

Canadian Olympic and Paralympic Sport Institute Network

HIGH PERFORMANCE SPORT-RELATED CONCUSSION GUIDELINES

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RÉSEAU DES INSTITUTS DU SPORT



**Contributors: Dr. Brian Benson (CMO CSI Calgary), Dr. Suzanne Leclerc (CMO INS), Dr. Steven Dilkas (CMO CSI Ontario), Dr. Paddy McCluskey (CMO CSI Pacific), Dr. Christine Atkinson (CMO CSI Atlantic), Dr. Mike Wilkinson (CMO COC), Dr. Andrew Marshall (CMO CPC), Dr. Andy Van Neutegem (Vice President, Performance Sciences, Research and Innovation, Own the Podium).*

Preamble

This document provides a guideline for high performance sport organizations (i.e., National Sport Organizations (NSOs)) in the Canadian Olympic and Paralympic Sport Institute (COPSI) Network. Due to the different settings and rules of individual sports, international federations, and healthcare jurisdictions, adoption of these concussion guidelines may need to be done in accordance with their specific regulatory environment²⁶. This guideline is not meant to be used as a prescriptive clinical practice directive or legal standard of care and should not be interpreted as such. Rather, it provides recommendations for healthcare professionals working in the high-performance sport system that can be adapted for different sports and regulatory environments, consistent with evidence, expert consensus, and experience. The COPSI Network and Own the Podium (OTP) support each Canadian Sport Institutes and Centres research initiatives in the spirit of advancing the applied science and clinical care for athletes sustaining a sport-related concussion.

Recommendations / suggestions were provided based on the Oxford Centre for Evidence-Based Medicine Levels of Evidence²⁷. If the quality and quantity of such evidence are sufficient (level 1-3) to be confident that any portion of the assessment or management strategy should be conducted, we *recommend* that assessment or management strategy. If liability or medico-legal concerns advise an element of an assessment or management strategy, we *recommend* that element. Where evidence is of limited quantity and/or quality (level 4 or 5), and that limited evidence advises a particular component of assessment or management as best practice, we *suggest* it.

Disclaimer

Although the present document contains specific evidence-informed information that was considered current as of August 2023, the contributing authors acknowledge that sport-related concussion guidelines will continue to evolve, and the most current emerging research evidence may add to or replace these guidelines. Therefore, this document is not intended to replace seeking help from a trained medical professional with concussion expertise in the process of adapting and implementing the guidelines. The COPSI Network concussion guidelines will be reviewed annually and updated with any new medical and scientific advances, and/or with any learned experiences through implementation.

1. Concussion Definition

Sport-related concussion (SRC) is defined as:

"a traumatic brain injury caused by a direct blow to the head, neck or body resulting in an impulsive force being transmitted to the brain that occurs in sports and exercise-related activities. This initiates a neurotransmitter and metabolic cascade, with possible axonal injury, blood flow change and inflammation affecting the brain. Symptoms and signs may present immediately, or evolve over minutes or hours, and commonly resolve within days, but may be prolonged.

No abnormality is seen on standard structural neuroimaging studies (computed tomography or magnetic resonance imaging T1- and T2-weighted images), but in the research setting, abnormalities may be present on functional, blood flow or metabolic imaging studies. Sport-related concussion results in a range of clinical symptoms and signs that may or may not involve loss of consciousness. The clinical symptoms and signs of concussion cannot be explained solely by (but may occur concomitantly with) drug, alcohol, or medication use, other injuries (such as cervical injuries, peripheral vestibular dysfunction) or other comorbidities (such as psychological factors or coexisting medical conditions)"³⁰.

The **operational definition** of concussion (used interchangeably with mild traumatic brain injury (mTBI) when neuroimaging is normal)³⁸ developed by the Mild Traumatic Brain Injury Task Force of the American Congress of Rehabilitation Medicine Brain Injury Special Interest Group requires a plausible



mechanism of injury and clinical evidence of an acute physiological disruption of brain function³⁷. The operational definition provides clinicians with well-defined practical criteria (with qualifiers) to base a clinical diagnosis. The diagnostic criteria based on evidence reviews and Delphi method for expert consensus are as follows:

Criterion 1: Mechanism of Injury

- transfer of mechanical energy to the brain from external forces (e.g., significant impact to the head, face, neck, or body).

Criterion 2: Clinical Signs

- *one or more* of the following immediately following injury:
 - loss of consciousness (e.g., no protective action taken on falling after impact or lying motionless and unresponsive).
 - alteration of mental status (or upon regaining consciousness), evidenced by reduced responsiveness or inappropriate responses to external stimuli; slowness to respond to questions or instructions; agitated behavior; inability to follow two-part commands; or disorientation to time, place, or situation.
 - complete or partial amnesia for events (or after regaining consciousness). If post-traumatic amnesia cannot be reliably assessed (e.g., due to polytrauma or sedating analgesics), retrograde amnesia (i.e., a gap in memory for events immediately preceding the injury) can be used as a replacement for this criterion.
 - other acute neurologic sign(s) (e.g., observed motor incoordination upon standing, seizure, or tonic posturing).

Criterion 3: Acute Symptoms

- *2 or more* new or worsening symptoms including:
 - acute subjective alteration in mental status (e.g., confused, disoriented, dazed).
 - physical symptoms such as headache, nausea, dizziness, balance problems, vision problems, sensitivity to light, and/or sensitivity to noise.
 - cognitive symptoms such as feeling slowed down, “mental fog,” difficulty concentrating, and/or memory problems.
 - emotional symptoms such as uncharacteristic emotional lability and/or irritability.

Qualifiers

- experiencing 2 symptoms within a single category is sufficient.
- other symptoms may be present, but they should not be counted toward Criterion 3.
- the onset of other symptoms (physical, cognitive, and emotional) may be delayed by a few hours, but they nearly always appear less than 72 hours from injury.

Criterion 4: Clinical Examination and Laboratory Findings

- cognitive impairment on acute clinical examination.
- balance impairment on acute clinical examination.
- oculomotor impairment or symptom provocation in response to vestibular-oculomotor challenge on acute clinical examination.
- * elevated blood biomarker(s) indicative of intracranial injury.



Qualifiers

- clinical and laboratory tests meeting standards of reliability and diagnostic accuracy should be considered for Criterion 4.
- impairment is defined as a clinically meaningful discrepancy between post-injury test performance and pre-injury (baseline) test performance or age-appropriate normative reference data (where available).
- the diagnostic sensitivity of most clinical and laboratory tests decreases over the first 72 hours following injury and the rate of sensitivity decline differs between specific tests.
- * although specific advanced neuroimaging (e.g., diffusion MRI, functional MRI (resting, task), magnetic resonance spectroscopy (MRS), cerebral blood flow, relaxometry, quantitative susceptibility mapping, near infrared spectroscopy (NIRS), etc.), fluid-based biomarkers (e.g., blood, urine, saliva, cerebrospinal fluid), genetic testing (e.g., apolipoprotein E $\epsilon 4$ (*APOE4* $\epsilon 4$) allele, mRNA expression in peripheral blood mononuclear cells, etc.), and emerging technologies (e.g., auditory and visual quantitative electroencephalograms (EEG) or brain event-related potentials (ERP), brainstem potential to speech sounds (Frequency-Following Response (FFR)), heart rate (HR), blood pressure and HR variability (HRV), transcranial doppler ultrasound, eye tracking technologies (pupillary light reflex, reaction time, gaze stabilization, pursuits, saccades, fixation), rotatory chairs, Sensory Organization Test (SOT), robotic devices (Kinarm), inertial sensors, virtual reality modalities, Fitbit, etc.) have demonstrated sensitivity in detecting acute neurological impairments of concussion and tracking recovery, there is **not sufficient evidence at this time to recommend routine use of these modalities in clinical practice**. These tools remain valuable in the study of concussion with the goal of validating for clinical diagnosis and monitoring/ascertaining neurobiological recovery⁴¹.

Criterion 5: Neuroimaging

- * trauma-related intracranial abnormalities on computed tomography (CT) or structural magnetic resonance imaging (MRI).

Qualifiers

- * neuroimaging is **not necessary to diagnose concussion** (or mild TBI). Its primary clinical role is to rule out head and brain injuries that might require neurosurgical or other medical intervention in an acute care setting.
- * if a post-traumatic intracranial abnormality is present (e.g., contusions, intracranial hemorrhage), this is **indicative of traumatic brain injury (TBI), and not concussion**.
- the Canadian CT Head Rule is a validated clinical decision aid to help physicians rule out the presence of intracranial injuries that would require neurosurgical intervention without the need for CT imaging (Appendix B)³⁹.

Criterion 6: Not better accounted for by confounding factors

- pre-existing and/or co-occurring health conditions determined to not fully account for the clinical signs, acute symptoms, clinical examination and laboratory findings that are necessary for the diagnosis such as:
 - **signs** better accounted for by acute musculoskeletal pain, psychological trauma, alcohol, or substance intoxication, pulmonary or circulatory disruption, syncope prior to fall.



- **symptoms** better accounted for by drug, alcohol, or medication use, musculoskeletal injury involving the neck or peripheral vestibular dysfunction, psychological conditions such as acute stress reaction to trauma, and pre-existing health conditions.
- **clinical exam and laboratory findings** better accounted for by drug, alcohol, or medication use, co-occurring physical injuries or psychological conditions, pre-existing health conditions, or factors influencing the validity of the symptom reporting or test results.

Qualifiers

- consideration should be given to cultural and linguistic differences in symptom reporting and test performance.
- clinical and laboratory test interpretation requires age-appropriate scales and/or cut-off scores³⁷.

2. Sport Concussion Policy, Protocol and Education

The implementation of laws and protocols that mandate removal from play following actual or suspected concussion, receiving medical clearance to return-to-play from a qualified healthcare professional, and educating coaches, parents and athletes regarding concussion signs and symptoms have demonstrated a significant reduction in recurrent concussion rates^{30,33}.

It is *recommended* that all *high-risk (e.g., high-speed, contact/collision/combat, acrobatic or other sports having environmental or fall risk) Olympic winter and summer NSOs/PSOs have an up-to-date sport concussion policy and protocol in place that is, at a minimum, compliant with Rowan's Law (Concussion Safety, 2018, S.O. 2018, c. 1 - Bill 193)¹⁶, which specifically addresses: 1) concussion education/awareness, 2) code of conduct, 3) removal from sport, and 4) return to learn/sport. All athletes, coaches, medical staff, integrated support team (IST) members, management, executive staff, officials, and other stakeholders should conduct themselves in ways that minimize the risk of concussion, maximize its recognition, and prevent continuation or premature return to high-risk sport activities until they have fully recovered, as judged by the team or consulting physician. It is also *recommended* that sports not meeting the criteria to be considered *high-risk have a concussion policy in place for concussions that may occur during training or competition. All stakeholders must review the concussion protocol prior to the first day of competitive season (or upon joining a team if thereafter). For coaches, formal qualification education requirements such as the Concussion Awareness Program of The Coaching Association of Canada¹⁷ must be met.

* **Olympic winter sports:** Alpine Skiing (Downhill, Slalom, Super-G, Giant Slalom, Super Combined, Team Event, Ski Cross), Bobsleigh, Figure Skating, Freestyle Skiing (Moguls, Aerials, Halfpipe, Slopestyle/Big Air), Ice Hockey, Luge, Skeleton, Ski Jumping, Snowboard (Halfpipe, Slopestyle, Snowboardcross, Alpine), Speed Skating – Short and Long Track.

* **Olympic summer sports:** Artistic Swimming, Athletics – Pole Vault, Basketball, Boxing, Cycling (BMX, Cyclo-cross, Road, Track, Mountain bike), Diving, Equestrian, Fencing, Field Hockey, Gymnastics, Handball, Judo, Karate, Rugby, Soccer, Taekwondo, Trampoline, Volleyball, Water Polo, Wrestling.

* **Paralympic winter sports:** Para-Alpine Skiing (Visually Impaired, Standing, Sitting), Para-Ice Hockey, Para-Snowboard.

* **Paralympic summer sports:** Blind Football, Para-Cycling, Para-Equestrian, Goalball, Judo, Sitting Volleyball, Soccer 7-A-Side, Wheelchair Athletics, Wheelchair Basketball, Wheelchair Rugby.



3. Pre-season Baseline (uninjured) Neurological Assessment

Concussion is a diffuse injury with many different signs and symptoms and the potential to adversely affect several neurological systems and brain processes. Each athlete is unique with a different set of physical, cognitive and psychosocial attributes that affects their individual susceptibility, outcome and recovery following a concussive injury. Neurological impairment following a concussion may be subtle, but if missed, may have grave immediate and potential long-term consequences in a high-risk sporting context. An annual standardized, pre-season multi-modal baseline assessment establishes normal neurological function at an individual level and helps facilitate clinical diagnosis of concussion and individualized, targeted management recommendations with an objective comparison of post-concussion assessment results.

Annual pre-season baseline assessments are also considered essential in the para-athlete population⁴⁸. Baseline assessments for these athletes should include a comprehensive evaluation of pre-injury cognitive function and abilities such as vision, speech, language, hearing, sensorimotor function, manual dexterity, postural stability, muscle tone, autonomic function, and a safe cervical spine range of motion as one or more such systems may be compromised making it challenging to ascertain neurologic impairment following a suspected concussion, particularly if the clinician conducting the post-concussion assessment has no prior knowledge of the athlete⁴⁸. Custom baseline and post-concussion assessments may be required for athletes with specific disabilities such as alternative methods of communication if there is visual impairment (e.g., Braille, assistive text-to-speech technology, frequency-following response (FFR)⁵⁰⁻⁵², electroencephalograph (EEG) and Evoked Response Potentials (ERP)^{52,53}), visual cues for intellectual impairment, caution with cervical spine assessment for Down's syndrome, achondroplasia, osteogenesis imperfecta, and spinal cord injured athletes, using the wheelchair error scoring system (WESS)⁴⁹ for balance assessment in athletes with lower limb neurological impairment (i.e., arthrogryposis, post-polio syndrome, muscular dystrophy, multiple sclerosis, spinal cord injury, spina bifida, amputees), and using a hand cycle ergometer for autonomic assessment and post-concussion exercise prescription for wheelchair athletes and amputees)⁴⁸.

It is recognized that pre-season baseline assessments have time, expertise, and cost implications, particularly if advanced technology, modalities, and techniques are used to comprehensively assess cognition, sensorimotor function, oculovestibular, electrophysiological, and autonomic nervous system function. Because advanced neuroimaging, fluid-based biomarkers, electrophysiological, autonomic, and other emerging technological assessments are demonstrating promise in measuring the acute neurobiological effects of concussion and changes over the course of recovery⁴¹, it is important to continue prospective longitudinal research using emerging objective assessment tools to ascertain the reliability, clinical usefulness, and potential integration into clinical practice (resource dependent) for high performance athletes.

During the pre-season and prior to the first day of the competitive season (if possible), we *recommend* all identified high-risk sport athletes undergo the following baseline assessments:

- Medical information questionnaire, including a detailed past medical history such as previous concussion, neck injuries and specific para-athlete disability, description of recovery from previous concussions, neurological conditions, psychological / psychiatric conditions, comorbidities such as migraines, attention-deficit/hyperactivity disorder (ADHD), dyslexia, learning disability, sleep disorder, temporomandibular joint (TMJ) disorder, visual pathology, medications, supplements, allergies, alcohol use, and recreational drug use.
- Validated screening questionnaires for anxiety, depression, and sleep disorders³¹ (i.e., SMHAT-1⁴⁴, GAD-7⁴⁵, PHQ-9⁴⁶, ASSQ⁷²)
- Sport Concussion Assessment Tool (SCAT6)³²



- Vision/Vestibular/Oculomotor Assessment (e.g., Visual Acuity using Snellen Chart (note corrected/uncorrected), King-Devick^{19,28}, Vestibular/Ocular Motor Screening (VOMS)^{20,29})
- Orthostatic Vital Signs (e.g., blood pressure (BP) and heart rate (HR) in the supine position (after 2 minutes rest) followed by repeat measures after 1 minute standing, with documentation of any symptoms (e.g., lightheaded, dizzy, nausea, blurred vision, fainting, lack of concentration) associated with postural change)
- Cognitive Assessment (may include web-based neurocognitive/neuropsychological assessment²¹ such as Immediate Post Concussion Assessment and Cognitive Test (ImPACT), ANAM, Axon, CogState Sport, etc.) in a distraction-free environment
 - it is recognized that web-based neurocognitive testing has cost and resource implications and should not take precedence over programs to provide clinical care^{26,30}.

Standardized pre-season baseline assessments should be completed under the supervision / guidance of the team or consulting physician on an annual basis, ideally at the time of COPSI Network Athlete Intake²². Assessments should be administered and interpreted by an individual or interdisciplinary team of healthcare professionals that are trained and experienced with the sport concussion clinical assessments (e.g., certified athletic therapist, physiotherapist, kinesiologist, physician, neuropsychologist, etc.).

To optimize test performance validity, **standardization** of baseline assessment procedures and measurement approaches are needed to be able to reliably assess for post-concussion neurological impairment following a sport-related concussion and to assist with ascertaining recovery (i.e., return to pre-injury levels of function and performance). Athletes should be instructed to refrain from consuming any caffeinated beverages or engaging in strenuous exercise within four (4) hours of baseline testing. It is also important that the athlete is tested in a nourished, hydrated and in a "wakefulness" state and should not be tested if the athlete has been under the influence of any drugs or alcohol in the 24hour period prior to baseline assessment.

Other important **assessment considerations** that may impact test results include having the athlete: a) void their bladder prior to testing, b) wear comfortable clothing and footwear, c) refrain from any tobacco/nicotine products 12 hours prior to testing, d) refrain from taking vitamins/supplements four (4) hours prior to testing, e) refrain from taking any medication four (4) hours prior to testing (unless medically necessary), f) considering the order of testing if a comprehensive multi-modal neurological assessment is conducted, g) clear instructions and supervision of testing, h) motivation for maximal effort (if applicable), and i) awareness of physical/mental fatigue (charted in notes section if recognized).

Important **environmental considerations** include: a) temperature 20 degrees Celsius, b) quiet environment with no external noises/conversations, c) avoiding distractions (e.g., smart phone silenced and put away, no parents/visitors/spectators), and d) avoiding food odors in close vicinity of testing.

4. Concussion Recognition and Removal from Sport Participation for Medical Evaluation

Evidence supports recognition and timely clinical assessment of any suspected concussion facilitating early diagnosis and recovery, reducing the risk of early complications and reducing the risk of potential subsequent brain and musculoskeletal injuries^{26,30}. All sport stakeholders including athletes, parents, coaches, IST members, officials, volunteers, and licensed healthcare professionals are responsible for the recognition and reporting of athletes with actual or suspected concussion³⁴. If a concussion is suspected (e.g., significant impact to the head, face, neck, or body) and the athlete demonstrates any of the visual signs/behaviors of a suspected concussion or reports any concussion-like symptoms³⁴ (Appendix A), the athlete **must** be removed from training / competition and evaluated immediately³².

We *recommend* a team certified athletic therapist, physiotherapist, chiropractor, or physician (hereafter



referred to as “medical team”) be onsite during practice/training and competition for high-risk sports. This individual must be trained and experienced in assessment and management of acute sport-related concussion.

In the event of a traumatic force delivered to the head, face, neck, or body where the athlete demonstrates any visible signs or symptoms of a suspected concussion:

- The athlete must report to the medical team for assessment (or event physician if no member of the medical team is present).
- Coaches should report any suspicion of a concussion to the medical team or event physician (if no member of the medical team is present).
- If the suspected concussed athlete is assessed by a healthcare professional not associated with the team, the team physician should also be notified (as soon as possible) to assist with management.
- If no member of the medical team is available, the suspected concussed athlete should be escorted by a teammate, coach, or responsible adult to a physician. Subsequent follow-up should then be arranged with the team or a consulting physician.
- In the case where athletes are competing out-of-country, follow-up with the team physician may be conducted by telephone, virtual consult, etc., where available. The team physician should also be contacted **PRIOR** to making air travel arrangements to return home.
- We *recommend* the diagnosis and management follow the principles laid out in the Summary and Agreement Statement of the Sixth International Symposium on Concussion in Sport - Amsterdam 2022³⁰.

The athlete should not be left alone following the injury and serial monitoring for deterioration by the medical team or responsible adult is essential over the initial few hours following injury. Problems may arise over the first 24-48 hours. We *recommend* that if the athlete experiences any of the following signs or symptoms (worsening headache, drowsiness, or inability to be awakened, inability to recognize people or places, repeated vomiting, unusual behavior (confusion or more irritable), seizures (arms and legs jerk uncontrollably), weakness or numbness in arms or legs, unsteadiness on their feet, slurred speech), they go to the nearest hospital emergency department immediately. The Canadian CT Head Rule is a validated clinical decision aid to help physicians rule out the presence of intracranial injuries that would require neurosurgical intervention without the need for CT imaging (Appendix B)³⁹. **Athletes CANNOT be cleared to return to unrestricted training, contact practice, and/or competition by paramedical staff or coaches.**

5. Acute Sport Concussion Assessment

a) Sideline / Field side Assessment

Standard emergency management principles must be adhered, with particular attention given to excluding a cervical spine injury, determining the disposition of athlete, and identifying any “Red Flags” listed in SCAT6 and the Concussion Recognition Tool 6 (Appendix A)³⁴. If an athlete is suspected of sustaining a more severe head or spine injury during training/competition, an ambulance must be called immediately to transfer the patient to the nearest emergency department for further medical assessment. If there is no concern for a more serious head or spine injury and after the first aid issues have been addressed, all suspected cases of concussion must be removed from the playing field and assessed by the medical team in a distraction-free environment where possible (i.e., medical room with only members of the medical team present). We *recommend* formal concussion assessment be completed using the SCAT6 and other clinical measures at the medical staff’s discretion.



A trained and experienced certified athletic therapist, physiotherapist or physician providing medical coverage for the sporting event may make the determination that a concussion has not occurred based on the results of a SCAT6 and multi-faceted medical assessment. It is important to note that any screening evaluation that does not include a multimodal assessment of signs, symptoms, balance, gait, neurological and cognitive changes associated with a potential concussion may be inadequate to allow continued sports participation³⁰. Athletes removed from sport with a suspected concussion and subsequently cleared to return to training or competition must undergo serial re-evaluations for up to 48 hours because of the possibility of delayed symptom onset³⁰. We *recommend* that if the athlete develops any delayed symptoms the athlete be removed from training or competition and undergo comprehensive assessment in the clinic by a physician experienced with concussion.

Because of the evolving nature of concussion in the acute phase, athletes suspected to have sustained a concussion after an acute sideline evaluation shall not return to practice or competition on the same day of injury, regardless of the resolution of concussion symptoms.

b) Clinic Assessment

Healthcare professionals lack a single “gold standard” assessment tool to reliably and objectively determine whether an athlete has sustained a sport-related concussion and/or definitively ascertain whether they have recovered. Concussion is a diffuse brain injury with many different signs and symptoms that differ from individual to individual and the potential for several coexisting, overlapping and confounding pathologies (e.g., cervical, vestibular, coexisting medical conditions such as anxiety, depression, migraine headaches, ADHD, etc.). Most clinical tests evaluate a single neurological system or brain process typically affected by concussion and high-performance athletes have an innate ability to adapt secondary compensatory mechanisms to injury⁴⁷. Thus, a comprehensive multi-modal neurological assessment battery which includes dual tasking may be necessary to reveal neurological impairment following concussion.

The Sport Concussion Assessment Tool (SCAT) has been shown to have the greatest utility in the first 72 hours and up to a week following the injury^{41,42}. After 72 hours, the Sport Concussion Office Assessment Tool (SCOAT6) should be used for serial multimodal assessments conducted in a clinical setting³¹.

The SCOAT6 includes the following assessments:

- timed 10-word recall (or 15-word if athlete finds easy) and digit backwards tests
- orthostatic blood pressure (BP) and heart rate (HR) in the supine position (after 2 minutes rest) followed by repeat measures after 1 minute standing, with documentation of any symptoms (e.g., lightheaded, dizzy, nausea, blurred vision, fainting, lack of concentration) associated with postural change
 - clinically significant if an athlete experiences postural change symptoms **and** systolic BP *drops* ≥ 20 mmHg, diastolic BP *drops* ≥ 10 mmHg or HR *increases* > 30 beats per minute (bpm)
- cervical spine evaluation (range of motion, palpation, etc.)
- neurological examination, including cranial nerves, limb tone, strength, deep tendon reflexes, sensation, cerebellar function
- balance (modified BESS or using a foam surface)
- timed tandem gait x 3, noting any inability, unsteadiness/sway, fall/overstep, dizziness/nausea
 - optional complex tandem gait (forwards / backwards with eyes closed)



- optional dual task gait with choice of three cognitive tasks
- modified Vestibular-Ocular Motor Screen (mVOMS)
- delayed word recall a minimum of 5 minutes after completion of the verbal list and memory tests
- computerised neurocognitive test batteries (e.g., ImPACT, ANAM, Axon, CogState Sport, etc.) may also add value (resource dependent)
- validated anxiety, depression, and sleep screening³¹.

Concussion remains a ***clinical diagnosis based on the clinician's judgement*** with the aid of a comprehensive clinical history and multi-modal neurological assessment as soon as possible following the injury, with comparison to healthy baseline assessment results (where available) to aid with decision-making and individualized treatment recommendations.

6. Sport Concussion Management

Depending on the athlete's symptom severity profile, relative (not absolute) rest (physical and cognitive) is advised in the initial **24 - 48 hours** post-concussion to reduce energy demands and ease discomfort / symptoms. Examples of physical and cognitive relative rest includes:

- minimizing exposure to visual and auditory stimulation (e.g., electronics, computer use, television, texting, social media streaming, video games, concerts, etc.)
- minimizing excessive cognitive tasks including studying, reading, etc.
- quiet, lower-light environments if light or noise sensitive
- removal from potential stressful situations such as media attention, interviews, team meetings, etc.

Other important aspects to consider in this immediate post-concussion period include:

- avoiding alcohol, driving or recreational drug use
- maintaining regularly scheduled fluid intake (hydration), sleep schedule, meals, and snacking (whole foods)
- avoiding new prescription medication or other analgesia unless prescribed by a physician experienced in concussion management.

After 24 - 48 hours of relative rest, athletes should be encouraged to become gradually and progressively more active while staying below their cognitive and physical symptom-exacerbation thresholds (i.e., physical or cognitive activity should not bring on new or worsen existing symptoms) if there is no risk of head impact, collision or falls. Slight worsening of symptoms (up to two points on a 10-point scale) with low-risk exercise or cognitive activity is acceptable if the symptoms improve within one hour³⁰. Other aspects of acute concussion management important to consider include:

- Brief napping (<30 minutes) if needed, but avoid excessive daytime sleep
- Strong evidence exists regarding the benefits of physical activity and aerobic exercise treatment as early interventions^{30,65}
- Cervicovestibular rehabilitation (i.e., individualized neck and balance treatment) is indicated for athletes with neck pain, stiffness and/or decreased range of motion, headaches, dizziness and/or balance problems^{30,66}



- Based on the results of a comprehensive multi-modal neurological assessment, vision therapy, psychotherapy and exercise prescription may be warranted by a certified health care professional experienced in the management of concussion
- It is *recommended* that the athlete progress through a graduated exertional return-to-sport strategy in accordance with the principles outlined in the Amsterdam 2022 Concussion in Sport Consensus Statement³⁰ (Appendix D: Return-to-Sport Strategy). It is important that youth and adult student-athletes return to full-time school activities (Appendix C: Return-to-Learn Strategy²⁵) before progressing to stages 4, 5 and 6 of the Return-to-Sport Strategy.

Each athlete's concussion should be individually managed based on the treating physician's clinical judgment.

7. Return to Sport

Evidence has demonstrated that the window for physiological recovery typically outlasts symptom recovery^{1,2,15,30}. There is also evidence to suggest that the risk of musculoskeletal injury is significantly higher for athletes sustaining a sport-related concussion in the subsequent 12 months following their concussive injury^{1,3-14}.

If the athlete's post-concussion clinical assessment is comparable to baseline (healthy, uninjured) or normative data (as judged by the treating physician), the elevated risks associated with return to high-risk sport must be discussed with the athlete along with prevention / risk reduction strategies. We *recommend* the athlete sign an informed consent letter acknowledging that they were explained the risks, given the opportunity to ask questions, and provided an opportunity to request an independent/second opinion by a physician experienced with sport-related concussion depending on the unique characteristics of their concussion history and duration of recovery (Appendix E: Athlete Informed Consent / Acknowledgement Letter).

We *recommend* athletes return to unrestricted training and competition only after the following circumstances have occurred:

- (1) there is complete resolution of concussion-related symptoms at rest,
- (2) there is no recurrence of concussion-related symptoms at exertion levels required for unrestricted training and competition,
- (3) the athlete's post-concussion neurological status has returned to baseline status (or normative data) as judged by the team physician, and
- (4) the athlete is confident to return to high-risk activity/sport and has been educated about the elevated risk of recurrence with risk-reduction strategies. We *suggest* using the Injury-Psychological Readiness to Return to Sport Scale^{70,71} or a similar validated scale to formally assess confidence to return to high-risk sport participation.

There is no mandatory period that an athlete must be withheld from participation following a concussion, as the return to sport decision is based on the individual circumstances of that athlete and team physician's professional judgment. It is recognized that the concussed athlete may be vulnerable to recurrence / further injury in the seven-day period following injury due the pathophysiology of concussion and the recovery process, even if symptoms resolve early and do not recur with cognitive or physical activity progression in the acute phase of injury^{1,15,62}.



The team physician remains solely responsible for making return to sport decisions based on these parameters, including in circumstances where the athlete is referred for an independent/second opinion to a physician with experience in sport-related concussion.

8. Persistent Symptoms

Approximately 20-30% of patients will experience persistent symptoms (i.e., symptom duration >4 weeks)^{30,63,64}. It is important to recognize that persistent symptoms may or may not necessarily reflect ongoing physiological injury to the brain or a single pathophysiological entity. There may be a constellation of non-specific post-traumatic symptoms that may be linked to coexisting and/or confounding factors such as anxiety, post-traumatic stress, depression, neck or musculoskeletal pain, vestibular injury, migraine, ADHD, learning disability, etc.). Any athlete with persistent symptoms requires comprehensive multi-modal assessment under the direction of a physician experienced in concussion management to identify specific primary and secondary pathologies that may be contributing to their protracted recovery. Depending on the unique characteristics of the athlete and duration of recovery, athletes may require a more advanced targeted assessment by a multi-disciplinary team with experience in one or more of the following areas:

- cervical (physiotherapist, athletic therapist, chiropractor)
- vestibular (therapist or audiologist with specialized vestibular training, otology/neurotology Ear, Nose and Throat (ENT) physician experienced with concussion)
- visual system (neuro-optometrist / neuro-ophthalmologist)
- auditory (audiologist)
- sleep (sleep specialist)
- autonomic nervous system (exercise physiologist, physiotherapist, athletic therapist)
- cognitive (neuropsychologist)
- mental health (psychologist, psychiatrist)
- headache / traumatic brain injury management (i.e., structural brain injury) (neurology, physiatry, neurosurgery)

We *recommend* treatment be individualized and targeted to the specific medical, physical, and psychosocial factors identified on the multi-disciplinary assessments.

9. Long-Term Effects

The potential long-term effects of sport-related concussion and repetitive head impacts are areas of ongoing public health interest and concern among both healthcare professionals and the general public³⁰. Studies establishing a definitive causal association between participation in sports and future neurodegeneration are methodologically limited by a failure to control for many factors associated with mental health, brain health and neurological disease including genetic factors, educational achievement, socioeconomic status, smoking, hypertension, diabetes, cardiovascular disease, sleep apnea, social isolation, white matter hyperintensities, diet, physical activity, or exercise⁶⁹. Future well-designed studies controlling for as many of these potential confounding as possible are needed to establish a clear causal association³⁰.

10. Prevention Strategies



Primary concussion prevention strategies (i.e., preventing the injury before it occurs) have been a daunting task for health care practitioners and sport scientists⁵⁵. Most concussion prevention research to date has been focused on modifiable extrinsic risk factors. There is a void or gap in sport concussion epidemiologic research on modifiable intrinsic risk factors^{55,56,57}. Effective sport-specific risk-reduction strategies supported in the literature include policy or rule changes reducing collisions in ice hockey and American football³³, neuromuscular warm-up programmes in rugby³⁵⁻³⁶, and mouthguard use in ice hockey³³. Implementation of optimal concussion management strategies that lead to early assessment, diagnosis, prompt treatment and medical clearance to return to sport (i.e., secondary prevention) have also been shown to reduce recurrent concussion rates³³ and the potential for long-term performance and health consequences.

The recursive nature of concussion susceptibility suggests that effective primary prevention strategies should be aimed at several risk factors concurrently to reduce athletes' susceptibility to injury⁵⁶. Until such time that there is sufficient evidence to recommend additional effective primary prevention strategies, the integration of promising modifiable intrinsic strategies in the pre-season to potentially reduce athlete's susceptibility to concussion and other injuries are important areas for further research in high performance sport. Promising intrinsic strategies identified in the literature include dynamic neck stabilization⁵⁸⁻⁵⁹ and a combination of dynamic vision, sensorimotor, and higher cognitive processing skills to be able to anticipate contact/collisions/falls and make a rapid neuromotor response to avoid injury mechanisms⁶⁷⁻⁶⁸. Improving psychological resiliency may also add further potential to reduce athlete's injury susceptibility.

11. Retirement from Sport Considerations

There is no clear evidence on how many concussions are considered too many to contemplate retirement from higher risk sport participation. There is evidence to suggest that a history of previous concussion increases the risk of recurrence and/or may lead to a protracted recovery³⁰. Retirement decisions are complex and because there is no absolute patient-specific, injury-specific, or imaging-related evidence to support retirement recommendations, decision-making should be individualized and consider athlete preferences and risk tolerance, type of sport, style of play, sociocultural factors, psychosocial factors, confidence and readiness to return to sport based on a comprehensive, multi-disciplinary clinical evaluation led by a physician experienced with sport-related concussion and high-performance sport⁶⁰. Athletes may require a 3rd party independent assessment to assist with retirement decision-making in cases where the athlete suffers persistent symptoms, or where the athlete experiences a pattern of repeat concussions with less impact force resulting in more severe symptoms that take longer to recover (i.e., reduced "threshold effect").

12. Parasport Considerations

Given the wide range of impairments among parasport athletes, clinicians face difficulties when applying traditional sport concussion assessment tools which are not validated nor applicable in many respects in this population⁴⁸. Without reliable and sensitive assessments of neurological function, it is also difficult to prescribe effective patient-tailored interventional therapies based on individual pathology.

The limited data on assessment and management of the concussed parasport athlete necessitates a need for prospective longitudinal concussion research in this population to gain a better understanding of normal neurologic function in athletes with different disabilities, develop objective, reliable and valid multi-modal baseline and post-concussion assessment tools customized to the type of disability and impairment, assess the effectiveness of management strategies that are targeted and individualized to athletes with various impairments, and develop evidence-based prevention strategies in this athletic population⁴⁸.



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Appendix A

Concussion Recognition Tool 6



What is the Concussion Recognition Tool?

A concussion is a brain injury. The Concussion Recognition Tool 6 (CRT6) is to be used by non-medically trained individuals for the identification and immediate management of suspected concussion. It is not designed to diagnose concussion.

Recognise and Remove

Red Flags: CALL AN AMBULANCE

If **ANY** of the following signs are observed or complaints are reported after an impact to the head or body the athlete should be immediately removed from play/game/activity and transported for urgent medical care by a healthcare professional (HCP):

- Neck pain or tenderness
- Seizure, 'fits', or convulsion
- Loss of vision or double vision
- Loss of consciousness
- Increased confusion or deteriorating conscious state (becoming less responsive, drowsy)
- Weakness or numbness/tingling in more than one arm or leg
- Repeated Vomiting
- Severe or increasing headache
- Increasingly restless, agitated or combative
- Visible deformity of the skull

Remember

- In all cases, the basic principles of first aid should be followed: assess danger at the scene, check airway, breathing, circulation; look for reduced awareness of surroundings or slowness or difficulty answering questions.
- Do not attempt to move the athlete (other than required for airway support) unless trained to do so.
- Do not remove helmet (if present) or other equipment.
- Assume a possible spinal cord injury in all cases of head injury.
- Athletes with known physical or developmental disabilities should have a lower threshold for removal from play.

If there are no Red Flags, identification of possible concussion should proceed as follows:

Concussion should be suspected after an impact to the head or body when the athlete seems different than usual. Such changes include the presence of **any one or more** of the following: visible clues of concussion, signs and symptoms (such as headache or unsteadiness), impaired brain function (e.g. confusion), or unusual behaviour.

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CRT6

Concussion Recognition Tool

To Help Identify Concussion in Children, Adolescents and Adults



1: Visible Clues of Suspected Concussion

Visible clues that suggest concussion include:

- Loss of consciousness or responsiveness
- Lying motionless on the playing surface
- Falling unprotected to the playing surface
- Disorientation or confusion, staring or limited responsiveness, or an inability to respond appropriately to questions
- Dazed, blank, or vacant look
- Seizure, fits, or convulsions
- Slow to get up after a direct or indirect hit to the head
- Unsteady on feet / balance problems or falling over / poor coordination / wobbly
- Facial injury

2: Symptoms of Suspected Concussion

Physical Symptoms	Changes in Emotions
Headache	More emotional
"Pressure in head"	More Irritable
Balance problems	Sadness
Nausea or vomiting	Nervous or anxious
Drowsiness	
Dizziness	Changes in Thinking
Blurred vision	Difficulty concentrating
More sensitive to light	Difficulty remembering
More sensitive to noise	Feeling slowed down
Fatigue or low energy	Feeling like "in a fog"
"Don't feel right"	
Neck Pain	

Remember, symptoms may develop over minutes or hours following a head injury.

3: Awareness

(Modify each question appropriately for each sport and age of athlete)

Failure to answer any of these questions correctly may suggest a concussion:

- "Where are we today?"
- "What event were you doing?"
- "Who scored last in this game?"
- "What team did you play last week/game?"
- "Did your team win the last game?"

Any athlete with a suspected concussion should be - IMMEDIATELY REMOVED FROM PRACTICE OR PLAY and should NOT RETURN TO ANY ACTIVITY WITH RISK OF HEAD CONTACT, FALL OR COLLISION, including SPORT ACTIVITY until ASSESSED MEDICALLY, even if the symptoms resolve.

Athletes with suspected concussion should **NOT**:

- Be left alone initially (at least for the first 3 hours). Worsening of symptoms should lead to immediate medical attention.
- Be sent home by themselves. They need to be with a responsible adult.
- Drink alcohol, use recreational drugs or drugs not prescribed by their HCP
- Drive a motor vehicle until cleared to do so by a healthcare professional



Appendix B

Canadian CT Head Rule

CT head is only required for minor head injury patients with any one of these findings:

High Risk (for Neurological Intervention)

1. GCS score < 15 at 2 hrs after injury
2. Suspected open or depressed skull fracture
3. Any sign of basal skull fracture*
4. Vomiting \geq 2 episodes
5. Age \geq 65 years

Medium Risk (for Brain Injury on CT)

6. Amnesia before impact \geq 30 min
7. Dangerous mechanism ** (*pedestrian, occupant ejected, fall from elevation*)

*Signs of Basal Skull Fracture

- hemotympanum, 'raccoon' eyes, CSF otorrhea/rhinorrhea, Battle's sign

** Dangerous Mechanism

- pedestrian struck by vehicle
- occupant ejected from motor vehicle
- fall from elevation \geq 3 feet or 5 stairs

Rule Not Applicable if:

- Non-trauma cases
- GCS < 13
- Age < 16 years
- Coumadin or bleeding disorder
- Obvious open skull fracture

Stiell IG, et al. The Canadian CT Head Rule for Patients with Minor Head Injury. *Lancet* 2001;357:1391-96.



Appendix C

Return-to-Learn Strategy

Step	Mental activity	Activity at each step	Goal
1	Daily activities that do not result in more than a mild exacerbation* of symptoms related to the current concussion	Typical activities during the day (e.g., reading) while minimising screen time. Start with 5–15 min at a time and increase gradually.	Gradual return to typical activities
2	School activities	Homework, reading or other cognitive activities outside of the classroom.	Increase tolerance to cognitive work
3	Return to school part time	Gradual introduction of schoolwork. May need to start with a partial school day or with greater access to rest breaks during the day.	Increase academic activities
4	Return to school full time	Gradually progress in school activities until a full day can be tolerated without more than mild* symptom exacerbation.	Return to full academic activities and catch up on missed work

Following an initial period of relative rest (24–48 hours following an injury at Step 1), athletes can begin a gradual and incremental increase in their cognitive load. Progression through the strategy for students should be slowed when there is more than a mild and brief symptom exacerbation.

* Mild and brief exacerbation of symptoms is defined as an increase of no more than 2 points on a 0–10 point scale (with 0 representing no symptoms and 10 the worst symptoms imaginable) for less than an hour when compared with the baseline value reported prior to cognitive activity³⁰.



Appendix D

Return-to-Sport Strategy

Each step typically takes a minimum of 24 hours.

Step	Exercise strategy	Activity	Goal
1	Symptom-limited activity	Daily activities that do not exacerbate symptoms (e.g., walking)	Gradual reintroduction of work/school
2	Aerobic exercise 2A—Light (up to approximately 55% maxHR) then 2B—Moderate (up to approximately 70% maxHR)	Stationary cycling or walking at slow to medium pace. May start light resistance training that does not result in more than mild and brief exacerbation* of concussion symptoms.	Increase heart rate
3	Individual sport-specific exercise Note: If sport-specific training involves any risk of inadvertent head impact, medical clearance should occur prior to Step 3	Sport-specific training away from the team environment (e.g., running, change of direction and/or individual training drills away from the team environment). No activities at risk of head impact.	Add movement, change of direction
Steps 4–6 should begin after the resolution of any symptoms, abnormalities in cognitive function and any other clinical findings related to the current concussion, including with and after physical exertion.			
4	Non-contact training drills	Exercise to high intensity including more challenging training drills (e.g., passing drills, multiplayer training) can integrate into a team environment.	Resume usual intensity of exercise, coordination, and increased thinking
5	Full contact practice	Participate in normal training activities.	Restore confidence and assess functional skills by coaching staff
6	Return to sport	Normal game play.	

* **Mild and brief exacerbation of symptoms** (i.e., an increase of no more than 2 points on a 0–10 point scale for less than an hour when compared with the baseline value reported prior to physical activity). Athletes may begin Step 1 (i.e., symptom-limited activity) within 24 hours of injury, with progression through each subsequent step typically taking a minimum of 24 hours. If more than mild exacerbation of symptoms (i.e., more than 2 points on a 0–10 scale) occurs during Steps 1–3, the athlete should stop and attempt to exercise the next day. Athletes experiencing concussion-related symptoms during Steps 4–6 should return to Step 3 to establish full resolution of symptoms with exertion before engaging in at-risk activities. Written determination of readiness to return to sport



should be provided by a qualified healthcare professional before unrestricted return to sport as directed by local laws and/or sporting regulations.

HCP, healthcare professional; maxHR, predicted maximal heart rate according to age (i.e., $220 - \text{age}$)³⁰.



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Appendix E

Return to Sport following Concussion

Athlete Informed Consent / Acknowledgement Letter

Date: _____

Athlete Name: _____

Address/City: _____

Dear Athlete,

We are pleased that you no longer have concussion-like symptoms and have remained symptom free at rest, with cognitive and low-risk high-intensity physical activity, and during your post-concussion testing, indicating you are making good progress in your recovery. You examine well and your clinical assessment is comparable to baseline and/or normative data. It is now safe for you to progress to normal unrestricted training / practice if you feel confident to do so.

A member of our healthcare team has discussed the risks associated with returning to sport, including the elevated risk of recurrence given your history. You have indicated that you understand the risks, desire to return to unrestricted sport participation, and that you feel confident to do so.

The long-term risk and effects of multiple concussions is something that is difficult to predict. We don't know how many concussions a person can experience before there may potentially be some permanent impairment. We do know that some individuals never fully recover after one, two or more concussions, and that others can have multiple concussions each with apparent full recovery. We also know that with each successive concussion, there may be an increased risk that the next concussion may take longer to recover or might not result in a full recovery. Furthermore, we know that the risk of persistent symptoms, permanent impairment, or in rare circumstances death, is increased if a concussed individual experiences another traumatic force to the brain before they have recovered. This is why we go to such great lengths to ensure that your concussion has recovered (to our best clinical ability) before consideration of return to unrestricted training or competition.

In your individual situation, you have the following history which may place you at higher risk of recurrent injury, prolonged concussion-like symptoms, or incomplete recovery if you experience another concussion:

1. You have now had at least ____ concussions diagnosed by a healthcare professional.
2. ____ of your concussions had a prolonged recovery (>1 month).

By signing this letter, you acknowledge that you understand that you are returning to a sport that has a risk for concussion, and that because of your history you have an increased risk of recurrence, willingly accept this risk, and want to return to sport. You also acknowledge that you were given the opportunity to ask questions, your questions were satisfactorily answered, and you were provided an opportunity to



request an independent/second opinion by a physician experienced with sport-related concussion depending on the unique characteristics of your concussion history and duration of recovery.

Sincerely,

Healthcare Team Representative Name: _____

Healthcare Team Discipline / Credentials: _____

Healthcare Team Signature: _____

Physician: _____

Physician Signature: _____

Athlete Name: _____

Athlete Signature: _____

Parent / Guardian Name (if under 18 years): _____

Parent / Guardian Signature: _____

Date: _____

City / Location: _____

