OHSU Brain Institute

TBI Symposium: From Research to Recovery

Berlin Guideline Update
and Complex Concussion Management

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Chair, Medical Advisory Committee USA Football 2013-2017
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Medical Advisory Board Vicis/C4C UW
Concussion In Sport - Berlin

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<td>• Willem Meeuwisse</td>
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<td>• Jiri Dvorak (FIFA)</td>
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[Logos for FIFA, Olympic Games, World Rugby, FEI]
Expert Panel

- Selected for scientific, clinical and academic understanding of the topic/field
- Expertise and experience
- Not presenting organizations per se
- Broadened to include more related disciplines, organizations and experts
Systematic Reviews

• Modified Delphi technique to determine the primary questions to be answered
  – 5 rounds to develop 12 questions

• Systematic Reviews
  – standardised process, using the Enhancing the Quality and Transparency Of health Research (EQUATOR) network, based on BJSM Author Guidelines and following the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines

60,000 published articles were initially screened
Consensus Statement on Concussion in Sport
The 5th International Conference on Concussion in Sport Held in Berlin

- Recognize
- Remove
- Re-evaluate
- Rest
- Rehabilitation
- Refer
- Recovery
- Return to Sport
- Reconsider
- Residual Effects and Sequelae
- Risk Reduction

Recognize:
Berlin Expert Panel’s Modification of the Definition of Sports Related Concussion

Sport related concussion is a traumatic brain injury induced by biomechanical forces. Several common features that may be utilized in clinically defining the nature of a concussive head injury include:

• SRC may be caused either by a direct blow to the head, face, neck or elsewhere on the body with an impulsive force transmitted to the head.

• SRC typically results in the rapid onset of short-lived impairment of neurological function that resolves spontaneously. However, in some cases, signs and symptoms evolve over a number of minutes to hours.

Recognize:
Berlin Expert Panel’s Modification of the Definition of Sports Related Concussion

- SRC may result in neuropathological changes, but the acute clinical signs and symptoms largely reflect a functional disturbance rather than a structural injury and, as such, no abnormality is seen on standard structural neuroimaging studies.
- SRC results in a range of clinical signs and symptoms that may or may not involve loss of consciousness. Resolution of the clinical and cognitive features typically follows a sequential course. However, in some cases symptoms may be prolonged.
- *The clinical signs and symptoms cannot be explained by drug, alcohol, medication use, other injuries (such as cervical injuries, peripheral vestibular dysfunction etc.), or other comorbidities (e.g. psychological factors or coexisting medical conditions etc.)*

Recognize:
Do the Published Biomechanical Studies Inform Us About the Definition of SRC?

• Although current helmet-based measurement devices may provide useful information for collision sports, these systems do not yet provide data for other (non-collision) sports, limiting the value of this approach. Furthermore, accelerations detected by a sensor or video-based systems do not necessarily reflect the impact to the brain itself, and values identified vary considerably between studies. The use of helmet-based or other sensor systems to clinically diagnose or assess SRC cannot be supported at this time.
Recognize: Sideline Evaluation

• The recognition of suspected SRC is therefore best approached using multidimensional testing guided via expert consensus. The SCAT5 currently represents the most well-established and rigorously developed instrument available for sideline assessment.

• There is published support for using the SCAT and Child SCAT in the evaluation of SRC. The SCAT is useful immediately after injury in differentiating concussed from non-concussed athletes, but its utility appears to decrease significantly 3–5 days after injury. The symptom checklist, however, does demonstrate clinical utility in tracking recovery.

• Baseline testing may be useful, but is not necessary for interpreting post-injury scores. If used, clinicians must strive to replicate baseline testing conditions. Additional domains that may add to the clinical utility of the SCAT tool include clinical reaction time, gait/balance assessment, video-observable signs and oculomotor screening.
Recognize: Sideline Evaluation

• The addition of sideline video review offers a promising approach to improving identification and evaluation of significant head-impact events, and a serial SRC evaluation process appears to be important to detect delayed-onset SRC.

• Other tools show promise as sideline screening tests but require adequately powered diagnostic accuracy studies that enroll a representative sample of athletes with suspected SRC.

• Collaboration between sporting codes to rationalise multimodal diagnostic sideline protocols may help facilitate more efficient application and monitoring. Current evidence does not support the use of impact sensor systems for real-time SRC screening.
Remove

• When a concussion is suspected, the athlete should be removed from the sporting environment and a multimodal assessment should be conducted in a standardised fashion (e.g., the SCAT5).

• Sporting bodies should allow adequate time to conduct this evaluation. For example, completing the SCAT alone typically takes 10 min. Adequate facilities should be provided for the appropriate medical assessment both on and off the field for all injured athletes.

• In some sports, this may require rule changes to allow an appropriate off-field medical assessment to occur without affecting the flow of the game or unduly penalising the injured player’s team.

• The final determination regarding SRC diagnosis and/or fitness to play is a medical decision based on clinical judgement.
Re-evaluate: Concussion Investigations

- Advanced neuroimaging, fluid biomarkers and genetic testing are important research tools, but require further validation to determine their ultimate clinical utility in evaluation of SRC.
Rest

- The basis for recommending physical and cognitive rest is that rest may ease discomfort during the acute recovery period by mitigating post-concussion symptoms and/or that rest may promote recovery by minimizing brain energy demands following concussion.

- 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 (i.e. activity level should not bring on or worsen their symptoms). It is reasonable for athletes to avoid vigorous exertion while they are recovering. The exact amount and duration of rest is not yet well defined in the literature and requires further study.
Rehabilitation

• SRCs can result in diverse symptoms and problems, and can be associated with concurrent injury to the cervical spine and peripheral vestibular system. The literature has not evaluated early interventions, as most individuals recover in 10–14 days.

• A variety of treatments may be required for ongoing or persistent symptoms and impairments following injury. The data support interventions including psychological, cervical and vestibular rehabilitation.

• In addition, closely monitored active rehabilitation programmes involving controlled sub-symptom-threshold, submaximal exercise have been shown to be safe and may be of benefit in facilitating recovery. A collaborative approach to treatment including controlled cognitive stress, pharmacological treatment, and school accommodations, may be beneficial.
Rehabilitation

• Further research evaluating rest and active treatments should be performed using high-quality designs that account for potential confounding factors, and have matched controls and effect modifiers to best inform clinical practice and facilitate recovery.
Refer:
Persistent Symptoms

• A standard definition for persistent post-concussive symptoms is needed to ensure consistency in clinical management and research outcomes. The Berlin expert consensus is that use of the term ‘persistent symptoms’ following SRC should reflect failure of normal clinical recovery—that is, symptoms that persist beyond expected time frames (i.e., >10–14 days in adults and >4 weeks in children).

• ‘Persistent symptoms’ does not reflect a single pathophysiological entity, but describes a constellation of non-specific post-traumatic symptoms that may be linked to coexisting and/or confounding factors, which do not necessarily reflect ongoing physiological injury to the brain.
A detailed multimodal clinical assessment is required to identify specific primary and secondary pathologies that may be contributing to persisting post-traumatic symptoms.

At a minimum, the assessment should include a comprehensive history, focused physical examination, and special tests where indicated (e.g., graded aerobic exercise test). Currently, while there is insufficient evidence for investigations, such as EEG, advanced neuroimaging techniques, genetic testing and biomarkers, to recommend a role in the clinical setting, their use in the research setting is encouraged.
Refer: Persistent Symptoms

- Treatment should be individualised and target-specific medical, physical and psychosocial factors identified on assessment. There is preliminary evidence supporting the use of:
  - a. an individualised symptom-limited aerobic exercise programme in patients with persistent post-concussive symptoms associated with autonomic instability or physical deconditioning, and
  - b. a targeted physical therapy programme in patients with cervical spine or vestibular dysfunction, and
  - c. a collaborative approach including cognitive behavioural therapy to deal with any persistent mood or behavioural issues.
Persistent Symptoms

- Currently, there is limited evidence to support the use of pharmacotherapy. If pharmacotherapy is used, then an important consideration in return to sport is that concussed athletes should not only be free from concussion-related symptoms, but also should not be taking any pharmacological agents/medications that may mask or modify the symptoms of SRC. Where pharmacological therapy may be begun during the management of an SRC, the decision to return to play while still on such medication must be considered carefully by the treating clinician.

- Overall, these are difficult cases that should be managed in a multidisciplinary collaborative setting, by healthcare providers with experience in SRC.
Recovery

- At present, it is reasonable to conclude that the large majority of injured athletes recover, *from a clinical perspective*, within the first month of injury. Neurobiological recovery might extend beyond clinical recovery in some athletes.

- There have been inconsistent findings regarding whether specific injury severity characteristics, such as loss of consciousness, retrograde amnesia, or post-traumatic amnesia, are associated with greater acute effects or prolonged recovery. Numerous *post-injury clinical factors*, such as the initial severity of cognitive deficits, the development of post-traumatic headaches or migraines, experiencing dizziness, difficulties with oculomotor functioning, and experiencing symptoms of depression have all been associated with worse outcomes in some studies.
Recovery

- The strongest and most consistent predictor of slower recovery from SRC is the severity of a person’s initial symptoms in the first day, or initial few days, after injury.
- Conversely, and importantly, having a low level of symptoms in the first day after injury is a favourable prognostic indicator.
- The development of subacute problems with migraine headaches or depression are likely risk factors for persistent symptoms lasting more than a month.
- Children, adolescents and young adults with a pre-injury history of mental health problems or migraine headaches appear to be at somewhat greater risk of having symptoms for more than 1 month.
Recovery

- Those with attention deficit hyperactivity disorder or learning disabilities might require more careful planning and intervention regarding returning to school, but they do not appear to be at substantially greater risk of persistent symptoms beyond a month.
- Very little research to date has been carried out on children under the age of 13. There is some evidence that the teenage years, particularly the high-school years, might be the most vulnerable time period for having persistent symptoms with greater risk for girls than boys.
Recovery: Establishing Time of Recovery for SRC

- Establishing the time of recovery after an SRC is a difficult task for healthcare providers. These determinations have been limited by lack of a gold standard as well as subjective symptom scores and imperfect clinical and NP testing.

- In addition, patients frequently experience more persistent symptoms, including, but not limited to, chronic migraines, anxiety, post-traumatic stress disorder (PTSD), attention problems and sleep dysfunction.

- Clinicians must determine whether these are premorbid maladies, downstream effects of SRC, or unrelated challenges while being mindful of the potential for repeat injuries when returning patients to sport too early.
Recovery: Establishing Time of Recovery for SRC

- Providers are often left in a quandary with limited data to make decisions. Moreover, recent literature suggests that the physiological time of recovery may outlast the time for clinical recovery. The consequence of this is as yet unknown, but one possibility is that athletes may be exposed to additional risk by returning to play while there is ongoing brain dysfunction.
Recovery:
Establishing Time of Recovery for SRC

- In a research context, modalities that measure physiological change after SRC can be categorised into the following:
  - functional MRI (fMRI)
  - diffusion tensor imaging (DTI)
  - magnetic resonance spectroscopy (MRS)
  - cerebral blood flow (CBF)
  - electrophysiology
  - heart rate
  - measure of exercise performance
  - fluid biomarkers
  - transcranial magnetic stimulation (TMS).
Recovery: Establishing Time of Recovery for SRC

• Owing to differences in modalities, time course, study design and outcomes, it is not possible to define a single ‘physiological time window’ for SRC recovery. Multiple studies suggest that physiological dysfunction may outlast current clinical measures of recovery, supporting a ‘buffer zone’ of gradually increasing activity before full contact risk.

• Future studies need to use generalisable populations, longitudinal designs following to physiological and clinical recovery, and careful correlation of neurobiological modalities with clinical measures. At this stage, these modalities, while useful as research tools, are not ready for clinical management.
Reconsider: The Child and Adolescent Athlete

- The management of SRC in children requires special paradigms suitable for the developing child. The paucity of studies that are specific to children, especially younger children, needs to be addressed as a priority, with the expectation that future CISG consensus meetings will have sufficient studies to review that are age-specific, of high quality, and with a low risk of bias.
- We recommend that child and adolescent guidelines refer to individuals 18 years or less. Child-specific paradigms for SRC should apply to children aged 5–12 years, and adolescent-specific paradigms should apply to those aged 13–18 years.
- The literature does not adequately address the question of age groups in which children with SRC should be managed differently from adults. No studies have addressed whether SRC signs and symptoms differ from adults.
Reconsider: The Child and Adolescent Athlete

- The expected duration of symptoms in children with SRC is up to 4 weeks, and further research is required to identify predictors of prolonged recovery. It is recommended that age-specific validated symptom-rating scales be used in SRC assessment, and further research is required to establish the role and utility of computerised NP testing in this age group.

- Similar to adults, a brief period of physical and cognitive rest is advised after SRC followed by symptom-limited resumption of activity.

- Schools are encouraged to have an SRC policy that includes education on SRC prevention and management for teachers, staff, students and parents, and should offer appropriate academic accommodation and support to students recovering from SRC. Students should have regular medical follow-up after an SRC to monitor recovery and help with return to school, and students may require temporary absence from school after injury.
Reconsider: The Child and Adolescent Athlete

- Children and adolescents should not return to sport until they have successfully returned to school. However, early introduction of symptom-limited physical activity is appropriate.

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<th>Graduated return-to-school strategy</th>
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<td><strong>Stage</strong></td>
<td><strong>Aim</strong></td>
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<tr>
<td>1</td>
<td>Daily activities at home that do not give the child symptoms</td>
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<tr>
<td>2</td>
<td>School activities</td>
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<td>3</td>
<td>Return to school part-time</td>
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<td>4</td>
<td>Return to school full time</td>
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Residual Effects and Sequelae

- The literature on neurobehavioral sequelae and long-term consequences of exposure to recurrent head trauma is inconsistent.
- Clinicians need to be mindful of the potential for long-term problems such as cognitive impairment, depression, etc. in the management of all athletes. However, there is much more to learn about the potential cause and effect relationships of repetitive head impact exposure and concussions.
- The potential for developing chronic traumatic encephalopathy (CTE) must be a consideration, as this condition appears to represent a distinct tauopathy with an unknown incidence in athletic populations.

Residual Effects and Sequelae

- A cause and effect relationship has not yet been demonstrated between CTE and SRCs or exposure to contact sports.
- As such, the speculation that repeated concussion or sub-concussive impacts causes CTE remains unknown.
- The new US National Institutes of Neurological Disease and Stroke (NINDS) and National Institute of Biomedical Imaging and Bioengineering (NIBIB) consensus criteria provide a standardized approach to describe the neuropathology of CTE.
  - More research on the long-term sequelae is needed to better understand the incidence and prevalence of CTE and other neurobehavioral conditions.
  - Future studies should attempt to determine if there are potential genetic predispositions and if the condition is likely to be progressive given certain modifiers. Ideally, well-designed prospective longitudinal cohort studies can answer these important questions.

Risk Reduction: Prevention

• While it is impossible to eliminate all concussion in sport, concussion-prevention strategies can reduce the number and severity of concussions in many sports. Until the past decade, there has been a relative paucity of scientifically rigorous evaluation studies examining the effectiveness of concussion-prevention strategies in sport.

• The evidence examining the protective effect of helmets in reducing the risk of SRC is limited in many sports because of the nature of mandatory helmet regulations. There is sufficient evidence in terms of reduction of overall head injury in skiing/snowboarding to support strong recommendations and policy to mandate helmet use in skiing/snowboarding.

• The evidence for mouthguard use in preventing SRC is mixed, but meta-analysis suggests a non-significant trend towards a protective effect in collision sports, and rigorous case–control designs are required to further evaluate this finding.
Risk Reduction: Prevention

- The strongest and most consistent evidence evaluating policy is related to body checking in youth ice hockey (ie, disallowing body checking under age 13), which demonstrates a consistent protective effect in reducing the risk of SRC. This evidence has informed policy change in older age groups in non-elite levels, which requires further investigation.

- There is minimal evidence to support individual injury-prevention strategies addressing intrinsic risk factors for SRC in sport. However, there is some promise that vision training in collegiate American football players may reduce SRC. Limiting contact in youth football practices has demonstrated some promising results in reducing the frequency of head contact, but there is no evidence to support the translation of these findings to a reduction in SRC.
Risk Reduction: Prevention

• Evaluation of fair play rules in youth ice hockey, tackle training without helmets and shoulder pads in youth American football, and tackle technique training in professional rugby do not lead to a reduction in SRC risk.

• A recommendation for stricter rule enforcement of red cards for high elbows in heading duels in professional soccer is based on evidence supporting a reduced risk of head contacts and concussion with such enforcement.
Risk Reduction: Prevention

- Despite a myriad of studies examining SRC-prevention interventions across several sports, some findings remain inconclusive because of conflicting evidence, lack of rigorous study design, and inherent study biases. A clear understanding of potentially modifiable risk factors is required to design, implement and evaluate appropriate prevention interventions to reduce the risk of SRC. In addition, risk factors should be considered as potential confounders or effect modifiers in any evaluation.

- Biomechanical research (e.g., video-analysis) to better understand injury risk behaviour and mechanisms of injury associated with rules will better inform practice and policy decisions.

- In addition, psychological and sociocultural factors in sport play a significant role in the uptake of any injury-prevention strategy and require consideration.
The Sport Concussion Assessment Tool 5th Edition (SCAT5)

• SCAT5 modifications
  – Declaration that the complete SCAT5 cannot be appropriately completed in less than 10 min.
  – Inclusion of an Immediate/Acute Assessment section, including indications for emergency management and observable signs of possible concussion.
  – Clarified instructions that the Symptom Checklist should be completed by the athlete in a resting state.
  – Different instructions for completing the symptom checklist at baseline and postinjury have been added.
  – Addition of questions that compare the athlete’s postinjury presentation with preinjury behaviour.

The Sport Concussion Assessment Tool 5th Edition (SCAT5)

• SCAT5 modifications
  – The SAC immediate and delayed word recall lists include an option to use 10 words instead of 5 to minimise ceiling effects.
  – All six versions of the SAC word lists are now presented with alternate stimulus sets for the word list and digits backwards. Their administration should be randomised at baseline and serially postinjury.
  – A notation of when the last trial of the word list was administered is required (the delayed recall should not be administered sooner than 5 min after the immediate memory subtest).
  – Digits Backwards now contains six versions of the digit strings, which should be randomised at baseline and serially postinjury.
  – A Rapid Neurological Screen has been included.

The Sport Concussion Assessment Tool 5th Edition (SCAT5)

- SCAT5 Modifications
  - A section has been added that includes affirmation that the SCAT5 was used or supervised by a healthcare professional and whether a concussion was diagnosed.
  - The Instruction section has been enhanced to include all of the modifications described above.
  - The Return to Sport progression emphasises that the initial period of physical and cognitive rest should typically only last 24-48 hours.
  - A Return to School progression has been added, including possible academic accommodations.
  - The SCAT5 specifically indicates that written clearance by a healthcare professional is necessary prior to returning to play/sport.
The Child Sport Concussion Assessment Tool 5th Edition (Child SCAT5)

- **Child SCAT5 Modifications**
  - The Potential Signs of Concussion Box was replaced with a ‘Red Flags’ Box in the initial assessment to highlight the potential of a structural brain injury that may require neurosurgical intervention.
  - Declaration that the complete Child SCAT5 cannot be appropriately completed in less than 10–15 min.
  - The modified Maddocks questions were removed because of the questionable reliability and usefulness in young children.
  - The Symptom Evaluation is recommended to be performed with the child in a resting state.
  - Neck pain was added to the list of child-reported and parent-reported symptoms.

The Child Sport Concussion Assessment Tool 5th Edition (Child SCAT5)

- **Child SCAT5 Modifications**
  - An overall rating of functioning (0-10) has been included for the Child Report and a rating (0-100) has been included for the Parent Report.
  - The Orientation questions were removed because of their doubtful usefulness in young children.
  - The Immediate Memory word lists include two additional five-word lists and optional 10-word lists are provided for older children in whom a ceiling effect is identified with the five-word lists. All six versions of the Standardised Assessment of Concussion word lists are now presented and they should be administered by choosing one at random for baseline testing and then using them serially post-injury.
  - The time at completion of the third trial of the word list is recorded and the Delayed Recall is not to proceed ≤5 min from completion of the Immediate Recall.
The Child Sport Concussion Assessment Tool
5th Edition (Child SCAT5)

• Child SCAT5 Modifications
  – Digits Backwards has been modified to include two additional digit lists and has been formatted to assist with administration of this test, in which a correct response from one string length advances to the next string length, but an incorrect response requires a second trial at the same string length. Administration of different digit lists should be randomised at baseline and serially post injury.
  – The Balance Examination includes the single-leg stance for children aged 10–12 years.
  – The Neck Examination and Coordination Examination have been removed and incorporated into a new section, the Rapid Neurological Screen (RNS).
  – The RNS includes assessment of balance and gait, ocular function, coordination and reading (assesses cognitive function, cranial nerves [acuity, diplopia], dysphasia, dysarthria and response time). Younger children who cannot read are asked to describe what they see in a photograph.
The Child Sport Concussion Assessment Tool 5th Edition (Child SCAT5)

- Child SCAT5 Modifications
  - The Return to School information has been modified to inform the student that prolonged school absence is not recommended and that appropriate accommodations should be made, in consultation with the medical team, teachers and parents/caregivers. The Return to School section includes a stepwise table that allows for symptom-limited cognitive activity.
  - The Return to Sport information has been modified to inform the student that a symptom-limited activity programme should be followed with healthcare professional guidance.
Sports and Recreation Concussions
Sports Concussion Recovery

- Majority (80-90%) resolve in short (7-10 day) period
- May take longer in children and adolescents

Expected time frames:
10–14 days in adults and up to 4 weeks in children

Recovery After SRC

• At present, it is reasonable to conclude that the large majority of injured athletes recover, from a clinical perspective, within the first month following injury. Neurobiological recovery might extend beyond clinical recovery in some athletes.

• There is a growing body of literature indicating the psychological factors play a significant role in symptom recovery and contribute to risk of persistent symptoms in some cases.

Prolonged Symptoms
Referral After SRC

- A standard definition for persistent post-concussive symptoms is needed to ensure consistency in clinical management and research outcomes. The expert consensus is that use of the term “persistent symptoms” following SRC should reflect clinical recovery that falls outside expected time-frames (i.e. >10-14 days in adults and >4 weeks in children).

Risk Factors for Post Concussive Syndrome

• Pre-morbid anxiety
  – Strong predictor of continued PCS
    • Ponsford J et al. Neuropsychology 2012;26:304-13

• Comorbid Major Depressive Disorder
  – Ranges from 26-42% in hospitalized TBI patients
  – 21.4% in mTBI
  – Can persist despite cognitive recovery
    • McCauley SR et al. Journal of Clinical and Experimental Neuropsychology 2001;23:792-808

• Negative illness perceptions
  • Hou R et al. J Neurol Neurosurg Psychiatry 2012;83:217-223

• Motivational factors
Non Sports Related Youth Concussion Outcomes

  – “Pre-existing child and family factors displayed an increasingly strong association with PCS over time”

  – “Patients with premorbid conditions (e.g. previous head injury, learning difficulties, or behavioral problems) may also have increased risk”
Predictors of Post Concussion Syndrome in Young Athletes

• Retrospective case-control study
• 40 patients with PCS (sx > 3 mo.) matched by age at injury and sex to SRC control patients
• Data collection
  – Demographic variables
  – Key medical, psychiatric, and family history
  – Acute-phase post-injury symptoms (0-24 hours)
  – Sub-acute-phase post-injury features (0-3 weeks)

Predictors of Post Concussion Syndrome in Young Athletes

• Risk for developing PCS
  – History of previous concussion (p = 0.010)
  – Delayed symptom onset (> 3 hours) (p < 0.001)

Predictors of Post Concussion Syndrome in Young Athletes

• Risk for developing PCS
  – History of mood disorders (p=0.002), other psychiatric illness (p=0.039)
  – History of significant life stressors (p = 0.036)
  – Family history of mood disorders (p = 0.006) and other psychiatric illness (p = 0.031)
  – Family history of migraine (p = 0.003)

Predictors of Post Concussion Syndrome in Young Athletes

• Development of PCS not predicted by:
  – Race
  – Insurance status
  – BMI
  – Sport
  – Helmet use
  – Type of symptom endorsement
  – Medication use
  – Learning disability
  – ADHD

Treatment of Persistent Concussion Symptoms
Subsymptom Threshold Exercise Training

- Prospective case series
- 7 men and 5 women (16-53 y.o.) with an average of 19 weeks of symptoms (6-40) after a concussion using the Graded Symptom Checklist (GSC).
- Symptom exacerbation during a graded treadmill exercise test

Subsymptom Threshold Exercise Training

• Subjects performed an incremental treadmill exercise test to the first sign of symptom exacerbation which defined maximum HR

• Exercised at 80% of maximum HR (the subsymptom threshold heart rate), once per day for 5 to 6 days per week

• Target HR adjusted by symptom monitoring and sequential treadmill exercise testing

Subsymptom Threshold Exercise Training

• Outcomes
  – Exercise time improved from a baseline mean of 9.75 +/- 6.38 minutes to 18.67 +/- 2.53 minutes at treatment termination (P = .001)
  – Symptoms improved  GCS at baseline 9.67 (range 2.39–18.46)  GCS at study conclusion 5.42 (range, 0.58–12.41)
  – No significant differences in resting HR or BP before and after intervention
  – No significant differences in the HR:VO2 or SBP:VO2 slopes before versus after treatment

Persistent Concussion Symptoms and Cervicovestibular Rehabilitation

- Prospective randomized controlled trial of concussed patients with symptoms of dizziness, neck pain and/or headaches of ≥ 10 days

- Patients aged 12-30 with n=15 in treatment group and n=14 in control group
  - For up to 8 weeks, both groups received postural education, range of motion exercises and cognitive and physical rest until asymptomatic followed by a protocol of graded exertion. The intervention group also received cervical spine and vestibular rehabilitation

### Primary Outcome Measure
- Number of days from treatment initiation until medical clearance to return to sport

### Secondary Outcome Measures
- 11-point Numeric Pain Rating Scale
- Activities-specific Balance Confidence Scale
- Dizziness Handicap Index
- SCAT2
- Dynamic Visual Acuity
- Head Thrust Test
- modified Motion Sensitivity Test
- Functional Gait Assessment
- Cervical Flexor Endurance (CFE) test
- Joint Position Error (JPE) test

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Formal vestibular function testing was not performed

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Persistent Concussion Symptoms and Cervicovestibular Rehabilitation

• Primary outcome
  – Treatment group, 73% (11/15) of the participants were medically cleared for RTP within 8 weeks of initiation of treatment
  – Control group, 7% (1/14)

• Secondary outcomes
  – Treatment group, greater improvement only in the SCAT2 total score (Wilcoxon rank-sum, p=0.009) and the Dizziness Handicap Inventory Score (Wilcoxon rank-sum, p=0.019)

Youth Sports Concussion and Post-Concussive Symptoms

• Prospective randomized controlled trial of patients with persistent symptoms ≥ 1 month following sports-related concussion

• Patients aged 11-17 received collaborative care (n =25) or care as usual (n=24).
  – Collaborative care -care management, cognitive behavioral therapy (CBT), and evidence-based pharmacotherapy

  – McCarty CA et al. “Collaborative Care for Adolescents with Persistent Post-Concussive Symptoms A Randomized Clinical Trial” Pediatrics 2016;138(4):e20160459
Youth Sports Concussion and Post-Concussive Symptoms

• Patients were assessed prior to randomization and after 1, 3 and 6 months.
• The two groups were compared over time using linear mixed effects regression models.

— McCarty CA et al. “Collaborative Care for Adolescents with Persistent Post-Concussive Symptoms A Randomized Clinical Trial” Pediatrics 2016;138(4):e20160459
Youth Sports Concussion and Post-Concussive Symptoms

• Primary outcome measures
  – *Post-concussive Symptoms* Health Behavior Inventory (HBI)
  – *Depressive Symptoms* The Patient Health Questionnaire (PHQ-9)
  – *Anxiety Symptoms* The PROMIS-PA8
  – *Quality of Life* The Pediatric Quality of Life Inventory (PEDS-QL)

• Secondary outcome measures
  – *Family Functioning* The General Functioning subscale of the Family Assessment Device (FAD-GF)
  – *Parental Mental Health* The PHQ-9
  – *Satisfaction with Care* Client Satisfaction Questionnaire and an additional 5 items assessing general satisfaction

  – McCarty CA et al. “Collaborative Care for Adolescents with Persistent Post-Concussive Symptoms A Randomized Clinical Trial” *Pediatrics* 2016;138(4):e20160459
Youth Sports Concussion and Post-Concussive Symptoms

- **Outcomes at 6 months**
  - *Post-concussive symptoms*: high levels reported by only 13% of intervention patients versus 41.7% of control patients (RR=.03) (HBI ≥ 22)
  - *Functional status*: child-report, improvement of a mean of 27.7 in the intervention group and 17.8 for controls (mean difference, 9.8; 95% CI, 0.9, 18.8) (PEDS-QL) and by parent-report, improvement of 33.3 points in the intervention group and 19.3 in the control group (mean difference, 13.8; 95% CI, 4.6, 23.1) (PEDS-QL)
  - *Depression*: 78.3% intervention patients demonstrated depressive symptom response (>50% reduction in depressive symptoms) compared to 45.8% of patients in the usual care group (RR=1.71(1.05,2.79) (PHQ-9)
  - McCarty CA et al. “Collaborative Care for Adolescents with Persistent Post-Concussive Symptoms A Randomized Clinical Trial” Pediatrics 2016;138(4):e20160459
Youth Sports Concussion and Post-Concussive Symptoms

• Outcomes at 6 months
  • Satisfaction with care  82.6% of intervention patients were “very satisfied” with their care as compared to 45.8% of patients in the control group (p=.001)  87% of parents of intervention patients and 29.2% of parents of patients in the control group reported “very satisfied” with care (p<0.0001).

  – McCarty CA et al. “Collaborative Care for Adolescents with Persistent Post-Concussive Symptoms A Randomized Clinical Trial” Pediatrics 2016;138(4):e20160459
## Persistent Symptoms Outcomes

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<tr>
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<th>Exercise</th>
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What are we treating?
Referral After SRC

• Treatment should be individualised and target-specific medical, physical and psychosocial factors identified on assessment. There is preliminary evidence supporting the use of:
  – an individualized symptom-limited aerobic exercise program in patients with persistent post-concussive symptoms associated with autonomic instability or physical deconditioning, and
  – a targeted physical therapy program in patients with cervical spine or vestibular dysfunction, and
  – a collaborative approach including cognitive behavioural therapy to deal with any persistent mood or behavioural issues.

Referral After SRC

- Overall, these are difficult cases that should be managed in a multidisciplinary collaborative setting, by health care providers with experience in SRC.

Confounding Factors

- Overlooking or misinterpreting pre-existing, co-existing and/or persisting musculoskeletal and psychological symptoms can result in spurious and expensive treatment, unnecessary restrictions from academic, sporting and social activities, and skewed data regarding sports concussions.
THANK YOU