch for as a coach and parent?
- How is the athlete progressing?
- How long is the recovery process?
- Have they received proper clearance to return to play?

**RETURN TO LEARN / WORK / PLAY**

<table>
<thead>
<tr>
<th>Symptom-limited Activity (Home)</th>
<th>Light Cognitive Activity</th>
<th>½ Day School/Work (Restrictions)</th>
<th>Full Day School/Work (Restrictions)</th>
<th>Light Physical Activity</th>
<th>Sport Specific Activity (Restrictions)</th>
<th>Non-Contact Training Drills (P Complex)</th>
<th>Chicago Blackhawks Test (+ Baseline)</th>
<th>Full Practice</th>
<th>Game Play</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
</tr>
</tbody>
</table>

2-3 days max

Buffalo Treadmill Test

Exertion Test

Return to Play

Each stage must be separated by at least 24 hours. If symptoms occur at any one stage, athlete must return to previous stage.
Stage 1

• Moderate, symptom-limited physical and cognitive rest (2-3 days max!!)
  – Light to moderate physical activity (I stick with light), screens ok, cognitive activity ok
    • Rule of thumb: do whatever doesn’t provoke your symptoms too much and DO NOT do anything which places you at risk of hitting your head
  – Do not drive at all for first 48 hrs (Schmidt et al., 2016; Newton et al., 2018; Christensen et al., 2019)
  – Advise to maintain C/S ROM – Concussion & WAD happen together
    • Can I manipulate – Not yet! Possible worsening of blood flow impairments (wait at least 10 days)
    • Can begin c-spine rehab and soft-tissue work
  – Dark room/sunglasses not necessary! If done for too long, can create prolonged sensitivity to light (sunglasses outside and if absolutely needed for comfort)
    • Sensory symptoms (light & noise) may be due to hyperactivity of the thalamus (Sensory processing and integration centre) – Sours et al., 2015
  – Provide athlete information package & diet plan – App
    • Acute inflammation can drive chronic symptoms (Collins-Praino et al., 2018) – need to be diligent on this
    – Write a letter to athlete’s physician – Template on resource portal!
    – Complete Academic/work accommodation letter if necessary – on resource portal!
  – Once asymptomatic for at least 24 hours, move on to stage 2

Other considerations for stage 1

• Vision - Master et al., 2014
  – 69% of pediatric concussion patients have visual or oculomotor issues following concussion
    • Accommodation (51%), Convergence (49%), Saccades (29%)
  – Possible reason for including oculomotor rehab early?
• Heart Rate Variability & Autonomic Dysfunction
  – Concussion = ↓ HRV
    • Sympathetic overload = constantly ↑ HR
  – Optimal HRV → improved neurocog, visual acuity, focus, concentration, executive function
    • ↓ HRV → marker of generalized anxiety, PTSD
  – Can be modified through diet, exercise, & breathing exercises
    • In addition to prescribing light to moderate daily exercise, can include breathing exercises
    – Breathing between 4.5 to 6.5 times per minute has been found to produce greatest HRV in people
• Sleep Hygiene Handout (Resources Portal)
  – 45% of adolescents have sleep difficulties (trouble falling asleep) in the first 10 days after concussion – correlated with greater symptom burden (Howell et al., 2019)
Summary of First Visit

- History & Symptom Score
- Rule out more sinister pathology (Neuro exam)
- Education & Reassurance
  - What a concussion is (not brain damage), expected recovery, etc
  - Return to school, work & play process
- POM:
  - Daily light exercise & cognitive activities that doesn't provoke symptoms – increase gradually to tolerance
  - C-spine ROM exercises
  - Diet plan – strongly encourage this for first few weeks after injury
  - Don’t drive yet – can give RTD protocol
  - No dark room – use sunglasses as you normally would (avoid indoors)
  - Consider: Breathing/vision exercises, use sleep hygiene handout
- Write a letter to patient’s physician – co-management!
- Provide academic and work accommodations
- Rebook for 1 week from now (treadmill test)

Rest and treatment/rehabilitation following sport-related concussion: a systematic review

Kathryn J Schneider,1 John J Leddy,2 Kevin M Guskiewicz,3 Tad Seifert,4 Michael McCrea,5 Noah D Silverberg,6 Nina Feddermann-Demont,7,8 Grant L Iverson,9 Alix Hayden,10 Michael Makdissi11,12

ABSTRACT
Aim or objective The objective of this systematic review was to evaluate the evidence regarding rest and active treatment/rehabilitation following sport-related concussion (SRC).

Design Systematic review.

Data sources MEDLINE (OVID), CINAHL (Ebscohost), Psycinfo (OVID), Cochrane Central Register of Controlled Trials (OVID), SPORTdiscus (Ebscohost), EMBASE (OVID) and Proquest Dissertations and Theses Global (Proquest) were searched systematically.

Eligibility criteria for selecting studies Studies were included if they met the following criteria: (1) original research; (2) reported SRC as the diagnosis; and (3) evaluated the effect of rest or active treatment/rehabilitation. Review articles were excluded.

Results Twenty-eight studies met the inclusion criteria (9 regarding the effects of rest and 19 evaluating active treatment). The methodological quality of the literature was limited; only five randomised controlled trials (RCTs) met the eligibility criteria. Those RCTs included rest, conical and vestibular rehabilitation, sub symptom threshold aerobic exercise and multifaceted collaborative care.

Summary/conclusions A brief period (24–48 hours) of cognitive and physical rest is appropriate for most patients. Following this, patients should be encouraged to gradually increase activity. The exact amount and duration of rest are not yet well defined and require further investigation. The data support interventions including cervical and vestibular rehabilitation and multifaceted collaborative care. Closely monitored sub symptom threshold, submaximal exercise may be of benefit.
Stage 2

- Light cognitive activity
  - Increase cognitive load
  - Reading, watching TV, doing homework
  - If symptoms increase, then take a break and try again once symptoms subside
  - If able to tolerate 45 mins of activity with no increase in symptoms - the following day they can progress to stage 3
Return to School

“A balance must be struck between cognitive rest, post-concussive symptoms and the return to school following concussion. Returning to the school environment and resuming classwork too early may not be tolerated and may even worsen some postconcussion symptoms; yet, excessive activity restriction and postponement of the return process can have a negative effect on recovery caused by anxiety and depression from loss of academic standing, inactivity and social isolation. Once cognitive activities are tolerated for at least 30–45 min at home, we and others encourage attempts at school return, even though the child may not be ready to learn. Addressing symptom triggers, attending partial school days and allowing periods of rest while at school can help during this important transition period.”

Rose et al., 2015

Return to Learn / Work / Play

Each stage must be separated by at least 24 hours. If symptoms occur at any one stage, athlete must return to previous stage.
Stage 3

- ½ day of school (or work)
  - Either morning or afternoon
  - No tests, no homework, no gym, no recess
    - Can provide specific academic accommodations (next slide)
    - No manual labour or heavy equipment at work (power tools, saws, etc)
  - Even if they are good by noon, they must still go home
  - If any symptoms arise while at school/work or shortly after, then they should drop back to stage 2 (light cognitive activity/working from home)
  - If no symptoms during school/work, or later in the day, then they can progress to stage 4 the next day
  - May initiate return to driving provided symptoms have resolved
    - Return to driving should be step-wise as well (i.e., passenger → short trips around home → longer trips with passenger → driving alone)

American Medical Society for Sports Medicine position statement on concussion in sport

<table>
<thead>
<tr>
<th>Table 4 Return to learn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilitate communication and transition back to school.</td>
</tr>
<tr>
<td>▶ Notify school personnel after injury to prepare for return to school.</td>
</tr>
<tr>
<td>▶ Obtain consent for communication between medical and school teams.</td>
</tr>
<tr>
<td>▶ Designate point person to monitor the student’s status related to academics, recovery and coping with injury, and communicate with medical team.</td>
</tr>
<tr>
<td>▶ School health professional, guidance counselor, administrator, athletic trainer.</td>
</tr>
<tr>
<td>▶ Develop plan for missed assignments and exams.</td>
</tr>
<tr>
<td>▶ Adjust schedule to accommodate reduced or modified attendance if needed.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Classroom adjustments</th>
</tr>
</thead>
<tbody>
<tr>
<td>▶ Breaks as needed during school day.</td>
</tr>
<tr>
<td>▶ Reduce in-class assignments and homework.</td>
</tr>
<tr>
<td>▶ Allow increased time for completion of assignments and testing.</td>
</tr>
<tr>
<td>▶ Delay exams until student is adequately prepared and symptoms do not interfere with testing.</td>
</tr>
<tr>
<td>▶ Allow testing in a separate, distraction-free environment.</td>
</tr>
<tr>
<td>▶ Modify due dates or requirements for major projects.</td>
</tr>
<tr>
<td>▶ Provide preprinted notes or allow peer notetaker.</td>
</tr>
<tr>
<td>▶ Avoid high-risk or strenuous physical activity.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>School environment adjustments</th>
</tr>
</thead>
<tbody>
<tr>
<td>▶ Allow use of headphones/ear plugs to reduce noise sensitivity.</td>
</tr>
<tr>
<td>▶ Allow use of sunglasses to reduce light sensitivity.</td>
</tr>
<tr>
<td>▶ Limit use of electronic screens or adjust screen settings, including font size, as needed.</td>
</tr>
<tr>
<td>▶ Allow student to leave class early to avoid crowded hallways.</td>
</tr>
<tr>
<td>▶ Avoid busy, crowded or noisy environments—music room, hallways, lunch room, vocational classes, assemblies.</td>
</tr>
</tbody>
</table>

Clinicians should individualize adjustments based on patient-specific symptoms, symptom severity, academic demands, as well as pre-existing conditions, such as mood disorder, learning disability or attention deficit/hyperactivity disorder.

Athletes with complicated or prolonged recover may require a multidisciplinary team with specific expertise across the scope of concussion management.
Academic outcomes following adolescent sport-related concussion or fracture injury: a prospective cohort study

- Prospective cohort study to compare effects of adolescent sport-related concussion and sport-related extremity fracture on academic outcomes in school grades and attendance.
  - Secondary objective was to determine which academic accommodations were most helpful during recovery.
- Outcome measures included: change from overall grade pre- and post-injury, change in core subject report card grades, days missed from school, perception of school related accommodations.
  - A 5% drop in grades was considered minimally clinically important difference.
  - Students were given log books and instructed to track their school attendance and present it on their follow-up visit.
- There were 126 sport-related concussions and 77 sport-related fractures included for analysis.
  - There were no differences between the groups on demographics.
- There was no significant difference (pre- to post-injury) in change overall grades or core grades (i.e., English, math, science) in students who sustained a concussion or fracture.
  - No change in grades when stratifying by sex, age, history of previous concussion, and public vs. private school attendance.
- 87.9% of students logged their post-injury attendance with sport-related concussion missing significantly more days (average of 4 full or partial days) compared to fracture group.
- The following accommodations were found to be the most helpful by students:
  - Concussion group: reduced attendance, not participating in gym and communication with teachers
  - Fracture group: not participating in gym and extra time/breaks to complete exams.

Communication is the problem!

Academic accommodations form and/or the CCMI smartphone app solves this problem by keeping everyone in the loop on recovering student-athletes.

Once you update your SOAP notes on the system the app will automatically update what the patient is allowed to do/not allowed to do at that particular stage – there is also a place where teachers, coaches, trainers can provide progress updates and ask questions if need be!
### Return to Learn / Work / Play

<table>
<thead>
<tr>
<th>Stage</th>
<th>Activity</th>
<th>School/Work (Restrictions)</th>
<th>Physical Activity</th>
<th>Sport Activity (Restrictions)</th>
<th>Non-Contact Drills (↑ Complex)</th>
<th>Chicago Blackhawks Test (+ Baseline)</th>
<th>Full Practice</th>
<th>Game Play</th>
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<tbody>
<tr>
<td>1</td>
<td>Symptom-limited Activity (Home)</td>
<td>Light Cognitive Activity</td>
<td>Full Day School/Work</td>
<td>Light Physical Activity</td>
<td>Sport Specific Activity (Restrictions)</td>
<td>Non-Contact Training Drills (↑ Complex)</td>
<td>Chicago Blackhawks Test (+ Baseline)</td>
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</tr>
<tr>
<td>2</td>
<td>2-3 days max</td>
<td>Buffalo Treadmill Test</td>
<td>Exertion Test</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Each stage must be separated by at least 24 hours. If symptoms occur at any one stage, athlete **must return to previous stage**.

### Stage 4

- Full day of school/work – with restrictions
  - No tests, no homework, no gym, no recess
  - Same work restrictions apply
  - Same idea - any symptoms during school day or later on, move back to half days
  - Initiate Return to Driving program if asymptomatic
  - No symptoms – progress to Stage 5
Specific accommodations are soon to be added to the app so that you can make these accommodations through your SOAP notes!

RETURN TO LEARN / WORK / PLAY

Each stage must be separated by at least 24 hours. If symptoms occur at any one stage, athlete must return to previous stage.
Stage 5 (visit 2 → 5-7 days)

- **Buffalo Concussion Treadmill Test**
  - Even if still symptomatic
  - Monitor for symptom exacerbation during
  - Ask parent/patient to look for any symptoms after
  - If Passed, Academic restrictions lifted:
    - No gym still enforced (depending on what they are doing)
    - Can do tests & start catching up with homework
    - Can move to stage 6 - Light, Sport-Specific Activity
    - This will be shown on the athlete, as well as the coaches & trainer's app once selected on your SOAP
    - There is also a sample letter on the Resources Portal
  - If failed, begin exercising at subsymptom threshold level.

Use of graded exercise testing in concussion and return-to-activity management

**Buffalo Concussion Treadmill Test**
- The only functional test shown to diagnose safely and reliably physiological dysfunction in concussion and differentiate it from other diagnoses
- Based on the Balke cardiac treadmill test.

**RTP or RTA guidelines**
- "Using the BCTT, if athlete is able to exercise without symptom exacerbation, then the individual can be deemed to be physiologically recovered and can begin graduated RTP. If symptoms exacerbated, then test stopped before peak exertion and athlete requires more recovery time." – Darling et al., 2014
- Leddy et al., 2017 - Doing treadmill test during ACUTE stages of injury is safe and did not prolong recovery for anyone in their studies
- Popovich et al., 2018 - “Guided sub-symptomatic exercise testing performed in the early stages of a SRC was associated with more rapid symptom resolution, and return to sport”
- Leddy 2019 - “This is the first study to show that individualized sub-symptom threshold aerobic exercise prescribed during the first week after a sport-related concussion safely speeds recovery.”
History of the BCTT

- Mostly in PCS
  - Leddy & Willer started experimenting with subsymptom threshold exercise before 2010 in people with PCS
  - Thoughts were – Rest isn’t working, let’s try exercise
  - Needed to figure out “symptom threshold”
    - Balke treadmill test – cardiac stress test, walking test, safe, gradual increase in HR & BP
  - PCS patients (i.e., symptomatic)
    - Thought was that “concussion” as a physiologic entity should be exercise intolerant
      - If they failed the treadmill test (symptom increase), then the ongoing symptoms were attributed to a “physiologic cause” – cerebral blood flow
      - If they passed the treadmill test (no symptoms), then it was no longer a “concussion” (blood flow issue, autonomic issue, physiologic), but due to something else:
        - Neck issue, vestibular, psychological, visual, migraine, etc.
- Ethical issues of having concussed patients exercise
  - Started with really chronic → worked
  - Less chronic → also worked
  - Gradually worked down and joined by others (Lawrence, Grool, etc.) and now first RCT done to show that it may be effective in very acute patients

History of the BCTT at CCMI

- Chronic state
  - Used to determine cause of persistent symptoms and assign exercise level (threshold)
  - Started out as 3 weeks after injury, then 2, then 10 days...
- Acute state
  - Historically used after symptoms had gone away and the athlete was fully returned to full-time school
  - Once 10 days out, treadmill no matter what
  - Now, 5-7 days, treadmill no matter what! This may start even earlier soon (more research needed)
BUFFALO TREADMILL TEST

Leddy & Willer, 2013

Individuals with known cardiovascular, pulmonary, or metabolic disease; signs and symptoms suggestive of cardiovascular or pulmonary disease; or individuals aged ≥45 years who have more than one risk factor to include:

1) family history of myocardial infarction, coronary revascularization, or sudden death before 55 yr of age;
2) cigarette smoking;
3) hypertension;
4) hypercholesterolemia;
5) impaired fasting glucose;
6) obesity (body mass index >30 kg/m)

Definitions: SBP, systolic blood pressure; DBP, diastolic blood pressure.

BUFFALO TREADMILL TEST

• Open up Buffalo Treadmill test from SOAP notes
• Take a resting heart rate in the room (have patient sit quietly for at least 2 minutes before taking reading)
• Take a resting Borg Scale (RPE) number
• Ask about overall Condition using 0 to 10 point scale (if ≥ 7 forego the test until another day)

Rate Your Overall Condition

0 1-2 3-4 5-6 7-8 9-10
Feel terrific, no symptoms Feel some symptoms but quite tolerable Symptoms a little worse Symptoms much worse Feeling quite symptomatic Feel terrible, worst I ever felt
BUFFALO TREADMILL TEST

- Have Borg Scale and 0-10 overall condition chart on treadmill so patient can easily reference them (also available on database)

- Start treadmill Test
  - 2.5 mph warm-up for 2 mins
  - Start at 3.3 mph for 1 min – after 1st min raise the incline by 1%
  - Record HR, RPE (Borg Scale), & overall condition each minute
  - Continue to raise the incline by 1% at each minute until:
    - Patient cannot continue (i.e., RPE reaches 19 or 20) OR
    - Patient’s HR reaches age adjusted max (220-age) OR
    - Patient reports ANY increase in concussion symptoms (fail) OR
    - Incline of 15 is reached...
**BUFFALO TREADMILL TEST**

- If the patient reaches maximum incline and can still continue, i.e.:
  - Has not reached a Borg Scale rating of 19 or 20
  - Has not reached aged adjusted max HR (220-age)
  - Has not had an increase in any symptoms
  - Then, keeping the incline at 15, increase the speed by 0.4mph for each subsequent minute until the stopping criteria are fulfilled.
- If the patient is reporting increased symptoms → stop the test → record the symptoms that the patient is reporting & HR/Borg scale
  - **Pass (no symptoms)** = Athletes (move on to stage 6), Non-athletes → discharge if asymptomatic
    - If still symptomatic, follow PCS algorithm to continue care
  - **Fail (symptoms)** = go back to full days of school/work w/ restrictions
    - Begin subsymptom threshold exercise program (@ 80% of threshold HR)

---

**Graded aerobic treadmill testing in pediatrics**

**Conclusion**

- Graded aerobic treadmill testing is safe and valuable assessment tool to evaluate and manage pediatric patients with concussions.
Return to Work – Sedentary Job & Non-athletic

Sometimes a combination of in-office and home-based work may be more useful for gradual return to work.

- **Stage 1:** Symptom-limited rest @ home (2-3 days max)
- **Stage 2:** Light Cognitive Activity or Work at Home
  - Work modified hours from home if possible
- **Stage 3:** ½ Days of Work (with restrictions)
  - Allow frequent breaks, reduced screen time if needed
- **Stage 4:** Full Days of Work (restrictions)
  - Same possible restrictions – just add more time in the office
- **Stage 5:** Full Return to Work with No Restrictions
  - Gradually lift restrictions

Return to Work – Physical Job or an Athlete

- **Visit 1**
  - Modify to non-physical duties
  - Allow frequent breaks, reduced screen time if needed
- **Visit 2**
  - Same possible restrictions – just add more time in the office

Combination
RETURN TO LEARN / WORK / PLAY

Each stage must be separated by at least 24 hours. If symptoms occur at any one stage, athlete must return to previous stage.

Asymptomatic non-athletes are now DISCHARGED!

Stage 6

• Sport Specific Activity – Athletes ONLY!
  – Light skating, passing, shooting, running routes
  – Individual drills (specified drills listed for virtually every sport on the app!)
  – No contact or any team-based drills where there could be incidental contact
  – Trainer/coach should let you know how they did (app provides this progress reporting feature)
  – If ok with that, progress to stage 7
Track Recovery Progress

Step-by-step recovery protocols help keep you informed and athletes safe!
Track your players recovery every step of the way

• What stage of recovery are they on?
• Are they allowed to practice or compete?
• What are they allowed to do at practice?
  • Includes recommended drills and restrictions at each stage
• What to watch for as a coach and parent?
• How is the athlete progressing?
• How long is the recovery process?
• Have they received proper clearance to return to play?

RETURN TO LEARN / WORK / PLAY

Each stage must be separated by at least 24 hours.
If symptoms occur at any one stage, athlete must return to previous stage.
Stage 7

- Non-contact training drills
  - Increased intensity/complexity of drills
  - Still individually based w/ no risk of incidental contact
    - Specific drills on app
  - Can begin resistance training
  - Again, coach/trainer should communicate athlete progress (app)
  - If **completely asymptomatic**, → Chicago Blackhawks protocol & Re-testing of baseline (need to book for 1 hr - more for ImPACT testing)
  - If symptomatic, player continues practicing non-contact with team.

**RETURN TO LEARN / WORK / PLAY**

Each stage must be separated by at least 24 hours. If symptoms occur at any one stage, athlete **must return to previous stage**.
Brown et al. (2019) Abstract only

Symptom recovery does not equal clinical recovery!

Physiological impairment persists despite being asymptomatic. Clinical tests of physiological recovery plus the use of baseline test, if available, are the best way to help determine recovery.

Lyng et al. (2019) Abstract only

AGAIN...Symptom recovery does not equal clinical recovery!

Persistent Neurovascular Coupling Dysregulation During Subacute Recovery Phase Following Concussion

Concussion diagnosis is characterized by a lack of objective markers, so there is a paucity of better understanding of the pathophysiology. Neurovascular coupling (NVC), an important factor in cerebral blood flow (CBF) regulation, is a tight temporal relationship between neuronal activity and CBF in order to maintain cerebral homeostasis. PURPOSE: To estimate NVC on Day-3, Day-21, and Day-90 following concussion in comparison to normal, uninjured controls. METHODS: Twenty-nine male and female collegiate athletes (20±1 years) sustaining a sports-related concussion were enrolled in a longitudinal study. For the Day-3 data, data were obtained on Day-3 (N=29), Day-21 (N=29), and Day-90 (N=23) following the head injury. Thirty-five sports-match non-injured controls were also enrolled and data were obtained at a single time point. Symptom number and severity and cognition were assessed using the Sports Concussion Assessment Tool’s 2nd Edition (SCAT-5). To assess NVC, continuous middle cerebral artery blood flow velocity (MCAV) was obtained bilaterally with 2 MHz transcranial Doppler ultrasound (TCD) while subjects were seated in an upright position. As a measure of working memory and executive function, the 2-back (control task) and 2-back (cognitive task) tasks were performed for 3 minutes each. NVC was estimated as the percentage change in MCAV between the 2-back (MCAV2Bk) and 0-back (MCAV0Bk) tasks for each subject. The equation used was NVC [%] = [(MCAV2Bk - MCAV0Bk) / MCAV0Bk] X 100. A non-parametric Wilcoxon rank sum test was utilized to compare NVC means between the controls and concussed athletes at the three time points. RESULTS: On Day-3 subsequent to the head injury, concussed athletes, compared to the controls, displayed higher symptom number (12.2±6.6 vs. 2.4±5.4, p<0.001) and symptom severity (46.0±50.5 vs. 20.0±32.5) with resolution of symptoms by Day-21. The concussed group exhibited lower percentage of correct responses on the 2-back task in comparison to the controls on Day-3 (52±13% vs. 70±15%, p<0.002), Day-21 (69±12% vs. 82±12%, p=0.002), and Day-90 (69±10% vs. 79±10%, p<0.001). Compared to non-injured controls (2.5±3.7), lower NVC was observed on Day-3 (0.3±6.0 vs. p=0.03), Day-21 (1.8±2.1 vs. p=0.01), and Day-90 (1.8±2.1 vs. p=0.01) with persistent decline observed on Day-90 (4.3±3.0 vs. p<0.001) following concussion. No difference in NVC was observed within the three points post-concussion. CONCLUSION. NVC remained dysregulated during the acute phase and worsened during subacute phase following concussion suggesting persistent physiological impairment beyond symptom resolution. Future studies with a large sample size and longer follow-up period are needed to track the physiological recovery trajectory and examine if there is an association between dysregulation of NVC and higher risk of secondary injuries post-concussion.
The Use of an Intensive Physical Exertion Test as a Final Return to Play Measure in Concussed Athletes

- The Blackhawks test – study by CCMI
- The first ever publication on this particular test – this was done in collaboration with the Blackhawks medical staff & McMaster University in Hamilton
- 759 athletes completed the ‘Gapski-Goodman Test’ (GGT), or modified Gapski-Goodman Test (mGGT) during study period (13 months)
- De-identified data was extracted and analyzed from the database system
  - Mean Age: 15.5 years (Range: 13-25)
  - Various sport & skill levels
  - 40.7% Female, 59.3% Male
  - MOI:
    - Hockey (44.7%)
    - Football (10.8%)
    - Soccer (9.9%)
    - Rugby (6.1%)
    - Basketball (5.5%)
- 14.6% of athletes who were asymptomatic and had completed all return to play steps FAILED the GGT or mGGT, potentially indicating incomplete recovery despite having completed all standard RTP stages
  - Increased risk of failing if a non-cardio-based sport (i.e., skiing, baseball) – may not be the right test for these
  - Increased risk of failing in those with higher initial symptom scores (possibly injury severity), and those with a pre-existing diagnosed anxiety issue
- Overall conclusion however = Self-reported symptoms at rest inadequate for RTP. Exertional testing such as the GGT may be revealing ongoing physiologic disruption that is not picked up by traditional RTP protocols
- RTP decisions should involve supervised intensive, dynamic, and sport-specific physical exertion testing

Exertional Tolerance Assessments after mTBI: a Systematic Review

- Examined all studies looking at physical exertion testing in mTBI patients
- Most studies used a treadmill or stationary bike as the exercise modality
  - Protocol methods varied according to intensity, duration, progression, etc.
- Most common outcome measures were self-reported symptoms, heart rate, and blood pressure
- Summary/Conclusions:
  - "The strongest evidence indicates that exertional assessments can provide important insight about mTBI recovery and should be administered using symptoms as a guide."
Do post-concussion like symptom responses change following exercise or sport participation in a non-concussed cohort?

**Purpose**
- Wanted to see if physical exertion (in non-concussed athletes) increased concussion-like symptoms

**Design**
- Pre-post observational design.

**Sample**
- 260 participants (146 male and 114 female) – ALL NON-Concussed
- Two groups:
  - 1) participants engaging in self-selected activities at a New Zealand University Athletic Centre and
  - 2) participants engaging in rugby training at a Rugby Football Club.
- Participants were excluded if they experienced a concussion within the last 3 months.

**Methods**
- All participants completed a pre- and post-exercise questionnaire consisting of SCAT 2 symptom scale, intensity of exercise measured with Borg’s scale, duration of exercise and type of exercise.
- Second cohort was examined to determine symptom response with structured sport activity (rugby training).

**Results:** Physical exertion has little effect on self-reported concussion symptoms within a healthy non-concussed population.

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**Blackhawks Protocol**

- Very intense – **For HIGH-RISK athletes ONLY!!**
  - Make sure you ask about any cardiac issues
  - Select: Modified program for adolescents, Full program for elite

- You need
  - 1 hour (1/2 hr for test and then 1/2 hour for baseline re-test…another 1/2 hour for ImPACT but you don’t have to be present)
  - Exercise bike (models: Monark, Lifefitness/20-level bike, are preferred)
  - Other bikes: NOT Recumbant (upright stationary bike only) needs to have measurable resistance levels and needs to measure RPMs
Some Notes on Blackhawks

1. The test is to assess physical capacity and readiness to return to play
   - Not to assess someone’s ability to pedal a bike or do a perfect burpee
   - I.e., not looking for form, looking for are they trying their hardest and are they getting any symptoms
2. Tensions are a guide
   - Follow as closely as you can but if someone is unable to pedal then reduce tension slightly
   - Really at the end of the day you want to work someone at near max capacity to see if they are ready to return to sport – not to make sure that they complete the test exactly as instructed
Baseline Re-testing

- If they pass the Blackhawks with no symptoms, let them cool down, then re-test baseline scores **(if they have a baseline that is less than 1 year old)**
  - If baseline is more than 365 days old it is EXPIRED and not to be used.
  - **Any deviation from baseline is considered significant!**
    - Lee et al., 2017 – exertion did not change symptoms or any other SCAT scores vs. pre-exercise in healthy people
    - Devilbiss et al., 2019 – many SCAT tests showed improvement following exertion
    - K-D test also not affected by fatigue/exertion (Kriebel et al., 2016; Devilbiss et al., 2019)
- CCMI Data – of the 85% of people who pass blackhawks on their first attempt, roughly 30% will fail one or more elements of their post-injury test compared to baseline!

- Then have them re-do their ImPACT test **(if applicable)**
  - **Must be done in the clinic** – put them in a room with a computer with a mouse and set them up

ImPACT Post-Injury Testing
Neuropsychological Testing (Berlin)

- Cognitive recovery may occasionally precede or lag behind clinical symptom resolution, suggesting that the assessment of cognitive function should be an important component in the overall assessment of SRC and, in particular, any RTP protocol.
- Post-injury NP testing may be used to assist RTP decisions and is typically performed when an athlete is clinically asymptomatic.
  - May also add important information in the early stages after injury – for example return to school, or assessing for limitations/restrictions for school/cognitive load.
- Pre-season baseline NP testing may be helpful or add useful information to the interpretation of these tests.

Return to play following a sports concussion: The “added value” of post-exertion assessment

Decision of return to play (RTP) after a concussion is critical given the potential consequences of premature RTP. Athletes should not be cleared for full contact activity until they demonstrate normal cognitive functioning on both rest and post-exertion assessments. Accordingly, this study aimed to examine post-exertion cognitive performance in asymptomatic collegiate athletes who were cleared to return-to-play. Twenty-two recently concussed athletes who completed step 4 of Zurich’s RTP protocol and 39 teammate controls participated in the study. They completed a Switch task before and after an acute bout of moderate cardiovascular exercise (80%–85% maximal predicted maximal heart rate for 20-minute) on an ergocycle. Based on their performance on both conditions (Rest, Post-exertion), concussed athletes were categorized into the Pass or Fail group. Specifically, they were placed in the Fail group if their performance was 2 SD lower than the control group’s average score. A χ² test was used to test for equality of proportions between conditions. Although, the proportion of athletes categorized in the Fail group was higher in post-exercise (31.82%) relative to rest (22.73%), it did not reach statistical significance (χ² = 0.20, p = 0.66). Irrespective of condition, 45% of concussed athletes were categorized in the Fail group. Of these, 10% failed on both conditions, 13% failed on rest only, and 22% failed on post-exercise. The current study suggests that 1 out of 2 athletes who successfully completed the RTP protocol exhibited diminished cognitive functions compared to controls. The use of a sensitive cognitive test, combined with physical exertion, can prevent premature RTP in identifying athletes would have otherwise received medical clearance.
Neurocognitive test failure following physical exertion

• 39 concussed athletes were included (age = 16.27 ± 1.32 yrs)
• They were followed throughout the return to play process
  – Once they completed all steps and passed their ImPACT (as compared to their pre-injury baseline) they were put through a physical exertion test and then re-tested on ImPACT
• Results:
  – 28% of athletes who had initially passed ImPACT at rest, failed at least one component following physical exertion
  – This is why we do the Blackhawks!!

Zaring 2015 – Masters Thesis
# Return to Learn / Work / Play

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</tbody>
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- 2-3 days max  
- Buffalo Treadmill Test  
- Exertion Test  
- Return to Play

Each stage must be separated by at least **24 hours**. If symptoms occur at any one stage, athlete **must return to previous stage**.

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History of concussion and risk of subsequent injury in athletes and service members: a systematic review and meta-analysis

Results
- 27 studies were included for review.
  - 15 had good methodological quality, 11 had acceptable quality and 1 had low methodological quality.
- Risk of any secondary injury
  - The odds of sustaining a secondary injury was 2.55 times higher for those with a previous concussion compared to those without concussion history (2.55 OR, 95% CI: 1.44-4.50).
  - The odds of sustaining a secondary injury was 4.44 times higher in athletes with a previous concussion history compared to athletes without a history of concussion (4.44 OR, 95% CI: 1.44-14.36).
  - The odds of sustaining a secondary injury was 1.88 times higher in service members with a previous concussion history compared to those without a history of concussion (1.88 OR, 95% CI: 1.18-3.01).
- Risk of extremity injury
  - The odds of sustaining a lower extremity injury was 1.60 times higher in those with a previous concussion history compared to those without concussion history (1.60 OR, 95% CI: 1.12-2.26).
  - The odds of sustaining a lower extremity injury was 1.82 times higher in athletes with a previous concussion history compared to athletes without a history of concussion (1.82 OR, 95% CI: 1.17-2.83).
  - No studies on lower extremity risk for service members.

Conclusion: There was a statistically increased risk for all injuries, sustaining a secondary concussion and sustaining a lower extremity injury in those with a history of concussion compared to those without a history of concussion.

Implication for practice: Rehabilitation targeted to cervical, vestibular and oculomotor treatment can help aid in recovery and potentially mitigate risk of future injury.
First concussion did not increase the risk of subsequent concussion when patients were managed appropriately

• This study used data from Cirque du Soleil (CdS) performers to determine whether having a concussion was causally related to subsequent concussions in the same individuals
  – This controls for inherent risks
  – Example: acrobats suffer more concussions, so if we compare the risks across all performers, acrobats will get more concussions – this will create a false sense that because acrobats have had a previous concussion, they are more at risk for another, when in fact, this is merely a fact of being an acrobat

Shrier et al., 2019

First concussion did not increase the risk of subsequent concussion when patients were managed appropriately

• Cirque has followed consensus guidelines for concussion since 2007 – appropriate management and progressive return to activity
• Researchers looked at the group as a whole to determine the risk of suffering a concussion, then they only looked at the group that had a previous concussion and compared the risk of the first concussion vs. the risk of the second concussion
• The chart on the left shows the traditional way of doing risk analysis (A), and the chart on the right shows a more appropriate way of doing this calculation (B)
  – As you can see, A shows a difference, indicating a significant increase in risk for a second concussion if you’d had one in the past, whereas B shows no significant risk associated with having had a previous concussion

Figure 1 (A) The cumulative incidence (Kaplan-Meier curves) of concussion among all artists (red) and among those artists with a first concussion (blue) is shown. The difference between the curves is highly statistically significant (p<0.01). (B) The cumulative incidence (Kaplan-Meier curves) is shown for the first concussion among artists with two or more concussions (red line) and for the second concussion among the same artists with two or more concussions (blue line). The curves are not statistically different from each other (p=0.28).
First concussion did not increase the risk of subsequent concussion when patients were managed appropriately

• Conclusion:
  – “Our conclusions are derived from a work environment in which concussions are managed by stepped increases in physical and mental stress and return to activity requires that these activities do not provoke symptoms. The analysis also requires the assumption that concussion risk is stable over time, which is expected in CdS where performances in January and September are similar. More complex methods are required when fatigue and style of play (i.e., risk) may change over the course of a season in sport. We conclude that concussions managed according to current recommendations may not causally increase subsequent concussion risk in circus artists. Readers should be cautious when making inferences from studies that use traditional analyses which compare risks of subsequent concussion (or other injury) to the risk of a first injury.”

Return to play risk of repeat concussion in collegiate football players: comparative analysis from NCAS concussion study and CARE Consortium

• Looked to compare the data sets from the NCAA Concussion study (1999-01) and CARE Consortium Study (2014-2017) to examine how clinical management, RTP and risk of repeat concussion have changed over the past 15 years in College Football.
• During the NCAA Concussion study (1999-01) 2905 athletes were enrolled, of which 184 football players sustained a concussion. Concussed athletes underwent clinical assessment immediately, and @ 3 hours, 1, 2, 3, 5, 7, and 90 days after injury.
• The CARE Consortium study (2014-2017) enrolled 40 000 athletes, of which 701 football sustained a concussion.
  – The study collected preseason baseline data. The CARE injury protocol involved follow-up clinical testing of concussed athletes at <6 hours, 24-48 hours, when asymptomatic, start of RTP, unrestricted RTP, and 6 months after injury.
Return to play risk of repeat concussion in collegiate football players: comparative analysis from NCAS concussion study and CARE Consortium

**Results**

- Overall, time from injury to asymptomatic time point in CARE study was 8.83 days compared with 3.42 days in NCAA study. Median reported symptom duration in the CARE study was 5.92 days compared to 2 days in the NCAA study.

- CARE study demonstrated athletes had on average 7.25 symptom free waiting period (days between being symptom free and RTP) compared with 3.25 days in the NCAA study.

- The total time for unrestricted return to play after a concussion was 6.67 days in the NCAA study compared to 16.08 days in the CARE study. Clinicians are more conservative in concussion management than 15 years earlier. Our findings support contemporary international consensus recommendations that athletes observe a lengthier period of recovery and rehabilitation prior to RTP after concussion. This approach allows adequate time for brain recovery after injury, and reduces an athlete’s risk of repetitive concussion during the acute window of cerebral vulnerability, which may be crucial to preventing persistent problems.

- The rate of within-season repeat concussion in the NCAA study was 6.52% compared to 3.85% in the CARE study, which was 41% lower risk of sustaining a subsequent in-season concussion – Wow! (managing the injury appropriately reduces risk of repeat concussions)
  - Average interval between the first and repeat concussion in the NCAA study was 5.59 days compared to 56.41 days in the CARE study, 50.82 days longer between concussions.

Authors conclusion: Clinicians are more conservative in concussion management than 15 years earlier. Our findings support contemporary international consensus recommendations that athletes observe a lengthier period of recovery and rehabilitation prior to RTP after concussion. This approach allows adequate time for brain recovery after injury, and reduces an athlete's risk of repetitive concussion during the acute window of cerebral vulnerability, which may be crucial to preventing persistent problems.

Other Considerations

- Risk of subsequent concussions
- Risk of MSK injuries upon RTP
- Initiating treatment/rehab
### MSK injury risk after sport-related concussion

**Background:** Clinical management of sport-related concussion typically involves a symptom checklist, clinical examination of mental status, and neuropsychometric testing. However, recent studies have identified unresolved, impaired sensorimotor function after athletes return to sport. A review and meta-analysis of all current literature regarding risk of subsequent musculoskeletal (MSK) injury after concussion has yet to be published in the medical literature.

**Purpose/Hypothesis:** To determine the odds that athletes will sustain MSK injury after concussion. It was hypothesized a priori that concussion would increase the risk for MSK injury.

**Study Design:** Systematic review and meta-analysis.

**Methods:** PubMed and Google Scholar were searched from January 2000 to November 2017. Reference lists of the included studies were manually searched. Two reviewers independently searched the literature for studies published in English that reported MSK injury after athletes returned to play following a concussion. Two independent reviewers completed data extraction using PRISMA guidelines and assessed study quality using the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies from the National Institutes of Health. Random-effects meta-analyses were used to calculate odds ratio (OR) and incidence rate ratio (IRR) of MSK injury after concussion. The primary study outcome of interest was the number of athletes who sustained MSK injury after concussion.

**Results:** Eight studies met inclusion criteria for meta-analysis. Meta-analysis results indicated that athletes who had a concussion had 2.11 times greater odds of sustaining a MSK injury than athletes without concussion (OR: 2.11; 95% CI: 1.46–3.06). In addition, athletes with concussion demonstrated a higher incidence of MSK injury after return to sport compared with nonconcussed athletes (IRR: 1.67; 95% CI: 1.42–1.96). Further analysis showed that both male and female athletes with concussion were at an increased risk of MSK injury compared with their respective same-sex, nonconcussed controls (OR > 1.56; P < .03).

**Conclusion:** Based on the evidence of higher risk of MSK injuries after concussion, standard clinical assessments for athletes with concussion should include not only physical symptoms and cognitive function before return to sport but also neuromuscular risk factors associated with increased risk for MSK injuries.

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### Effect of Concussions on Lower Extremity Injury Rates at a Division I Collegiate Football Program

**Background:** Football has one of the highest injury rates (IRs) in sports, ranging from 4.1 to 8.6 per 1000 athlete-exposures (AEs). Previous research has reported that athletes may be at an increased risk of suffering lower extremity (LE) injuries after a concussion.

**Purpose/Hypothesis:** The purpose of this study was to evaluate the rate of LE injuries in collegiate football athletes after a concussion. We predicted that the overall LE IR would increase after a concussion and that each position group would also demonstrate a similar increase in LE injuries after a concussion.

**Study Design:** Cohort study; Level of evidence, 2.

**Methods:** Daily attendance and injury records were prospectively collected by licensed team medical providers for the 2013 through 2016 college football regular seasons. Each injury report included the date of injury, position group, body part injured, and type of injury. IRs per 1000 AEs with 95% CIs were calculated to evaluate LE injuries at different time points after a concussion (remainder of season: next season, any additional seasons) and by months (6 months, 6-12 months, >12 months). Mcnemar exact tests were utilized to establish injury rate ratios (IRR) to compare the IR between variables.

**Results:** There was no significant difference in LE IRs between the athletes post- versus preconcussion (P = .24) or between the position and concussion (corrected) athletes (P = .08). There was an increased LE IR beyond 12 months in the post-concussion group (IRR: 2.69; 95% CI: 1.86–3.96) compared with the no concussion group (IRR: 1.85; 95% CI: 1.04–3.36). Male position players had an increase in LE injuries after a concussion (IRR: 6.22; 95% CI: 1.31-23.68; P = .03) compared with lineman with no concussion.

**Conclusion:** There was no initial increase in LE IRs immediately after a concussion; however, there was an increased LE IR more than 12 months after a concussion. There was no increase in LE injuries demonstrated by skill and other position groups. Line position players experienced an increased LE IR the next season after a concussion or greater than 12 months after the injury.
Other Considerations

- Risk of subsequent concussions
- Risk of MSK injuries upon RTP
- Initiating treatment/rehab

Initiating Treatment/Rehab

- Evidence supports:
  - Subsymptom Threshold Exercise (start within 5-7 days)
  - Cervical spine - manual therapy & rehab
  - Vestibular rehab
  - Vision Rehab
  - Reducing inflammation (diet plan right away)

Evidence suggests that this is best when initiated within first 10-14 days if still symptomatic!
Cervicovestibular rehab RCT

- 31 mTBI (mean age 15, range 12-30) in subacute stage
  - still symptomatic after 10 days of injury
  
  - Split into 2 groups:
    - Both groups - postural education, ROM exercises, and cognitive and physical rest until asymptomatic - then RTP via Zurich until fully cleared by sportsMD blinded to their group
    - Group 1 also received individualized cervical spine manual therapy (mobilizations, soft tissue, neuromotor retraining) and vestibular rehab (habituation, gaze stabilization, adaptation exercises, balance exercises, and canalith repositioning as needed)
    - Both groups saw the physio 1x/wk for 8 weeks
  
  - After 8 weeks sig more in group 1 were fully cleared to RTP than in group 2 (73% in group 1 vs. only 7% in grp 2)

Early treatment for dizziness after sport-related concussion: RCT

- N = 41 concussed subjects (aged 10 to 23 yrs old) within 14 days of injury and still experiencing symptoms beyond day 10
  
  - Randomized into 1 of 2 groups:
    - Group 1: Progressive Treatment Group (n=22) – experimental group
      - Got individually tailored exercises designed to provoke symptoms and progress over time to always be pushing and improving
    - Group 2: Subtherapeutic Treatment Group (n=19) – active control group
      - Got sham-type treatments and treatments that were minimally progressive (not pushing into symptoms, but stopping immediately at first onset)
    - There were no significant differences between the groups in terms of previous concussion hx, ADHD, learning disabilities etc.
  
  - Subjects in both groups received treatment that could have been perceived as the correct treatment by patients - this was to keep blinding (patients DID NOT know which group they were in)
  
  - All patients were seen 2x/week for a MAXIMUM of 8 total visits OR until they were fully cleared to RTP by the sports medicine physician (whichever came first)
Early treatment for dizziness after sport-related concussion: RCT

• Results:
  – Median time to symptom resolution:
    • Experimental group = 2x faster than the sham group (95%CI: 0.95 – 4.15)
  – Median time to medical RTP clearance (physician blinded to group)
    • Experimental group = Clearance 2.91x faster than the Sham group (95% CI: 1.01 – 8.43)
  – Interestingly, those WITH a previous history of concussion recovered faster than those without (HR: 2.53; 95%CI 1.22 – 5.26) and were cleared to RTP faster (HR: 5.26; 95%CI 1.59 - 17.45)
  – Conclusion: “The statistical results suggest that individually prescribed progressive physical therapy intervention, including manual techniques, vestibular rehabilitation, oculomotor and neuro- motor retraining delivered to individuals while symptomatic, beginning as early as 10 days after a sports-related concussion may be effective in shortening recovery time”

Summary of Acute Management

• Rule out more sinister pathology
• Symptom-limited activity (2-3 days max)
  – Initiate diet plan
  – Light cognitive & physical activity as long as doesn’t significantly provoke symptoms
  – If still significantly symptomatic, re-evaluate & treat/rehab (c-spine, VOMS, reassurance)
• Visit 2 – 5-7 days – Buffalo treadmill test, (overall symptoms <7/10)
  – Pass → non-contact exercise
  – Fail → subsymptom-threshold exercise
• Bring through stages based on symptoms
  – If no symptom exacerbation, progress to next stage (if at least 24 hours)
  – If symptom exacerbation, fall back to previous stage
  – Treat as necessary (definitely if 7-10 days has passed)
• Once at 2 weeks, if still having symptoms, start treating like PCS case & ramp up treatment/rehab if not already doing it (more on exact protocol in PCS module)
• Err on side of caution with clearance decisions! Longer time out is BETTER!!
• If no baseline to compare, take your time and “Clear at own risk” – book in for a baseline test in 3 months time