Consensus statement on concussion in sport: the 6th International Conference on Concussion in Sport–Amsterdam, October 2022

Jon S Patricios,[1] Kathryn J Schneider,[2] Jiri Dvorak,[3] Osman Hassan Ahmed,[4,5] Cheri Blauwet,[6,7] Robert C Cantu,[8,9] Gavin A Davis,[10,11] Ruben J Echemendia,[12,13] Michael Makdissi,[14,15] Michael McNamee,[16,17] Steven Broglio,[18] Carolyn A Emery,[2] Nina Feddermann-Demont,[19,20] Gordon Ward Fuller,[21] Christopher C Giza,[22,23] Kevin M Guskiewicz,[24] Brian Hainline,[25] Grant L Iverson,[26,27] Jeffrey S Kutcher,[28] John J Leddy,[29] David Maddocks,[30] Geoff Manley,[31] Michael McCrea,[32] Laura K Purcell,[33] Margot Putukian,[34] Haruhiko Sato,[35] Markku P Tuominen,[36] Michael Turner,[37,38] Keith Owen Yeates,[39] Stanley A Herring,[40,41] Willem Meeuwisse[42]

For numbered affiliations see end of article.

Correspondence to
Dr Kathryn J Schneider, Sport Injury Prevention Research Centre, Faculty of Kinesiology, University of Calgary, Calgary, AB T2N 1N4, Canada; kjschnei@ucalgary.ca

JSP and KJS are joint first authors.

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ABSTRACT

For over two decades, the Concussion in Sport Group has held meetings and developed five international statements on concussion in sport. This 6th statement summarises the processes and outcomes of the 6th International Conference on Concussion in Sport held in Amsterdam on 27–30 October 2022 and should be read in conjunction with the (1) methodology paper that outlines the consensus process in detail and (2) 10 systematic reviews that informed the conference outcomes. Over 3½ years, author groups conducted systematic reviews of predetermined priority topics relevant to concussion in sport. The format of the conference, expert panel meetings and workshops to revise or develop new clinical assessment tools, as described in the methodology paper, evolved from previous consensus meetings with several new components. Apart from this consensus statement, the conference process yielded revised tools including the Concussion Recognition Tool-6 (CRT6) and Sport Concussion Assessment Tool-6 (SCAT6, Child SCAT6), as well as a new tool, the Sport Concussion Office Assessment Tool-6 (SCOAT6, Child SCOAT6). This consensus process also integrated new features including a focus on the para athlete, the athlete's perspective, concussion-specific medical ethics and matters related to both athlete retirement and the potential long-term effects of SRC, including neurodegenerative disease. This statement summarises evidence-informed principles of concussion prevention, assessment and management, and emphasises those areas requiring more research.

INTRODUCTION

This Amsterdam 2022 International Consensus Statement on Concussion in Sport (Statement) builds on previous Concussion in Sport Group (CISG) statements with the goal of updating current recommendations for sport-related concussion (SRC) through an evidence-informed consensus methodology. The purpose of this Statement is to provide a summary of the evidence and practice recommendations based on science and expert panel consensus recommendations at the time of the conference. Additional outputs of the consensus process include freely available evidence-informed tools to assist in the detection and assessment of SRC, including the Concussion Recognition Tool-6 (CRT6), Sport Concussion Assessment Tool-6 (SCAT6), Child SCAT6, Sport Concussion Office Assessment Tool-6 (SCOAT6) and Child SCOAT6. Apart from this Statement, in the interest of knowledge translation, the tools are free to distribute in their original formats.

This Statement is developed for the healthcare professional (HCP) involved in the care of athletes at risk of SRC or who have sustained a suspected SRC at any level of sport (ie, recreational to professional). The authors recognise that differences in geography, healthcare structure and culture are important considerations when implementing the principles presented. Thus, this Statement provides recommendations that can be adapted for different sport, clinical and cultural environments and is not meant to be used as a prescriptive guideline. We also recognise that the science of concussion continues to evolve, and the Amsterdam Statement reflects the state of the evidence at the time of the Consensus Conference and will need to be updated as new scientific information emerges. Also included are recommendations for future research where notable gaps in the literature have been identified. Although this Statement provides recommendations and is a summary of the consensus process, it should be read in combination with the 10 systematic reviews and methodology papers that informed the consensus process and outcomes.

MEDICOLEGAL CONSIDERATIONS

This Statement is not intended as a clinical practice directive or legal standard of care and should not

Key points

- ⇒ The Amsterdam 2022 International Consensus Statement on Concussion in Sport summarises published evidence at the time of the conference and should be read together with the 10 systematic reviews and the methodology paper.
- ⇒ Content and methodological advances were made in the consensus process including anonymous voting, summaries of alternate viewpoints, declarations of conflicts of interest in the open conference, plus inclusion of the athlete voice, para sport considerations and ethical perspectives.
- ⇒ The Concussion in Sport Group definition of concussion was updated while work continues toward a unified conceptual and operational definition.
- ⇒ Sport-specific strategies recommended as concussion prevention interventions include policy or rule changes reducing collisions, neuromuscular training in warm-ups, mouthguard use in ice hockey and implementation of optimal concussion management strategies to reduce recurrent concussion rates.
- ⇒ The Concussion Recognition Tool-6 (CRT6), Sport Concussion Assessment Tool-6 (SCAT6) and Child SCAT6 provide updated iterations of the acute sport-related concussion (SRC) tools best used in the first 72 hours (and up to 1 week) after injury. New office tools, the Sport Concussion Office Assessment Tool-6 (SCOAT6) and Child SCOAT6, were designed to better guide evaluation and management in an office setting from 72 hours after injury and for serial evaluations in the following weeks. The overlap between the SCAT6 and SCOAT6 is intentional and designed to facilitate easy transitions across tools.
- ⇒ The results of computerised neurocognitive tests should be interpreted in the context of broader clinical findings and are not to be used in isolation to inform management or diagnostic decisions.
- ⇒ Advanced neuroimaging, fluid-based biomarkers, genetic testing and emerging technologies are valuable research tools for the study of concussion but not yet suited for routine use in clinical practice.
- ⇒ Return-to-learn and return-to-sport strategies have been updated based on evolving evidence.
- ⇒ Strong evidence exists regarding the benefits of physical activity and aerobic exercise treatment as early interventions.
- ⇒ Cervicovestibuar rehabilitation is indicated for athletes with neck pain, headaches, dizziness and/or balance problems.
- ⇒ Individuals with persisting symptoms (ie, symptom duration >4 weeks) should be evaluated with a multimodal clinical assessment including the use of standardised and validated symptom rating scales.
- ⇒ The potential long-term effects of SRC and repetitive head impacts are areas of ongoing public health interest and concern among both healthcare professionals and the general public. It is proposed that a working group representing multiple disciplines and perspectives be established to guide appropriate research in this area.
- ⇒ Decisions regarding retirement or discontinuation from contact or collision sports are complex, multifaceted and should be individualised to consider patient, injury, sport-specific, ethical and psychosocial factors. A comprehensive multidisciplinary clinical evaluation is often necessary to inform decisions.
- ⇒ Limited evidence exists on SRC in patients aged 5–12 years.

Continued

Key points Continued

- ⇒ Concussion diagnosis and management in para athletes is challenging with limited data, requiring further research and dedicated clinical recommendations that consider a range of impairments.
- ⇒ Future research and consensus processes for concussion in sport should continue to evolve with an inclusive and interdisciplinary approach.

be interpreted as such. The information conveyed is provided in good faith and without warranties of any kind, either expressed or implied. It does not constitute medical, legal or other professional advice or services. This document is only a guide and is of a general nature, consistent with the reasonable practice of an HCP. Individual assessment, treatment, management and advice will depend on the facts and circumstances specific to each individual case. Given the many different cultures, resources, healthcare systems and other factors to be considered when managing athletes at risk of or who have sustained a concussion, the summary of evidence and recommendations from this Statement can be used and adapted to inform local and regional processes. It is intended that this Statement will be formally reviewed and updated before the end of 2027.

METHODS

The proposed conference process was developed by the Scientific Committee and informed by the *British Journal of Sports Medicine* (BJSM) author guidelines for consensus statements,[1] built on previous methodology[2] and consensus processes in other fields.[3–7] The detailed methodology for the consensus process is outlined in figure 1 and explained in detail in a separately published paper.[8] Electronic voting (e-voting) by the expert panel on the content of this Statement is reflected in figure 2. Consensus agreement was defined a priori as 80% majority. Dissenting viewpoints are also presented in figure 2. All original research studies informing the recommendations in this Statement are cited in the associated systematic reviews.

Equity, diversity and inclusion statement

The 31 expert panellists represented multiple disciplines from nine different countries (Australia, Canada, Finland, Japan, South Africa, USA, UK, Switzerland, Czech Republic), six were women, two identified as non-White and one was a former Paralympian. Experts were all senior clinicians and researchers across multiple disciplines and areas of expertise, but several early career researchers were involved as authors in the systematic reviews. Although more expansive than previous consensus processes, the need for greater geographical and demographic diversity and inclusion among the expert panel and authors has been identified by the Scientific Committee, and a postconference survey was conducted to help determine equity, diversity and inclusion (EDI) focus areas.

SPORT-RELATED CONCUSSION

The Consensus Statement from the Berlin 2016 International Conference on Concussion in Sport[9] refers to the ‘11 Rs’ of SRC (RECOGNISE, REDUCE, REMOVE, REFER, RE-EVALUATE, REST, REHABILITATE, RECOVER, RETURN-TO-LEARN/RETURN-TO-SPORT, RECONSIDER and RESIDUAL EFFECTS) to provide a logical flow of clinical concussion

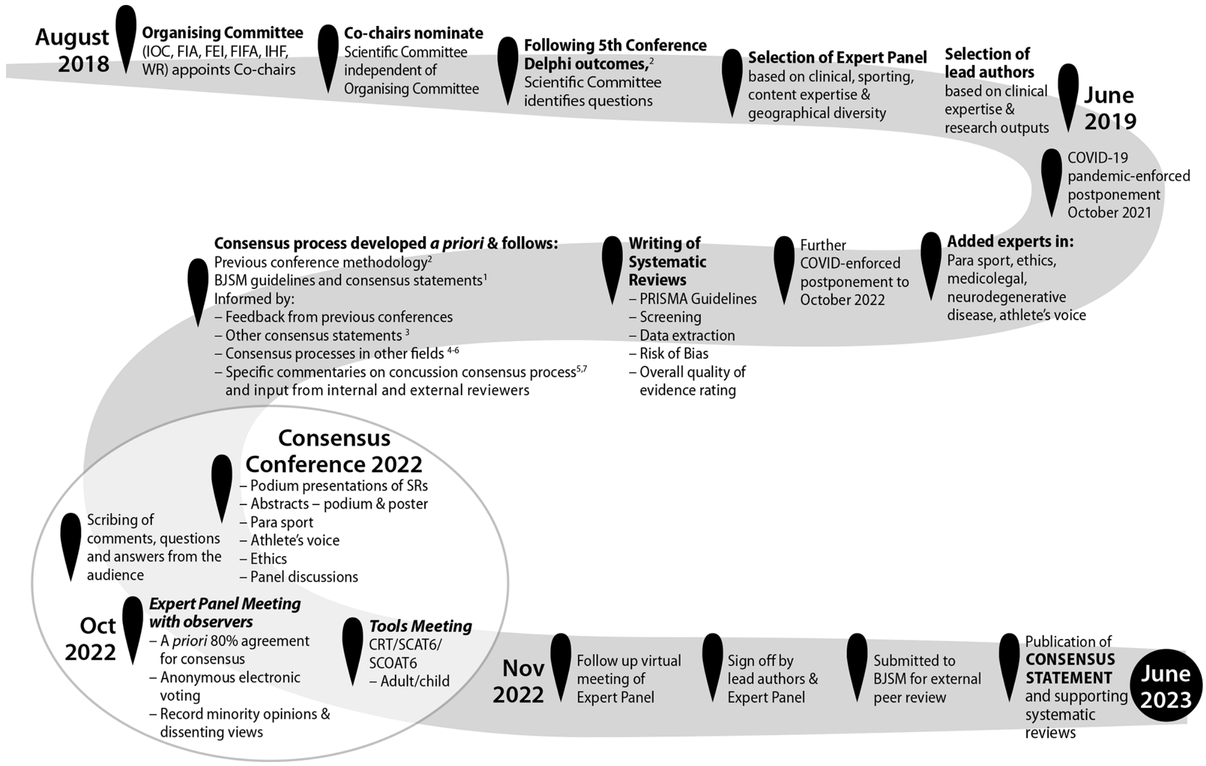

Figure 1 Methodology and process for the Sixth International Conference on Concussion in Sport and the Development of the Amsterdam 2022 Consensus Statement. CRT, Concussion Recognition Tool; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; SCAT6, Sport Concussion Assessment Tool-6; SCOAT6, Sport Concussion Office Assessment Tool-6; SRs, systematic reviews.

management and considerations. A similar format has been followed for the Amsterdam 2022 Statement with additional 'Rs' including RETIRE, to address issues related to potential career-ending decisions, and REFINE, to highlight the need to embrace ongoing strategies to advance the field.

New recommendations determined at the Amsterdam 2022 meeting that were anonymously e-voted on by the expert panel (figure 2) are italicized.

RECOGNISE: DEFINITION OF SPORT-RELATED CONCUSSION

The CISG proposed a conceptual definition of SRC in 2001.[10] This definition has undergone updates and modifications at subsequent CISG meetings, with the most recent being in Berlin in 2016.[9] In preparation for the Amsterdam International Consensus Conference on Concussion in Sport, the Scientific Committee considered that the Berlin definition required modification to align with more recent scientific evidence relating to advances in our understanding of SRC pathophysiology. The conceptual definition, accepted as a majority decision (78.6%) but not reaching an 80% consensus, is:

Sport-related concussion is 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).

The conceptual definition above does not provide specific diagnostic criteria. Diagnostic criteria using an operational definition for mild traumatic brain injury have recently been published.[11] They were developed by the Mild Traumatic Brain Injury Task Force of the American Congress of Rehabilitation Medicine (ACRM) Brain Injury Special Interest Group through rapid evidence reviews and a Delphi expert consensus process. A unified conceptual and operational definition remains a desirable aim of both the CISG and ACRM.

REDUCE: PREVENTION OF CONCUSSION

A focus on primary concussion prevention will mitigate the burden of injury, risk of recurrent injury and potential for persisting symptoms. Sport policy-makers and HCPs are encouraged to identify and optimise SRC prevention strategies in their environment. Implementing primary prevention of SRC across all levels of sport is a priority that can have a significant public health impact. In the past 5 years, there has been a threefold increase in studies examining the effectiveness of SRC prevention that have assessed policy and rule changes, personal protective equipment, training strategies and management. Studies including children and adolescents represented over 60% of studies evaluating SRC prevention strategies.[12]

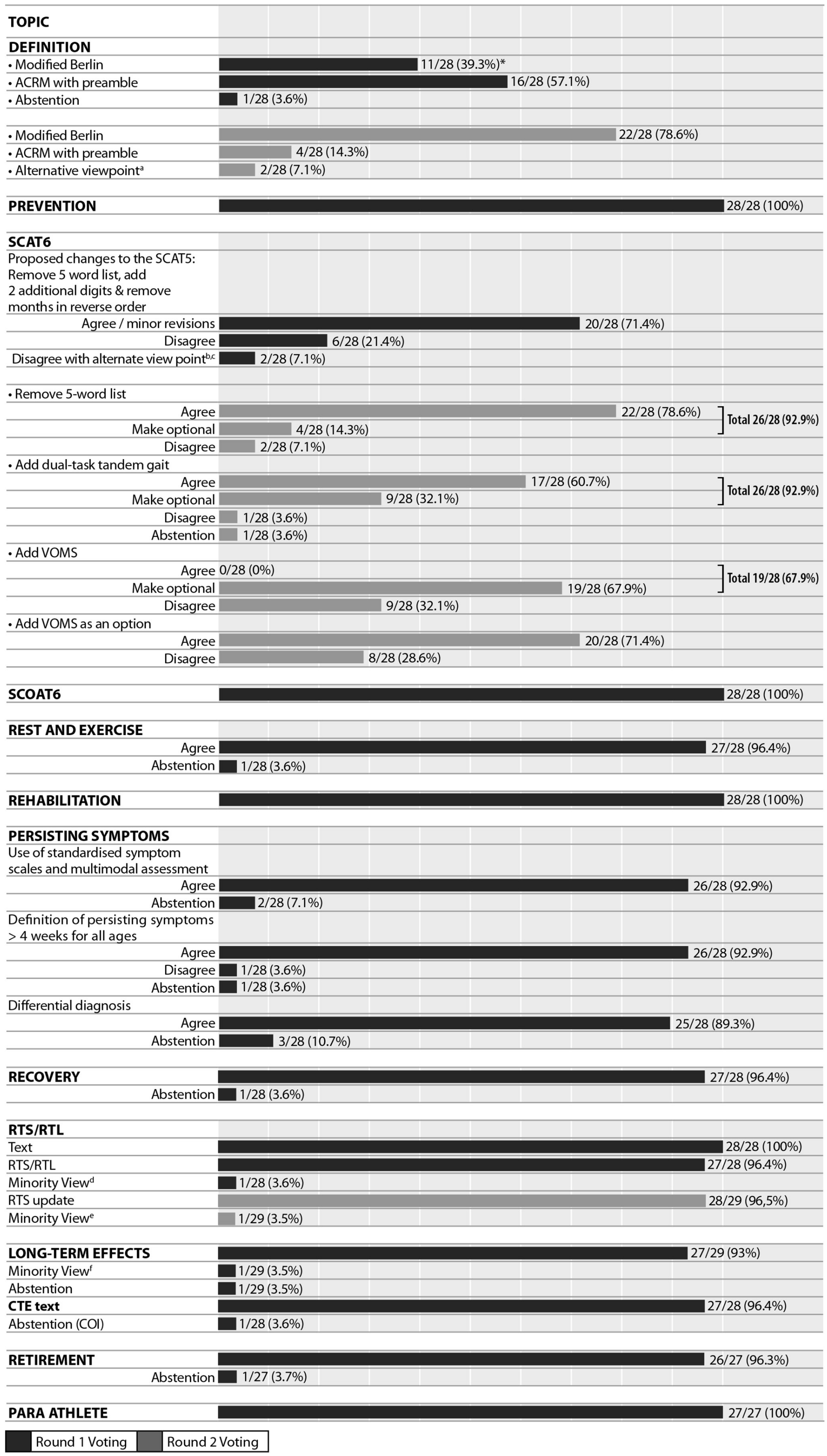

Figure 2 Expert panel voting for content included in the 2022 Amsterdam Consensus Statement. Dissenting opinion: [a]In this setting, concussion needs to be defined based on pathological constructs, not clinical ones, as the symptoms of concussion are non-specific. There is a differential diagnosis for concussion presentations/symptoms that must be considered. Using a definition schema based only on symptoms would greatly increase false-positive diagnoses and negatively affect patient care. [b]Recommend retaining a timed version of the months of the year in reverse. [c]Make no

Figure 2 (Continued)

changes. [d]Must not rely on daily schedule protocol for RTS. [e]Suggest a change to stage 3. [f]Do not include CTE because it is a neuropathological diagnosis. Notes: * 'Agree' or 'Agree with minor revisions' votes were considered as consensus support for the presented text. • Twenty-nine members of the expert panel were in attendance in Amsterdam; one was absent due to illness; the moderator did not vote making the maximum number of votes 28. • One expert panel member had to leave urgently in the late afternoon, reducing the total number to 27 for the last two topics. • Thirty members of the expert panel attended the follow-up Zoom meeting (Topics 9. RTS update and 10. Long-term effects); again, the session moderator did not vote making the maximum number of votes 29. ACRM, American Congress of Rehabilitation Medicine; COI, Conflict of interest; CTE, chronic traumatic encephalopathy; FEI, Fédération Equestre Internationale; FIA, Fédération Internationale de l'Automobile; FIFA,Fédération Internationale de Football Association; IIHF, International Ice Hockey Federation; IOC, International Olyympic Committee; RTL, return-to-learn; RTS, return-to-sport; SCAT, Sport Concussion Assessment Tool; SCOAT6, Sport Concussion Office Assessment Tool-6; VOMS, Vestibular-Ocular Motor Screen; WR, World Rugby.

Policy or rule changes

The policy disallowing body checking in child or adolescent ice hockey reduced the rate of concussion in games by 58%.[12] Further, the policy had no unintended consequences, as a greater number of years of experience in body checking leagues did not reduce concussion rates in adolescent ice hockey leagues that allow body checking across all levels of play.[13–16] Evidence supports that policies disallowing body checking in youth ice hockey prevent concussions, and these policies should be applied for all levels of children's ice hockey and most levels of adolescent ice hockey.[12 15–18]

Policy and rules limiting the number and duration of contact practices, intensity of contact in practices and strategies restricting collision time in practices in American football across all age groups have led to an overall 64% reduction in practice-related concussions and to reduced head impact rates.[12] Future research should focus on the prospective evaluation of relevant sport-specific policy and rule modifications aimed to reduce SRCs and head impact rates. Limiting contact practice in American football should inform related policies and recommendations for all levels of play.[12]

Personal protective equipment

Mouthguards were associated with a 28% reduced concussion rate in ice hockey across all age groups, indicating that mouthguards should be mandated in child and adolescent ice hockey and supported at all levels of play.[12] Evaluation of headgear in non-helmeted contact and collision sport requires more research to inform headgear recommendations.[12]

Training strategies

Participation in on-field neuromuscular training (NMT) warm-up programmes completed at least three times per week has been associated with a lower rate of concussion in Rugby Union (rugby) across all age groups.[19] NMT warm-up programmes are recommended in rugby to reduce concussion rates. The effect of NMT programmes to reduce concussion rates specifically has not been assessed in other sports. While extensive evidence exists to support the effectiveness of NMT warm-up programmes in reducing all injuries and lower extremity injuries, more research is needed for NMT warm-up programmes in women and other team sports specifically targeting exercise components aimed to reduce concussion rates.[20]

Concussion management

Optimal concussion management strategies including implementing laws and protocols (eg, mandatory removal from play following actual or suspected concussion; requirements to receive clearance to return-to-play from an HCP; and education of coaches, parents and athletes regarding concussion signs and symptoms) are associated with a reduction in recurrent concussion rates.[12]

The panel unanimously supported the following recommendations for prevention:

- *Mouthguard use should be supported in child and adolescent ice hockey.*
- *Policy disallowing body checking should be supported for all children and most levels of adolescent ice hockey.*
- *Strategies limiting contact practice in American football should inform related policies and recommendations for all levels.*
- *NMT warm-up programmes are recommended, based on research in rugby, and more research is needed for female athletes and in other team sports specifically targeting exercise components aimed to reduce concussion rates.*
- *Policy supporting optimal concussion management strategies to reduce recurrent concussion rates is recommended.*

REMOVE: SIDELINE EVALUATION

The recognition of concussion is the first step to initiating the management of SRC. Removal of a player from the field of play should be done if there is suspicion of a possible concussion to avoid further potential injury. This may be based on a player's symptoms or signs observed by other players, medical staff or officials (on the field or video). Signs that warrant immediate removal from the field include actual or suspected loss of consciousness, seizure, tonic posturing, ataxia, poor balance, confusion, behavioural changes and amnesia.[21] Players exhibiting these signs *should not return* to a match or training that day, *unless evaluated acutely by an experienced HCP* with a multimodal assessment (as noted below) who determines that the sign was not related to a concussion (eg, the player has sustained a musculoskeletal injury and thus unable to balance). Maddocks' questions remain part of a useful and brief on-field screen for athletes >12 years of age without clear on-field signs of a concussion; incorrect answers warrant a more comprehensive off-field evaluation as does any clinical suspicion of concussion. Symptoms and signs of a concussion may evolve over minutes, hours or days. Whether acute concussion is suspected or confirmed, the player should be serially re-evaluated in the coming hours and days.[21 22]

Designed to assist in the multimodal evaluation of athletes, previous versions of the SCAT have been shown to be most effective in discriminating between concussed and non-concussed athletes within 72 hours of injury and up to 5–7 days postinjury, although their clinical utility appears to diminish after 72 hours. Ceiling effects were apparent on the 5-word list learning and concentration subtests.[21] Use of more challenging tests, including the 10-word list, was recommended. Differences were found among the 3 forms of the list learning task,[23] suggesting that the forms are not equivalent in difficulty. Test–retest data revealed limitations in temporal stability across subtests.[21] Except for the symptom scale, these tools may not be appropriate for use in the return-to-sport (RTS) decision-making process beyond 7 days postinjury. Empirical data are limited in some sports and for preadolescent, female and para athletes, suggesting a need for more globally diverse research including athletes from underrepresented groups.

The bullet points below present the recommendations and considerations for modifying the previous iteration of the SCAT[22] to develop the SCAT6 and Child SCAT6.[21] The Child SCAT6 should be used in patients aged 8–12 years. The final determinations of content included in the SCAT6 and Child SCAT6 were based on findings from the systematic review as well as expert panel discussions highlighting the importance of the scientific evidence while balancing pragmatic considerations for the development and utility of the tools. For example, some expert panel members were hesitant to make changes that would invalidate existing normative data. Factors such as applicability and time constraints that exist during the acute/sideline evaluation guided considerations. The initially proposed changes to the SCAT5 that were voted on did not reach a consensus in the first round of voting. Following further discussions, subsequent voting on individual subcomponent tests to add/remove from the SCAT5 occurred to incorporate a specific test as 'recommended' or 'optional'. Each proposed change, except for the Vestibular-Ocular Motor Screen (VOMS), had >80% agreement to include as either recommended or optional (see figure 2 for details). As a result, the VOMS was not included in the SCAT6. Further, detailed deliberations regarding the development of the SCAT6 occurred during a dedicated Tools Meeting on day 4 of the Amsterdam Conference. As with previous versions, the SCAT6 and Child SCAT6 require validation.

The following recommendations were made based on the systematic review and subsequent expert panel discussions:

- *Create both paper and electronic formats of SCAT6/Child SCAT6/CRT6.*
- *Explore the development of alternate tools for serial evaluation in the office setting.*
- *Improve psychometric properties: longer word list (eg, 12- or 15-word list) and remove the 5-word list.*
- *Further examine form differences on existing 10-word lists and consider the use of regression-based norms.*
- *Create a cognitive composite score to improve test–retest reliability and reduce false positives.*
- *Add digits (ie, increase the longest string by two digits) to the digit span backward subtest to reduce ceiling effects.*
- *Revise months backward to include a component of timed information processing.*
- *Add timed dual gait tasks.*
- *Implement tests and/or procedures to assess the performance validity of baseline testing.*
- *Add a more robust set of visible signs to the SCAT6/Child SCAT6/CRT6, including: Falling with no protective action, tonic posturing, impact seizure, ataxia/motor incoordination, altered mental status and blank/vacant/dazed look.*
- Support serial SCAT6/Child SCAT6 assessments after an athlete is removed from play, for example, half-time after the game and 24–48 hours after injury.

Typically, the process of conducting a multimodal screen to evaluate a potential concussion takes at least 10–15 min. Sport organisations are strongly advised to allow for at least that amount of time for an adequate evaluation and to accommodate such an assessment off-field, preferably in a quiet area away from the pressures and scrutiny of match play. For athletes with potential signs of a concussion, any screening assessment short of a multimodal evaluation of symptoms, signs, balance, gait, neurological and cognitive changes associated with a potential concussion may be inadequate to allow continued sports participation. Sports whose rules currently do not facilitate such evaluations should strongly consider enacting rule changes in the interest of player welfare.

Based on the research on previous iterations, the SCAT has optimum utility in the first 72 hours and up to a week after injury.[22 24] The SCOAT6 or Child SCOAT6 tools are intended for multimodal and serial evaluations conducted in the office after 72 hours.

RE-EVALUATE: THE OFFICE ASSESSMENT

The purpose of developing a Sport Concussion Office Assessment Tool (SCOAT6/Child SCOAT6) was to give HCPs a standardised, expansive and age-appropriate clinical guide to a multidomain evaluation in the subacute phase (72 hours to weeks postinjury), with a view to guide individualised management.[25]

In some cases, a SCAT/Child SCAT may have been performed close to the time of acute injury, in which case the comparison of recorded symptoms and signs will be of value. In other scenarios, the SCOAT6/Child SCOAT6 may be the initial assessment used to inform SRC diagnosis and management.

The SCOAT6/Child SCOAT6 is designed to assist clinicians in assessing important clinical manifestations influencing the presentation of concussion, identifying areas for potential individualised therapeutic interventions, directing the need for specialist referral(s) and monitoring recovery.

The SCOAT6/Child SCOAT6 does not replace the HCP's clinical acumen; rather, it provides a standardised framework that can be adapted to help inform the clinical evaluation in an office setting. The Child SCOAT6 should be used in patients aged 8–12 years, while the SCOAT6 should be used in patients 13 years and older. These tools are meant to be used within the expertise and areas of competency of the clinician. We recognise that consultation time, available resources and practitioner experience will vary. As with earlier versions of the SCAT, the SCOAT6 requires evaluation, including an appraisal of its psychometric properties, validation (including at different time points postinjury, in different populations, cultures and languages) and modification with time and evolving evidence.[25]

The athlete's history of concussions, how each concussion was managed and recovery time should be noted. Medical and psychological diagnoses that may modify the presentation or recovery such as migraine, other headache disorder, anxiety and depression should be documented. The SCOAT6/Child SCOAT6 symptom scale mirrors that of the SCAT6/Child SCAT6. Preinjury (baseline), sideline or acute symptom scores, if available, should be used for comparison.[25]

The following were recommended to be included in an official evaluation of SRC (details included in the SCOAT6):

- *Word recall and Digit Backwards tests: The 10-word immediate recall and digit string backwards tests should be used.* If the athlete finds the word recall task too easy (eg, exhibits a ceiling effect), a 15-word list may be used.
- *Measurement of systolic and diastolic blood pressure as well as heart rate taken in two positions:*
  - *Supine position, rest for 2 min and take measurements.*
  - *Follow with the standing position, measure again after 1 min.*

  Symptoms brought on by a change in postural position (eg, lightheaded, dizzy or motion sensation) should be noted in the patient's record.
- *Evaluation of cervical spine range of motion, muscle spasm and palpation for segmental or midline tenderness.*

- *A neurological examination includes the assessment of cranial and spinal nerves, motor function, sensation and deep tendon reflexes.*
- *Timed tandem gait as a single task and a more complex dual task with the addition of a cognitive task (such as serial 7's, months backwards or word recall backwards).*
- *The modified Vestibular-Ocular Motor Screen (VOMS).*
- *Delayed word recall a minimum of 5 min after completion of the immediate word recall test.*

New content discussed at the dedicated Tools workshop (Day 4 of the Amsterdam Conference) led to additional recommended items for the Child SCOAT6 including:

- Additional symptoms for child and parent reports that capture multiple subacute domains.
- An age-appropriate measure of cognitive reaction time such as the Symbol Digit Modalities Test.
- Validated paediatric measures of (1) orthostatic tachycardia, (2) orthostatic intolerance, (3) vestibular and oculomotor function and (4) child mental health and sleep questionnaires.

It is not unusual to have athletes experience fear, anxiety or depression associated with concussion or as preinjury conditions exacerbated by concussion injury. Where deemed appropriate, HCPs are encouraged to screen for these symptoms using validated mental health screening instruments[26–28] *such as those included in the Sport Mental Health Assessment Tool (SMHAT).*[29]

Neurocognitive test batteries, where accessible, may add value to assessing SRC and its sequelae. Computer-based test batteries, especially in comparison of reaction times against patient baseline and community norms, may be useful. The results of these tests should be interpreted in the context of broader clinical findings and are not to be used in isolation to inform management or diagnostic decisions.[25]

The components of the SCOAT6/Child SCOAT6, many of which have been previously validated on their own and are typically used in clinical practice as individual tests, form a multimodal assessment that is designed to better inform the HCP's assessment and management of concussion and may be augmented by additional clinical measures and investigations. Where available, HCPs are further encouraged to make use of a multidisciplinary network to provide additional specialised diagnostic input, particularly in cases of persisting symptoms. In reviewing studies informing the SCOAT6, the period defined for the included papers was 3-30 days. HCPs may choose to use the SCOAT6 beyond this time frame but should be aware of the parameters of the review.

REST AND EXERCISE

The best available evidence shows that recommending strict rest until the complete resolution of concussion-related symptoms is not beneficial following SRC. Relative (not strict) rest, which includes activities of daily living and reduced screen time, is indicated immediately and for up to the first 2 days after injury.[30] Individuals can return to light-intensity physical activity (PA), such as walking that does not more than mildly exacerbate symptoms, during the initial 24–48 hours following a concussion.[30]

- *Clinicians are encouraged to recommend early (after 24–48 hours) return to PA as tolerated (eg, walking or stationary cycling while avoiding the risk of contact, collision or fall).*[30]
- *The best data on cognitive exertion show that reduced screen use in the first 48 hours after injury is warranted but may not be effective beyond that.*[31 32]
- *Individuals can systematically advance their exercise intensity based on the degree of symptom exacerbation experienced during the prior bout of aerobic exercise.*
- *HCPs with access to exercise testing can safely prescribe subsymptom threshold aerobic exercise treatment within 2–10 days after SRC, based on the individual's heart rate threshold (HRt) that does not elicit more than mild symptom exacerbation during the exercise test (eg, 'mild'=testing stops with an increase of more than two points on a 0–10 point scale when compared with the pre-exercise resting value). Subsymptom threshold aerobic exercise treatment can be progressed systematically based on the determination of the new HRt on repeat exercise testing (every few days to every week).*[33 34]

Athletes may continue/advance the duration and intensity of PA or prescribed aerobic exercise provided there is no more than mild (increase of no more than 2 points vs the pre-exercise value) and brief (<1 hour) exacerbation of their concussion-related symptoms.[30]

PA/exercise and cognitive exertion should be stopped if concussion symptom exacerbation is more than mild and brief and may be resumed once symptoms have returned to the prior level. Clinicians should inform their patients that mild symptom exacerbation during PA, prescribed aerobic exercise treatment or during cognitive activity is typically brief (under an hour) and does not delay recovery. Prescribed subsymptom threshold aerobic exercise within 2–10 days of SRC is effective for reducing the incidence of persisting symptoms after concussion (symptoms >1 month) and is also effective for facilitating recovery in athletes suffering from symptoms lasting longer than 1 month.[34] *Importantly, individuals should be advised to avoid the risk of reinjury (ie, contact, collision or fall) until determined by a qualified HCP to be safe for higher risk activities.*[30]

Sleep disturbance in the 10 days after SRC is associated with an increased risk of persisting symptoms and may warrant evaluation and treatment.[35 36]

REFER

Where the clinical environment allows, referral to clinicians with specialised knowledge and skills in concussion management should be considered for the targeted treatment of persisting symptoms.[37] This may include the management of cervicogenic symptoms, migraine and headache, cognitive and psychological difficulties, balance disturbances, vestibular signs and oculomotor manifestations.

Persisting symptoms (>4 weeks across all age groups) may be pre-existing, concussion-related or both. Serial multimodal evaluation using a tool such as the SCOAT6/Child SCOAT6, and additional detailed clinical evaluations for specific symptoms (eg, headaches, dizziness, cognition) can help guide referrals. Specialist clinicians whose diagnostic assessments, clinical evaluations and treatment interventions for SRC may be of use as part of a clinician network may vary depending on the region, practice culture and local healthcare environment, and available areas of competency and expertise.[25] This SRC clinician network may include sports medicine physicians, athletic trainers/therapists, physiotherapists, occupational therapists, sports chiropractors, neurologists, neurosurgeons, neuropsychologists, ophthalmologists, optometrists, physiatrists, psychologists and psychiatrists.

Specific recommendations include:

- *The term 'persisting symptoms' is used for symptoms that persist >4 weeks across children, adolescents and adults.*

- *Persisting symptoms can be assessed using standardised and validated symptom rating scales. However, evidence-based recommendations regarding the use of other specific tests or measures in the clinical diagnosis of persisting symptoms in any age group are not possible based on existing research.*[37]
- *A multimodal clinical assessment, ideally by a multidisciplinary team, is indicated to characterise individuals with persisting symptoms, including the types, pattern and severity of symptoms, and any associated conditions or other factors that may be causing or contributing to the symptoms.*

Symptoms attributed to concussion are non-specific, commonly also reported by healthy individuals and those with conditions other than concussion, and can be exacerbated by a variety of biopsychosocial factors aside from concussion, which should be assessed in the context of persisting symptoms. Other problems may exist prior to injury (but can be exacerbated by a concussion), co-occur with persisting symptoms or mimic persisting symptoms but do not arise from concussion. Common considerations in the context of persisting symptoms include mental health issues; learning or attention difficulties; visual, oculomotor, cervical and vestibular problems; headache disorders and migraine; sleep disturbance; dysautonomia, including orthostatic intolerance and postural orthostatic tachycardia syndrome; and pain.

REHABILITATION

If dizziness, neck pain and/or headaches persist for more than 10 days, cervicovestibular rehabilitation is recommended.[38] *If symptoms persist beyond 4 weeks in children and adolescents, active rehabilitation and collaborative care may be of benefit. For children, adolescents and adults with dizziness/balance problems, either vestibular rehabilitation or cervicovestibular rehabilitation may be of benefit. The inclusion of subsymptom threshold aerobic exercise (as outlined above) in combination with other treatments should be considered. In the case of a recurrence of symptoms when progressing through the return-to-learn (RTL) or return-to-sport (RTS) strategies, re-evaluation and referral for rehabilitation may be of benefit to facilitate recovery.*[38]

Rehabilitation may be targeted to individual symptoms or maybe more general and focus on overall recovery. The effects of combinations of rehabilitation, optimal timing for initiation of rehabilitation and modifying factors (such as age and sex) are not yet well established and require further evaluation.

RECOVERY

Assessment of clinical recovery

The determination of clinical recovery was found to vary across research studies and healthcare practices and depended on the research question under evaluation. Primary recovery outcomes include symptom ratings, specific clinical tests or groups of tests and functional domains such as RTL and RTS. In some investigations, only one clinical recovery outcome is reported, and these different outcomes make it difficult to compare results across studies. It is important to consider functional outcomes that are meaningful to athletes/patients such as a return to their preinjury levels of function and performance.[38] Thus, we recommend that clinical evaluation and future research include three components in the determination of recovery:

1. Assessment of symptom reports (including concussion-related symptom resolution at rest, with cognitive activities and following physical exertion).
2. Other outcomes relevant to ongoing symptoms or a specific research question (eg, response to physical exertion, post-traumatic headaches, standing balance, dynamic balance, vestibulo-ocular reflex (VOR) function, oculomotor (OM) function, symptom reproduction with VOR and OM testing (eg, VOMS), cognition, dual tasking).
3. Measures of return to activity such as RTL and RTS (see below).

Role of biomarkers and technology in assessing recovery

Advanced neuroimaging, fluid-based biomarkers, genetic testing and other emerging technologies are useful for research focused on SRC diagnosis, prognosis, and recovery. However, further research is required to validate their use in clinical practice to assess recovery and aid in the clinical management of SRC.[39]

In the research setting, the employment of advanced neuroimaging, fluid-based biomarkers, electrophysiological measures and modalities assessing autonomic dysfunction show promising sensitivity to acute neurobiological effects and changes over the course of SRC recovery. Moreover, evidence across multiple biomarker domains suggests that a time window of physiological change may extend beyond clinical recovery (ie, resolution of clinical signs and symptoms). However, it remains unknown whether residual alterations are pathological, adaptive or benign processes given insufficient longitudinal data linking neurobiological change to clinical indices of recovery.[39]

RETURN-TO-LEARN AND RETURN-TO-SPORT

Since the introduction of the RTL and RTS strategies, there has been a fivefold increase in the time to unrestricted RTS.[40] Many questions remain about how to optimise RTL and RTS. Importantly, measures used to assess recovery have moved beyond symptoms, cognitive function and balance, to include measures of oculomotor and vestibular function, as well as biobehavioural and physical examination findings (as per SCOAT6/Child SCOAT6).[25] While immediate and early postinjury symptoms remain the most robust predictor of recovery, the emergence of new assessment tools and variability in recovery endpoints underscores the importance of consistent definitions and measurement approaches. The systematic review of RTL and RTS found that continuing to play and delayed access to HCPs after SRC are associated with longer recovery.[41] In addition, similar RTL and RTS management strategies can be implemented in different cohorts (eg, age, sex) with minimal differences in the time for recovery.[41]

The systematic review revealed wide variability in clinical time points for recovery from SRC, making the integration and interpretation of results from multiple studies challenging, and limiting our ability to develop recommendations applicable to the individual athlete.[41] *To improve our clinical recommendations, the following definitions have been adopted by the Amsterdam consensus panel:*

- ***Symptom resolution at rest****: resolution of symptoms associated with the current concussion at rest.*
- ***Complete symptom resolution****: resolution of symptoms associated with the current concussion at rest with no return of symptoms during or after maximal physical and cognitive exertion.*
- ***Return-to-learn (RTL)****: return to preinjury learning activities with no new academic support, including school accommodations or learning adjustments.*
- ***Return-to-sport (RTS)****: completion of the RTS strategy with no symptoms and no clinical findings associated with the current concussion at rest and with maximal physical exertion.*[41]

RETURN-to-learn (RTL)

The transition back to learning and to school following SRC is an important consideration for children, adolescents and young adults. The systematic review revealed that the vast majority of athletes (93%) of all ages have a full RTL with no additional academic support by 10 days.[41] While many students can quickly return to learning with no or minimal difficulty, the RTL process can be more challenging for those who have specific considerations (eg, high acute symptom severity, a prior learning disability) that may affect recovery. To minimise academic and social disruptions during the RTL strategy, HCPs should avoid recommending complete rest and isolation, even for the initial 24–48 hours, and instead recommend a period of relative rest. Early return to activities of daily living should be encouraged provided that symptoms are no more than mildly and briefly increased (ie, an increase of no more than 2 points on a 0–10 point scale for less than an hour). In consultation with educators, and accounting for social determinants of health, some students may be offered academic supports to promote RTL including:

- **Environmental adjustments**, such as modified school attendance, frequent rest breaks from cognitive/thinking/desk-work tasks throughout the day and/or limited screen time on electronic devices.
- **Physical adjustments** to avoid any activities at risk of contact, collision or falls, such as contact sports or game play during physical education classes or after-school activities, while allowing for safe non-contact PA (eg, walking).
- **Curriculum adjustments**, such as extra time to complete assignments/homework and/or preprinted class notes.
- **Testing adjustments**, such as delaying tests/quizzes and/or permitting additional time to complete them.[41]

Return-to-learn recommendations

Facilitating RTL (table 1) is a vital part of the recovery process for student-athletes. HCPs should work with stakeholders on education and school policies to facilitate academic support, including accommodations/learning adjustments for students with SRC when needed. Academic support should address factors that may prolong RTL (eg, social determinants of health, higher symptom burden) by adjusting environmental, physical, curricular and testing factors as needed. Not all athletes will need an RTL strategy or academic support. If symptom exacerbation occurs during cognitive activity or screen time, difficulties with reading, concentration or memory or other aspects of learning are reported, clinicians should consider the implementation of an RTL strategy at the time of diagnosis and during the recovery process. When the RTL strategy is implemented, it can begin following an initial period of relative rest (Step 1: 24–48 hours following injury), with an incremental increase in cognitive load (Steps 2–4).[41] Progression through the strategy is symptom limited (ie, no more than a mild and brief exacerbation of current symptoms related to the current concussion) and its course may vary across individuals based on tolerance and symptom resolution. Further, while the RTL and RTS strategies can occur in parallel, student-athletes should complete full RTL before unrestricted RTS.[41]

RETURN-to-sport (RTS)

Evidence from applied research and improved awareness of SRC have enhanced SRC policies and legislation, removal from play and medical oversight that allows athletes adequate time to achieve recovery before full RTS (table 2). Research is clear that HCPs should avoid prescribing absolute physical and cognitive rest (ie, 'cocooning') after SRC; instead, they should allow athletes to engage in activities of daily living (including walking) immediately following injury, even during the initial period of 24–48 hours of relative rest.[30 33] Light PA as well as prescribed subsymptom threshold aerobic exercise treatment in a safe and supervised environment can be used therapeutically (ie, as part of the treatment plan as outlined in the Rest and Exercise section). Athletes may begin Step 1 (ie, symptom-limited activity) within 24 hours of injury, with progression through each subsequent step typically taking a minimum of 24 hours. Progression through the later RTS strategy (Steps 4–6) should be monitored by an HCP. Incremental progression of the cognitive and physical load on the athlete, using the magnitude of symptom exacerbation as a guide, provides the athlete with the opportunity to increase confidence throughout recovery,[42] supporting psychological readiness to return to competitive play[43–46] and fostering a shared RTS decision-making model.[44 47 48] Unrestricted RTS following SRC typically occurs within 1 month of injury in children, adolescents and adults, with an estimated pooled mean time to RTS of 19.8 days (95% CI: 18.8 to 20.7 days, n=57 studies, I-squared=99.3%, Q-statistic <0.01).[41] Providers should manage athletes on an individual basis, accounting for specific factors that may affect their recovery trajectory, such as pre-existing factors (eg, migraine history, anxiety) or postinjury factors (eg, aggravation of injury, psychological stress, social factors) that impact recovery. When symptoms are persisting, worsen or are not progressively resolving 2–4 weeks postinjury, a multimodal evaluation[25] and referral for rehabilitation (see Rehabilitation section) is recommended.[38]

Return-to-sport recommendations

RTS participation after SRC follows a graduated stepwise strategy, as outlined in table 2. RTS occurs in conjunction with

Table 1 Return-to-learn (RTL) 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 (eg, 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 activity.

Table 2 Return-to-sport (RTS) strategy—each step typically takes a minimum of 24 hours

Step	Exercise strategy	Activity at each step	Goal
1	Symptom-limited activity	Daily activities that do not exacerbate symptoms (eg, 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 (eg, 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 (eg, 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 (ie, 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 (ie, 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 (ie, 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 RTS should be provided by an HCP before unrestricted RTS as directed by local laws and/or sporting regulations.

HCP, healthcare professional; maxHR, predicted maximal heart rate according to age (ie, 220-age).

*RTL (see RTL strategy) and under the supervision of a qualified HCP. Following an initial period of relative rest (Step 1: approximately 24–48 hours following injury), clinicians can implement Step 2 (ie, light (Step 2A) and then moderate (Step 2B) aerobic activity) of the RTS strategy as a treatment of acute concussion.[30 41] The athlete may then advance to Steps 3–6 on a time course dictated by symptoms, cognitive function, examination findings and clinical judgement. Differentiating early activity (Step 1), aerobic exercise (Step 2) and individual sport-specific exercise (Step 3) as part of the treatment of SRC from the remainder of the RTS progression (Steps 4–6) can be useful for the athlete and their support network (eg, parents, coaches, administrators and agents). Athletes may be moved into the later stages that involve risk of head impact (typically Steps 4–6 and Step 3 if there is any inadvertent risk of head impact with sport-specific activity) of the RTS strategy following authorisation by an HCP and **after** full resolution of concussion-related symptoms, abnormalities in cognitive function and clinical findings related to the current concussion, including the absence of symptoms with and after physical exertion. Each step typically takes at least 24 hours. Clinicians and athletes can expect a minimum of 1 week to complete the full rehabilitation strategy, but typical unrestricted RTS can take up to 1 month post-SRC. The time frame for RTS may vary based on individual characteristics, necessitating an individualised approach to clinical management. Athletes having difficulty progressing through the RTS strategy or with symptoms and signs that are not progressively recovering beyond the first 2–4 weeks may benefit from rehabilitation in addition to the RTL and RTS strategies[38] (see Rehabilitation section) and/or involvement of a multidisciplinary team of HCPs experienced in managing SRC (see Refer section).[37] **Medical determination of readiness to return to at-risk activities should occur prior to returning to any activities at risk of contact, collision or fall** (eg, multiplayer training drills), which may be required prior to any of Steps 4–6, depending on the nature of the sport or activity that the athlete is returning to and in keeping with local laws/requirements.*

RECONSIDER: POTENTIAL LONG-TERM EFFECTS

There is increasing societal concern about possible problems with later-in-life brain health in former athletes, such as mental health problems, cognitive impairment and neurological diseases. The literature was reviewed for published studies using research designs that could estimate future risk to former athletes (ie, cohort studies and case–control studies). These research designs, either prospective or retrospective, require that an exposed and an unexposed group be followed through time to the outcome of interest.[49]

Studies that examined mental health as an outcome found that (1) former amateur athletes (primarily American football players) are not at increased risk for depression or suicidality during early adulthood or as older adults,[50–54] (2) former professional soccer players are not at increased risk for psychiatric hospitalisation during their adult life[55] and (3) former professional football and soccer players are not at increased risk for death associated with having a psychiatric disorder[56 57] or as a result of suicide.[55–59]

Other studies evaluated cognitive impairment, neurological disorders (eg, dementia) and neurodegenerative diseases (e.g., Alzheimer's disease, Parkinson's disease and amyotrophic lateral sclerosis (ALS)) as the outcome. Former male amateur athletes were not at increased risk for cognitive impairment, neurological disorders or neurodegenerative diseases compared with men from the general population.[53 60–62] In contrast, studies of former professional athletes examining causes of death reported greater mortality rates from neurological diseases and dementia in former professional American football players[63–65] and professional soccer players.[66] Former professional football players[64 65] and soccer players[59 66 67] have greater mortality rates from ALS. ALS is a rare disease with a possible genetic cause in some cases of men who develop the disease before age 50,[68] and it involves a *highly selective population of neurons, about half of which are in the spinal cord, which makes identifying specific trauma-related aetiological mechanisms challenging.*

The studies, to date, are methodologically limited because most were not able to examine, or adjust for, many factors that can be associated with the mental health and neurological outcomes of interest. The studies examining cognitive impairment and neurological outcomes did not examine genetic factors and usually did not consider or control for factors known to be important for brain health in the general population, such as educational attainment, socioeconomic status, smoking, hypertension and cardiovascular disease, diabetes, sleep apnea, white matter hyperintensities, social isolation, diet, PA or exercise.[69–79] *To establish a clear causal association between sports participation early in life and cognitive impairment or dementia late in life or to quantify that association, future well-designed case–control and cohort studies, that include as many individual risk-modifying and confounding factors as possible, are needed.*

Chronic traumatic encephalopathy-neuropathological change and traumatic encephalopathy syndrome[49]

Historically, a clinical condition associated with chronic traumatic brain injury in boxers was described using terms like punch drunk,[80] *dementia pugilistica*[81] *and chronic traumatic encephalopathy (CTE).*[82 83] *In recent years, CTE has been described as a neuropathological entity.*[84–86] *To avoid conceptual confusion between the pathology and a possible clinical condition, the postmortem neuropathology is referred to as CTE neuropathologic change (CTE-NC). The literature suggests that CTE-NC is very uncommon in community samples and brain banks, using strict criteria for case identification, and more common in brain bank samples of former professional athletes with high exposure to repetitive head impacts. However, these studies of former athletes are not cohort studies that can examine causation or quantify risk and thus were not included in the systematic review. It is reasonable to consider extensive exposure to repetitive head impacts, such as that experienced by some professional athletes, as potentially associated with the development of the specific neuropathology described as CTE-NC.*

CTE-NC is not a clinical diagnosis. The first consensus criteria for traumatic encephalopathy syndrome (TES), a new clinical diagnosis, were published in 2021.[87] *These diagnostic criteria can be used to determine the extent to which CTE-NC identified after death was associated with this new clinical diagnosis during life. The prevalence of CTE-NC (a neuropathological entity) and TES (a clinical diagnosis) in former athletes, military veterans and people from the general population is not known. It is also not known whether (1) CTE-NC causes specific neurological or psychiatric problems, (2) the extent to which CTE-NC can be clearly identified within the presence of Alzheimer's disease neuropathology or (3) whether CTE-NC is inevitably progressive.*

RETIRE

There is no clear evidence of the factors that, if present, would unequivocally lead to retirement or discontinued participation in contact or collision sports.[88] *However, some sports have their own specific medical regulations regarding clearance for participation (e.g., retinal detachment in boxing).*

Decisions regarding retirement or discontinuation from contact or collision sports are complex and multifaceted and should involve clinicians with expertise in traumatic brain injury and sport and preferably a multidisciplinary team. The decision-making process should include a comprehensive clinical evaluation that considers important patient-, injury-, sport-specific and other sociocultural factors.[88]

The discussion should provide athletes with the scientific evidence and uncertainties of their condition balanced against the benefits of participation in sport. It should incorporate the athlete's preferences and risk tolerance as well as psychological readiness to make an informed decision. The discussion should be carefully documented and should use language that is appropriate for the health literacy of the individual to reduce the risk that the information is misinterpreted. For children and adolescents, the parent/guardian should be involved in the discussion. HCPs should make the athlete aware of the role(s) they are playing in the athlete's care, stating clearly if they have any potential or actual conflicts of interest. The shared decision-making process should be individualised and incorporate a comprehensive clinical evaluation that may involve a multidisciplinary team and considers patient-, injury-, sport-specific and other sociocultural factors. These principles also apply to all of those involved in the coaching and management of the athlete.[88]

In the child or adolescent athlete, additional concerns are a successful return to school and to maintain healthy levels of PA. This often requires a multidisciplinary process that includes the child/adolescent, parent/caregivers, HCPs, school leadership and teachers in the discussions.

Given the positive benefits of exercise on health, care must be taken to avoid restricting all PA. All athletes who ultimately retire from contact or collision sports should be encouraged to continue non-contact or low-contact PA and have the health benefits of exercise explained.

REFINE

Additional topics of relevance to SRC were included in the Amsterdam consensus. Several considerations that could strengthen the consensus process were identified and are described below.

Para sport

Participation in sport across the lifespan for people with disabilities, estimated at 15%–25% of the global population, is increasing.[89] *Modern definitions of disability are broad-ranging and inclusive of impairment types that span the Paralympic movement (eg, physical disability, blind/low vision, intellectual disability), Special Olympics (eg, intellectual disability, developmental disability) and Deaflympics (eg, deaf, hard of hearing).*[90] *Many people with disabilities also participate, train and compete in mainstream sporting environments.*

The concussion experience of the para athlete is unique, due to the interaction of the individual's primary impairment and the pathophysiology of concussion. Para athletes may experience a concussion in widely played sports like ice hockey and soccer, as well as in para athlete-specific sports such as wheelchair racing and para swimming.[91 92] Commonly used SRC tools (eg, SCAT) are not validated in the para athlete population, who require a more individualised approach.

Although the literature describing SRC in people with disabilities is limited, elite Paralympic athletes are known to be at higher risk of injury when compared with athletes with no disability.[93–95] *Additionally, athletes with visual impairment may be at even greater risk of concussion, as the mechanisms of injury in this population are primarily through collisions or direct head contact.*[96 97]*Moreover, it is likely that prevention approaches, detection of initial symptoms, diagnosis, recovery (ie, potential for persisting symptoms of concussion) and treatment strategies* *may be impacted by the characteristics of the individual's underlying impairment.*

The recent position statement of the Concussion in Para Sport Group summarised expert opinion regarding concussion prevention, assessment and management in para sport participants.[96] *Most significantly, (1) individuals may benefit from baseline testing given the variable nature of their disability and the potential for atypical presenting signs/symptoms of concussion, (2) individuals with a history of central nervous system injury (eg, cerebral palsy, stroke) may require an extended period of initial rest, (3) testing for symptoms of concussion through recovery may require modification such as the use of arm ergometry as opposed to a treadmill/stationary bike and (4) RTS protocols must be tailored and include the use of the individual's personal adaptive equipment and, for applicable participants with visual impairment, partnership with their guide.*

Future research is needed to enhance our knowledge of concussion assessment and management in para sport participants. This should include longitudinal injury surveillance to examine modifiable risk factors and prevention strategies, establishing reference data for commonly used assessment tools, evaluating outcomes of concussion and the intersection of the individual's primary impairment type and understanding the unique challenges of under-researched subpopulations such as the female and child/adolescent with a disability.

Paediatrics

Brain development in the child (5–12 years) and adolescent (13–18 years) and the requirement for return to school guidance necessitate modified paradigms in paediatric SRC. Prevention efforts are important, and rule changes and contact practice limitations for children and adolescents participating in ice hockey and American football have demonstrated reduced SRC incidence rates.[12 13 15 16] The application of such rules in other sports requires more research. The benefits of mouthguards in children and adolescent ice hockey are clear and should be evaluated across all collision sports.[12] NMT warm-up programmes are recommended in rugby with more research needed in female athletes and other team sports.[19] Further research evaluating headgear in non-helmeted sports is required to inform recommendations.

Paediatric athletes are less likely to have trained medical personnel available on the sideline, and it is strongly recommended that the CRT6 be used by all adults supervising child and adolescent sport. The Child SCAT6 (8–12 years) and SCAT6 (adolescents) should be used by HCPs; however, baseline testing is of limited use in younger athletes because of neurocognitive development. Evaluation with the Child SCAT6/SCOAT6 provides a framework for multiple domain assessments and informs the clinician on implementing appropriate exercise, RTL and RTS, and rehabilitation. Such a multifaceted clinical evaluation is recommended to guide both management and the possible need for referral to practitioners from multiple disciplines experienced in paediatric SRC.

Return-to-school is a priority in children and adolescents, and while full RTL is recommended before unrestricted RTS, the two strategies can occur in parallel. The use of advanced neuroimaging, fluid biomarkers and other technologies is under investigation for SRC diagnosis, prognosis and recovery[39]; however, age-specific data are required to accommodate physiological and neurocognitive development in the child athlete.

Children and adolescents with repeat concussions wishing to continue to play or to progress to the next age-level group or elite pathway programmes require individualised assessment. Considering the health benefits of a physically active lifestyle, any child/adolescent advised against participating in contact sport should be encouraged to participate in other non-contact sporting or exercise activities.

The athlete's voice

The Scientific Committee deemed it important to include the athlete's perspective in this consensus process. There was athlete representation (both in-person and via prerecorded videos) at the conference but not on the subsequent scientific expert panel. Although none of these athletes had direct input into the consensus statement itself, the experience that they shared at the conference around the topics of concussion diagnosis, retirement due to concussion, concussion in youth sport, readiness to RTS following concussion, concussion in para athletes and prevention of concussion provided valuable first-person perspectives for the expert panel.

Ethical considerations, limitations and improvements

While many advances have been made, we recognise that future consensus processes should evolve and strive to improve areas that integrate principles of modern ethics, process, methodology and healthcare practice.[98] These include the five topics discussed below.

Equity, diversity and inclusion (EDI)

Historically, the expert panel of researchers and clinicians was selected on the basis of specific expertise but had limited demographic (eg, gender, race/ethnicity) and geographical (eg, country and continent of origin, low- and middle-income countries) diversity. The benefits of gender and ethnic diversity in advancing science and innovation are well described.[99 100] Although the Amsterdam Scientific Committee and expert panel were the most diverse to date in the concussion in sport consensus process, significant deficiencies and challenges remain in achieving greater inclusivity regarding demographic and geographical diversity. Addressing this will add diverse perspectives to broaden research, knowledge translation and clinical practice into the assessment and management of SRC globally.

Stakeholder voices

Beside including the athlete's voice, future consideration could be given to a more integrated codesign with stakeholder participation including parents, teachers, officials, coaches and sports administrators. Comments from the conference participants were also scribed, many of which included stakeholder voices expressing their perspectives and insights as youth athletes, para athletes, professional athletes, family members, sport policymakers and others.

Observer input

The expert panel session benefited from the presence of several observers experienced in the field of SRC. Many of these observers shared their input as co-authors on the systematic reviews, while others were able to provide comment during the public open forums at the conference. Consideration could be given to more formally documenting their appointment, allowing further expert input and including their input into the consensus process.

Sustainability of the consensus process

The exponential increase in SRC scientific publications has greatly amplified the workload on the authors involved in the preparation of the systematic reviews. Consideration could be given to the creation of teams of dedicated clinicians and scientists assigned to narrower topics and questions, or perhaps the development of 'living' or regularly updated systematic reviews where new data productions and scientific advancements are rapid.

Potential conflicts of interest and transparency

Considerable efforts were made to record potential conflicts of interest among the members of the leadership group, contributors to the systematic reviews, expert panels and commentators from the floor at the consensus meeting. All speakers declared their interests at the beginning of their presentations (which were recorded on a digital repository), and all contributors from the floor of the consensus meeting were required to do the same verbally. This greater transparency enabled a critical appreciation of the context from which questions, challenges and criticisms were made.

Timing of the consensus meeting and expert panel consensus meeting

All 10 systematic reviews (SRs) were read by the expert panel in advance of the meeting but were then not yet in their final published form. To ensure that the outputs of the consensus were aligned with the final SRs accepted for publication, the lead authors of the SRs as well as of the Consensus Statement cross-checked the recommendations. The final consensus statement was not submitted in its final revised form until the completion of this additional step of the process to ensure that the Consensus Statement aligned with the final SR recommendations.

FUTURE RESEARCH

As part of their task, each author group identified gaps in the research. These gaps included additional topic areas of research, other geographical locations (ie, outside of North America), cultural contexts and ages, sexes and genders, which are described in each systematic review. The audience was also invited to share priorities for future research. A total of 342 participants responded to prioritise their top five topics for research, with potential long-term effects ranking first and prevention ranking second (figure 3).

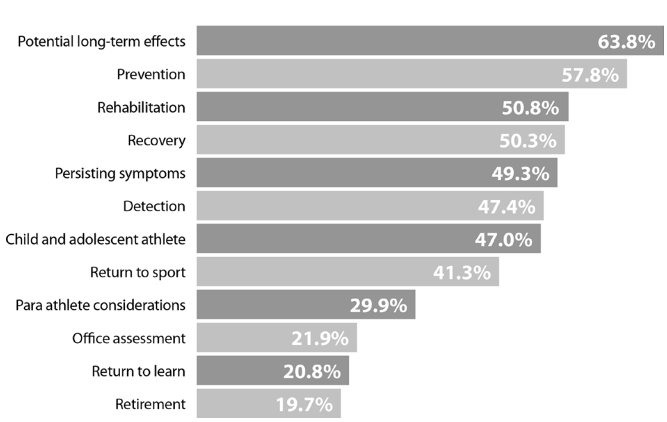

Figure 3 Percentage of conference attendees who voted for each topic as a top five priority for future research.

POTENTIAL LONG-TERM SEQUELAE

The potential long-term mental health and neurodegenerative effects of concussion and repetitive head impacts are of increasing interest in the field and have dominated the public discourse on the possible long-lasting effects of collision/contact sports participation. This consensus process has revealed a spectrum of perspectives and the complexities of answering these important questions to which they give rise. Defining the methodology for adequate study designs to better understand if there is a link between neuropathological findings and in vivo processes should be prioritised. The ethical and scientific challenges related to the issue of potential long-term effects of concussion require an ongoing and collaborative process. The Scientific Committee proposes the formation of an interdisciplinary working group, including members of CISG, as well as other clinicians, scholars and scientists, to continue deliberations on these topics in the interest of athlete care. As part of their charge, we recommend this group seek dedicated funding for research into long-term athlete health and consider a separate conference to afford greater time and attention to this topic.

CONCLUSIONS

The 6th International Conference on Concussion in Sport (Amsterdam 2022) was the culmination of a 5-year process resulting in the development of this Statement and the accompanying sports concussion assessment tools. This consensus process took 2 years longer than initially planned due to pandemic-related postponements and aimed to be more extensive than previous versions. This Statement summarises the state of the science, incorporates several novel aspects and has identified priorities for research. The conference outcomes are intended to serve as summaries of the evidence at the time of the Amsterdam Conference to inform HCPs and sports organisations in the interests of improving athlete care at all levels of sport.

Author affiliations
[1]Wits Sport and Health (WiSH), School of Clinical Medicine, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa
[2]Sport Injury Prevention Research Centre, Faculty of Kinesiology, University of Calgary, Calgary, Alberta, Canada
[3]Spine Unit, Schulthess Clinic Human Performance Lab, Zurich, Switzerland
[4]Physiotherapy Department, University Hospitals Dorset NHS Foundation Trust, Poole, UK
[5]The FA Centre for Para Football Research, The Football Association, Burton-Upon-Trent, UK
[6]Department of Physical Medicine and Rehabilitation, Spaulding Rehabilitation/Harvard Medical School, Boston, Massachusetts, USA
[7]Kelley Adaptive Sports Research Institute, Spaulding Rehabilitation, Boston, Massachusetts, USA
[8]CTE Center, Boston University School of Medicine,, Boston, Massachusetts, USA
[9]Neurology, Boston University School of Medicine,, Boston, Massachusetts, USA
[10]Murdoch Children's Research Institute, Parkville, Victoria, Australia
[11]Cabrini Health, Malvern, Victoria, Australia
[12]Psychology, University of Missouri Kansas City, Kansas City, Missouri, USA
[13]Psychological and Neurobehavioral Associates, Inc, Miami, Florida, USA
[14]Florey Institute of Neuroscience and Mental Health—Austin Campus, Heidelberg, Victoria, Australia
[15]La Trobe Sport and Exercise Medicine Research Centre, Melbourne, Victoria, Australia
[16]Department of Movement Sciences, KU Leuven, Leuven, Belgium
[17]School of Sport and Exercise Medicine, Swansea University, Swansea, UK
[18]Michigan Concussion Center, University of Michigan, Ann Arbor, Michigan, USA
[19]University Hospital Zurich, Zurich, Switzerland
[20]Sports Neuroscience, University of Zurich, Zurich, Switzerland
[21]School of Health and Related Research, University of Sheffield, Sheffield, UK
[22]Neurosurgery, UCLA Steve Tisch BrainSPORT Program, Los Angeles, California, USA
[23]Pediatrics/Pediatric Neurology, Mattel Children's Hospital UCLA, Los Angeles, California, USA
[24]Matthew Gfeller Center, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina, USA

[25]National Collegiate Athletic Association (NCAA), Indianapolis, Indiana, USA
[26]Physical Medicine and Rehabilitation, Harvard Medical School, Boston, Massachusetts, USA
[27]Sports Concussion Program, MassGeneral Hospital for Children, Boston, Massachusetts, USA
[28]Kutcher Clinic for Sports Neurology, Park City, Utah, USA
[29]UBMD Orthopaedics and Sports Medicne, SUNY Buffalo, Buffalo, New York, USA
[30]Melbourne Neuropsychology Services & Perry Maddocks Trollope Lawyers, Melbourne, Victoria, Australia
[31]Neurosurgery, University of California, San Francisco, San Francisco, California, USA
[32]Neurosurgery, Medical College of Wisconsin, Milwaukee, Wisconsin, USA
[33]Department of Pediatrics, McMaster University, Hamilton, Ontario, Canada
[34]Medical, Major League Soccer, New York, New York, USA
[35]Neurosurgery, Seirei Mikatahara Hospital, Hamamatsu, Japan
[36]Medisport Ltd, Tampere, Finland
[37]International Concussion and Head Injury Research Foundation, London, UK
[38]University College London, London, UK
[39]Psychology, University of Calgary, Calgary, Alberta, Canada
[40]Department of Rehabilitation Medicine, Orthopaedics and Sports Medicine, University of Washington, Seattle, Washington, USA
[41]Department of Neurological Surgery, University of Washington, Seattle, Washington, USA
[42]National Hockey League, New York, New York, USA

Twitter Jon S Patricios @jonpatricios, Kathryn J Schneider @Kat_Schneider7, Jiri Dvorak @ProfJiriDvorak, Osman Hassan Ahmed @osmanhahmed, Cheri Blauwet @CheriBlauwetMD, Carolyn A Emery @CarolynAEmery, Christopher C Giza @griz1 and Margot Putukian @Mputukian

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Contributors All authors participated as expert panelists for the Amsterdam International Consensus on Concussion in Sport. Authors participated in the expert panel meetings, reviewed the submitted version of the systematic reviews, methodology paper and tools that were submitted to *BJSM* and reviewed and approved the final manuscript for submission. JSP and KJS co-chaired the process and drafted the consensus statement.

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Competing interests OHA is a Senior Physiotherapist at University Hospitals Dorset NHS Foundation Trust (England) and is Para Football Physiotherapy Lead/Para Football Classification Lead at the Football Association (England). He also works on a consultancy basis with the Football Association as the squad physiotherapist to the England Cerebral Palsy Football squad and teaches a course on the Football Association's Advanced Trauma and Medical Management in Football course on a consultancy basis. He has a Visiting Senior Lecturer position at the University of Portsmouth, England (unpaid). He sits on several disability sport committees, including Para Football Foundation as Medical Unit Co-Lead (unpaid), the International Federation of Cerebral Palsy Football as Medical and Sports Science Director (unpaid) and the International Blind Sports Association as Medical Committee member (unpaid). He has Associate Editor positions at the British Journal of Sports Medicine (unpaid) and BMJ Open Sports & Exercise Medicine (unpaid). He is also an Institutional Ethics Committee external member for World Rugby (unpaid) and co-chair of the Concussion in Para Sport Group (unpaid). CAB is an Associate Professor of PM&R Journal at Spaulding Rehabilitation Hospital/Harvard Medical School and Chief Medical Officer at Spaulding Rehabilitation Hospital. She receives grant funding from the US Center for Disease Control and Prevention and the US National Institute on Disability, Independent Living, and Rehabilitation Research. She serves on the Board of Directors of the US Olympic & Paralympic Committee (unpaid) as well as on the International Paralympic Committee Medical Committee (unpaid) and the IOC Medical & Scientific Commission (unpaid). She serves as an Associate Editor of the British Journal of Sports Medicine (unpaid) and the PM&R Journal (unpaid). SPB Current or past research funding from the National Institutes of Health; US Centers for Disease Control and Prevention; Department of Defence (DoD)—USA Medical Research Acquisition Activity, National Collegiate Athletic Association (NCAA); National Athletic Trainers' Association Foundation; NFL/Under Armour/GE; Simbex and ElmindA. He has consulted for US Soccer (paid), US Cycling (unpaid), University of Calgary SHRed Concussions external advisory board (unpaid), medicolegal litigation and received speaker honorarium and travel reimbursements (including Concussion in Sport Group (CISG)) for talks given. He is the coauthor of Biomechanics of Injury (3rd Edition) and has a patent pending on Brain Metabolism Monitoring Through CCO Measurements Using All-Fiber-Integrated Super-Continuum Source (US Application No 17/164,490). He is/was on the editorial boards (all unpaid) for Journal of Athletic Training (2015 to present), Concussion (2014 to present), Athletic Training & Sports Health Care (2008 to present) and British Journal of Sports Medicine (2008–2019). RCC Senior Advisor NFL Head Neck & Spine Committee NOCSAE and Chair Scientific Advisory Committee Co-Founder, Medical Director Concussion Legacy Foundation Royalties Houghton Mifflin Harcourt Legal Expert Opinion. GAD is a member of the Scientific Committee of the Sixth International Conference on Concussion in Sport; an honorary member of the AFL Concussion Scientific Committee; Section Editor, Sport and Rehabilitation, Neurosurgery and has attended meetings organised by sport organisations including NFL, NRL, IIHF, IOC and FIFA; however has not received any payment, research funding or other monies from these groups other than for travel costs. JD is the co-founder and board member of CISG and Senior Advisor to BJSM. RJE is a paid consultant for the NHL and cochair of the NHL/NHLPA Concussion Subcommittee. He is also a paid consultant and chair of the Major League Soccer concussion committee and a consultant to the US Soccer Federation. He previously served as a neuropsychology consultant to Princeton University Athletic Medicine and EyeGuide. He is currently a co-principal investigator (PI) for a grant funded by the NFL (NFL-Long) through Boston Children's Hospital. He occasionally provides expert testimony in matters related to mild traumatic brain injury (mTBI) and sports concussion and occasionally receives honoraria and travel support/reimbursement for professional meetings. CAE holds external peer-reviewed research funding from Canadian Institutes of Health Research, Canada Foundation for Innovation, IOC Medical and Scientific Committee, NFL Play Smart Play Safe Program and World Rugby. She is an Associate Editor of BJSM (unpaid) and has received travel and accommodation support for meetings where she has presented. She is an external advisory board member for HitIQ. NF-D International independent FIFA Concussion Advisory Group. GOTS Concussion Committee Innovation and Technology Panel, UK Department for Digital, Culture, Media and Sport. International Consensus Group on Concussion in Sports (CISG), NINDSCDE Sports Concussion CDE Subacute Subgroup (National Institutes of Health). IFAB Concussion Expert Group. Member of Swiss Neurology Society, Swiss Society for Clinical Neurophysiology, European Neuro-Ophthalmology Society and CISG. Editorial Board Member of Journal of Concussion, Journal of Science and Medicine in Football. GF has received travel expenses to attend academic meetings from World Rugby. He has also collaborated on research projects with World Rugby as chief or co-investigator. He is a previous associate editor of the British Journal of Sports Medicine. He has not received any other payments or support from any sporting or commercial bodies. CCG discloses the following: Grants/research support: HitIQ (2022–2023); NIH NINDS (R01 NS110757 2019–2024); NINDS (U54 NS121688 2021-2026); UCLA Brain Injury Research Center, UCLA Steve Tisch BrainSPORT programme, Easton Clinic for Brain Health. Clinical Consultant (provide clinical care to athletes): NBA, NFL-Neurological Care Program, NHL/NHLPA, Los Angeles Lakers Advisory Board (non-compensated): Major League Soccer, NBA and US Soccer Federation. Advisory Board (compensated): Highmark Interactive Medicolegal: One or two cases annually Speaker's bureau: None. Stock shareholder: Highmark Interactive stock options (2018). Other financial or material support: book royalties—Blackwell/Wiley Publishing: prioritized. Neurological differential diagnosis. KMG has received grant funding from NFL for the NFL LONG study. He also serves on the NCAA Scientific Advisory Board in an unpaid capacity. BH works full time as a paid employee of the NCAA as Senior Vice President, Sport Science Institute, and as Chief Medical Officer. I serve as a volunteer advisory member for: US Football Medical Advisory Panel; CrashCourse by TeachAids; NBJA Youth Health & Wellness Working Group; External Advisory Board, DIAGNOSE CTE (Boston University). I am on the Board of Directors for the US Tennis Association, the Grand Slam Board; the International Tennis Integrity Agency and the Datalys Center. I am chair of the International Tennis Federation Sports Science & Medicine Commission. SAH is co-founder and senior advisor of the Sports Institute at UW Medicine (unpaid). Centers for Disease Control and Prevention and National Center for Injury Prevention and Control Board Pediatric Mild Traumatic Brain Injury Guideline Workgroup (unpaid). CISG (travel support). NCAA Concussion Safety Advisory Group (unpaid). Team Physician, Seattle Mariners. Former Team Physician, Seattle Seahawks. Occasional payment for expert testimony. Travel support for professional meetings. GLI serves as a scientific advisor for NanoDX, Sway Operations and Highmark. He has a clinical and consulting practice in forensic neuropsychology, including expert testimony, involving individuals who have sustained mTBIs (including former athletes) and on the topic of suicide. He has received past research support or funding from several test publishing companies, including ImPACT Applications, CNS Vital Signs and Psychological Assessment Resources (PAR). He receives royalties from the sales of one neuropsychological test

(WCST-64). He has received travel support and honorariums for presentations at conferences and meetings. He has received research funding as a PI from the NFL and subcontract grant funding as a collaborator from the Harvard Integrated Program to Protect and Improve the Health of NFL Players Association Members. He has received research funding from the Wounded Warrior Project. He acknowledges unrestricted philanthropic support from ImPACT Applications, the Mooney-Reed Charitable Foundation, the National Rugby League, Boston Bolts and the Schoen Adams Research Institute at Spaulding Rehabilitation. JK declares the following affiliations: NBA. US Ski and Snowboard. US Olympic & Paralympic Committee. NHL Players' Association. Major League Soccer Players' Association. NFL Players' Association. NeuroSync. Cognivue. JJL receives grant/research support from NIH, DoD and AMSSM. He is a member of the Scientific Advisory Board for Neuronasal, Highmark Innovations and Quadrant Biosciences. Minority stock options in Highmark Innovations and 360 Concussion Care. Expert consultant to NCAA. Consults with NFL and NHL teams on athlete care but does not receive any compensation from these organizations. He is on the Editorial Board of Journal of Head Trauma and Rehabilitation. DM Neuropsychologist and lawyer—legal practice in Medical Law. Legal representation provided to parties in personal injury legal proceedings. Former member of AFL Concussion Working Group—no remuneration. Past legal advisor to Cricket Australia and the AFL. Legal advisor to various professional sporting clubs. Past ARF concussion research funding received through the Florey Institute of Neuroscience & Mental Health. Member of the AFL Grievance Tribunal—no remuneration received. Legal advisor to private schools. Lectures (neuropsychology/law) to education providers—no remuneration. Cricket Victoria—former Director/Chair—no remuneration. Melbourne Grammar School—Audit & Risk Committee Member—no remuneration. CISG Board Member—no remuneration. Travel support to attend the 2022 CISG meeting. Abstained from discussions in the 2022 CISG consensus process in relation to 'chronic traumatic encephalopathy, neuropathological change and trauatic encephalopathy syndrome'and 'potential long-term sequelae'. MM Sport and exercise medicine physician working in private consulting practice. Shareholder of Olympic Park Sports Medicine Centre in Melbourne. Ex-senior physician at the Hawthorn Football Club (AFL). Ex-Chief Executive Officer of the AFL Doctors Association. Research grants received from the Australian Football League, outside the submitted work. Travel support received from the Australian Football League, FIFA and the IOC to attend and present at international conferences. Member of the Scientific Committee for the Sixth International Conference on Concussion in Sport. Honorary member of the International CISG. Honorary member of the Australian Rugby Union Concussion Advisory Group. Independent Concussion Consultant for World Rugby. GTM discloses grants from the US DoD—TBI Endpoints Development Initiative (Grant no W81XWH-14-2-0176), TRACK-TBI Precision Medicine (Grant no W81XWH-18-2-0042) and TRACK-TBI NETWORK (Grant no W81XWH-15-9-0001); NIHNINDS—TRACK-TBI (Grant no U01NS086090) and the NFL Scientific Advisory Board—TRACK-TBI LONGITUDINAL. US Department of Energy supports GTM for a precision medicine collaboration. One Mind has provided funding for TRACK-TBI patients' stipends and support to clinical sites. He has received an unrestricted gift from the NFL to the UCSF Foundation to support the research efforts of the TRACK-TBI NETWORK. GTM has also received funding from NeuroTruama Sciences to support TRACK-TBI data curation efforts. Additionally, Abbott Laboratories has provided funding for add-in TRACK-TBI clinical studies. MAM has received research funding to the Medical College of Wisconsin from the National Institutes of Health (NIH), Department of Veterans Affairs, US Centers for Disease Control and Prevention, DoD, NCAA, NFL and Abbott Laboratories. He receives book royalties from Oxford University Press. He serves as a clinical consultant to Milwaukee Bucks, Milwaukee Brewers and Green Bay Packers, and is Co-Director of the NFL Neuropsychology Consultants without compensation. He serves as a consultant for NeuroTrauma Sciences. He receives travel support and speaker honorariums for professional activities. MJM Chair, Ethics Expert Group, WADA (2021–2023) (paid). Member, International Boxing Association, Ethics and Integrity Committee, (2021–2022; resigned October 2022) (paid). Chair, Therapeutic Use Exemption Fairness Committee (2020 to present) (paid). Member, Steering Group, Sex Segregation in Sport, IAAF/World Athletics, (2019–2020) (unpaid). Member, International Ice Hockey Federation, Ethics and Integrity Committee (2019–2021) (paid). Member, IOC Consensus Statement Expert Group on Injuries in Children and Adolescents (2017) (unpaid). Member, Ethics Expert Group, WADA (2016–2021) (unpaid). Member, IOC Consensus Statement Expert Group on Pain Management (2016) (unpaid). WM is employed as the Chief Medical Officer of the NHL. JSP is an Editor of BJSM for which he receives a honorarium. He is an unpaid consultant to the World Rugby Concussion Advisory Group for which he also serves as an Independent Concussion Advisor (fee per consultation). Other unpaid positions include being medical advisor to South African Rugby, Co-chair of the Scientific Committee, 6th International Conference on Concussion in Sport (travel and accommodation subsidised), Board member of the CISG and a Scientific Advisory Board Member of EyeGuide. LKP CASEM Board Member, President-Elect 2022–2023 NIH R34 Grant for EPICC Study (Eye Problems In Concussed Children), Site PI. Speaker at various conferences. CISG member. Expert panellist for the Sixth International Conference on Concussion in Sport (travel and accommodation subsidised). MP declares the following: Consultant, Chief Medical Officer, Major League Soccer. Senior Advisor, NFL Head, Neck & Spine Committee. FA Research Task Force Committee member. UK Concussion Foundation Protocol Forum. US Soccer Medical Advisory Committee. CDC Concussion Consultant. CISG expert panel. NOCSAE Scientific Advisory Committee. IOC Mental Health Working Group. USOPC Mental Health Advisory Committee. Team Physician, US Soccer. Received funding for research; NCAA-CARE-DoD 2.0, ended 2020. He received honoraria and reimbursement for travel for speaking and conferences amended. He has written chapters for UpToDate and received royalties for the Netter's Sports Medicine textbook. He has provided work as an expert for cases involving concussion, team physician and other sports medicine topics. KJS has received grant funding from the Canadian Institutes of Health Research, NFL Scientific Advisory Board, IOC Medical and Scientific Research Fund, World Rugby, Mitacs Accelerate, University of Calgary with funds paid to her institution and not to her personally. She is an Associate Editor of BJSM (unpaid), independent consultant to World Rugby and has received travel and accommodation support for meetings where she has presented. She led and coordinated the writing of the systematic reviews that informed the Sixth International Conference on Concussion in Sport and Amsterdam Consensus Statement, for which she received an educational grant to assist with the administrative costs associated with the writing of the reviews (with funds paid to her institution and not to her personally). She is a member of the AFL Concussion Scientific Committee (unpaid position) and Brain Canada (unpaid position). She works as a physiotherapy consultant and treats athletes of all levels of sport from grassroots to professional. MT is employed full-time as the CEO and Medical Director of ICHIRF—a paid post he has held since April 2015. Hon Medical Adviser to the Professional Riders Insurance Scheme (PRIS)—discretionary Honorarium. Member of the Premier League Head Injury Advisory Group—no remuneration. Director of ICHIRF Ireland—no remuneration. Honorary Medical Adviser to the Concussion Foundation—no remuneration. Member of the expert panel for the Department of Digital, Culture, Media and Sport review into concussion in amateur sport—no remuneration. Attendance at conferences or meetings as a guest speaker—reimbursement of travel expenses, complimentary registration and payment of hotel accommodation and meals by the organising committee. No stocks or options in any concussion-related company. No consultancies, board or editorial positions related to concussion. KOY is Editor-in-Chief of the journal Neuropsychology and receives an editorial stipend from the American Psychological Association. He is an unpaid consulting editor for the journals Archives of Clinical Neuropsychology and Journal of Head Trauma Rehabilitation. He is an unpaid member of the Scientific Advisory Committee for Brain Injury Canada. He is the chair of the Canadian Concussion Network, which is funded by a grant from the Canadian Institutes of Health Research (CIHR) to his institution; he is the principal applicant for the grant but receives no income from it. He is a PI on another grant from CIHR from which he derives no income. He is a co-investigator on research grants from CIHR, the US NIH, Brain Canada Foundation and NFL Scientific Advisory Board; he derives income only from the grant from the NIH. He serves as a member of a CIHR grant review panel for which he receives a small honorarium. He receives book royalties from Guilford Press and Cambridge University Press. He has received travel support and honorarium for presentations to multiple organisations. He serves or has served on the following committees/boards for which he receives honorarium: (1) Independent Data Monitoring Committee, Care for Post-Concussive Symptoms EffecCveness (CARE4PCS-2) Trial, National Institute for Child Health and Human Development; (2) Observational Study Monitoring Board, Approaches and Decisions in Acute Pediatric TBI (ADAPT) Trial, National Institute of Neurological Disorders and Stroke National Research Advisory Council; (3) National Pediatric Rehabilitation Resource Center, Center for Pediatric Rehabilitation: Growing Research, Education, and Sharing Science, Virginia Tech University.

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ORCID iDs
Jon S Patricios http://orcid.org/0000-0002-6829-4098
Kathryn J Schneider http://orcid.org/0000-0002-5951-5899
Jiri Dvorak http://orcid.org/0000-0002-2178-2326
Osman Hassan Ahmed http://orcid.org/0000-0002-1439-0076
Cheri Blauwet http://orcid.org/0000-0001-8568-1009
Gavin A Davis http://orcid.org/0000-0001-8293-4496
Ruben J Echemendia http://orcid.org/0000-0001-6116-8462
Steven Broglio http://orcid.org/0000-0002-2282-9325
Carolyn A Emery http://orcid.org/0000-0002-9499-6691
Gordon Ward Fuller http://orcid.org/0000-0001-8532-3500
Brian Hainline http://orcid.org/0000-0002-0233-2434
Grant L Iverson http://orcid.org/0000-0001-7348-9570
John J Leddy http://orcid.org/0000-0002-0370-1289
Geoff Manley http://orcid.org/0000-0002-0926-3128
Michael McCrea http://orcid.org/0000-0001-9791-9475
Margot Putukian http://orcid.org/0000-0002-1478-8068
Haruhiko Sato http://orcid.org/0000-0001-7746-7512
Michael Turner http://orcid.org/0000-0003-2323-2456
Keith Owen Yeates http://orcid.org/0000-0001-7680-2892

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