Definition of sport-related concussion: the 6th International Conference on Concussion in Sport

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The field of sport-related concussion (SRC) has long-endured the absence of a universally accepted definition, complicated by different terminology such as 'concussion' and 'mild traumatic brain injury' (mTBI). Critical to this issue is agreement and implementation of conceptual and operational definitions. A conceptual (theoretical) definition explains what a disease entity is (eg, pathophysiology and typical clinical presentation), but does not identify which clinical features are necessary or sufficient to classify a 'case' with the disease.[1] An operational definition specifies how to determine whether an individual has the disease, such as by applying diagnostic criteria. Conceptual and operational definitions are complementary.

The Concussion in Sport Group (CISG) proposed a conceptual definition of SRC in 2001.[2] This definition has undergone updates and modifications at subsequent CISG meetings, with the most recent being in Berlin in 2016.[3] In preparation for the 6th International Conference on Concussion in Sport, the scientific committee considered that the Berlin definition may require further modification to align with more recent scientific evidence relating to advances in our understanding of the pathophysiology of SRC.

Concurrently, between 2018 and 2022, the Mild Traumatic Brain Injury Task Force of the American Congress of Rehabilitation Medicine (ACRM) Brain Injury Special Interest Group undertook an update of the 1993 ACRM definition for mTBI.[4] Expert panel member ratings of the diagnostic importance of various signs, symptoms and examination findings,[5] and a series of rapid evidence reviews informed an initial draft of the updated diagnostic criteria. The criteria then underwent a Delphi consensus process, with revisions after each round of voting, until expert consensus was reached.[5] Key elements of the ACRM diagnostic criteria for mTBI are reprinted in the table 1. There are also criteria for identifying individuals with suspected mTBI to guide clinical management when high diagnostic certainty is not possible. The ACRM diagnostic criteria note that 'the diagnostic label 'concussion' may be used interchangeably with 'mild TBI' when neuroimaging is normal or not clinically indicated.'[6]

COLLABORATIVE APPROACH

The CISG and the ACRM groups identified a shared goal for a unified definition that would benefit both clinicians and researchers, and subsequently collaborated to harmonise their efforts. This process involved multiple steps, including (1) seeking and circulating premeeting feedback from over 100 lead authors, coauthors, consensus meeting expert panellists involved in the preparation for the 6th International Conference on Concussion in Sport, and past CISG panellists on the proposed ACRM diagnostic criteria; (2) encouraging content in the article that introduces the ACRM diagnostic criteria that enhances the applicability of the criteria to the sporting context, while preserving the integrity of the ACRM Delphi methodology; (3) presenting the ACRM diagnostic criteria at a dedicated session during the 6th International Conference on Concussion in Sport, including receiving feedback from delegates during the open discussion and (4) discussing the ACRM diagnostic criteria during the expert panel meeting as part of the process of writing the 6th international consensus statement.

OUTCOME

The expert panel for the 6th International Conference on Concussion in Sport considered that adopting the ACRM diagnostic criteria was an aspirational goal. However, only 16/28 (57.1%) of the expert panel voted to incorporate the ACRM diagnostic criteria directly into the CISG consensus statement (consensus agreement defined a priori as ≥80%). A point of divergence was the scenario where an athlete with a biomechanically plausible mechanism of injury presents with acute symptoms of SRC but no clinical signs. It was recognised by the CISG expert panel that in this situation the ACRM diagnostic criteria classified the athlete with a 'suspected mTBI'. However, the CISG has consistently maintained that clinical signs of concussion may frequently be absent, and that in such cases, the diagnosis of SRC can be established by the presence of symptoms alone.

The expert panel considered this issue, and after deliberation, discussion points were clarified, modified definition options were shared with the expert panel and a vote was conducted. The outcome of this vote reached a majority decision threshold 22/28 (78.6% agreement) to adopt a modified version of the Berlin conceptual definition for SRC. The new conceptual definition, arising from the consensus conference in Amsterdam, is provided in the table 1.

IMPLICATIONS FOR CLINICAL CARE

In both the CISG definition and ACRM diagnostic criteria, an athlete who develops symptoms consistent with SRC should be removed from play and undergo a graded return to sport strategy. The ACRM diagnostic criteria for mTBI are consistent with the mantra 'when in doubt, sit them out.' According to the ACRM diagnostic criteria, an mTBI is 'suspected' if an athlete experiences symptoms that are believed to arise from an SRC, but there are no clinical signs and no objective clinical examination findings. Unless subsequently ruled out by a health care professional, mTBI is the presumptive diagnosis. Therefore, athletes who meet the ACRM diagnostic criteria for suspected mTBI have an SRC according to the CISG definition. The CISG definition does not specify a minimum threshold for SRC diagnosis and does not differentiate between levels of diagnostic certainty.

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Table 1 CISG definition of sport-related concussion and the ACRM diagnostic criteria for mild traumatic brain injury

CISG definition[7]	*ACRM diagnostic criteria[6]
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.	Mild traumatic brain injury (TBI) is diagnosed when, following a biomechanically plausible mechanism of injury (criterion 1) one or more of the criteria listed below are met. i. One or more clinical signs (criterion 2) attributable to brain injury †. ii. At least two acute symptoms (criterion 3) and at least one clinical examination or laboratory finding (criterion 4)‡ attributable to brain injury. iii. Neuroimaging evidence of TBI, such as unambiguous trauma-related intracranial abnormalities on CT or structural magnetic resonance imaging (criterion 5).§ Confounding factors do not fully account for the clinical signs, acute symptoms, and clinical and laboratory findings that are necessary for the diagnosis (criterion 6).
No abnormality is seen on standard structural neuroimaging studies (CT or MRI T1-weighted 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).	Suspected Mild TBI: A mild TBI is suspected when, following a biomechanically plausible mechanism of injury (criterion 1), one or more of the three criteria listed below are met. i. At least two acute symptoms (criterion 3) and the person does not meet other criteria sufficient for diagnosing mild TBI. ii. At least two clinical examination or laboratory findings (criterion 4) but the person does not meet other criteria sufficient for diagnosing mild TBI. iii. It is unclear whether signs (criterion 2), acute symptoms (criterion 3), and available clinical examination or laboratory findings (criterion 4) are accounted for by confounding factors (ie, it is unclear if criterion 6 is met).

*Adapted with permission from ACRM. Definitions and explanatory notes are described in detail in the ACRM diagnostic criteria paper.[6]
†Loss of consciousness, alteration of mental status, complete or partial amnesia for events immediately following the injury, other acute neurological sign(s).
‡Cognitive, balance or oculomotor impairment on acute clinical examination; elevated blood biomarker(s) indicative of intracranial injury.
§With Glasgow Coma Score 13–15. For further details, including definitions, explanatory notes and qualifiers, see the ACRM diagnostic criteria paper.[6]
ACRM, American Congress of Rehabilitation Medicine; CISG, Concussion in Sport Group.

Future research could help determine if these distinctions are important.

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Competing interests GAD is a member of the Scientific Committee of the 6th 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 sporting organisations including the 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. JP: Editor BJSM (honorarium); Member of World Rugby Concussion Advisory Group (unpaid); Independent Concussion Consultant for World Rugby (fee per consultation); Medical consultant to South African Rugby (unpaid); Co-chair of the Scientific Committee, 6th International Conference on Concussion in Sport (unpaid); Board member of the Concussion in Sport Group (unpaid); Scientific Board member, EyeGuideTM (unpaid). KJS has received grant funding from the Canadian Institutes of Health Research, National Football League Scientific Advisory Board, International Olympic Committee 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) and has received travel and accommodation support for meetings where she has presented. She is coordinating the writing of the systematic reviews that will inform the 6th International Consensus on Concussion in Sport, for which she has received an educational grant to assist with the administrative costs associated with the writing of the reviews. She is a member of the AFL Concussion Scientific Committee (unpaid position) and Brain Canada (unpaid positions). She works as a physiotherapy consultant and treats athletes of all levels of sport from grass roots to professional. 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 mild TBIs (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 principal investigator from the National Football League, and subcontract grant funding as a collaborator from the Harvard Integrated Programme to Protect and Improve the Health of National Football League 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. NDS: Employee salary from the University of British Columbia; Research grants from the Canadian Institutes of Health Research, Canada Foundation for Innovation, WorkSafeBC, and the US Department of Defense (no salary contributions); Research salary support from the Michael Smith Foundation for Health Research; Editorial board member for Neuropsychology and the Journal of Head Trauma Rehabilitation (unpaid); Chair of the American Congress of Rehabilitation Medicine Mild TBI Task Force (unpaid); Member of the Scientific Advisory Committee, Brain Injury Canada (unpaid); Clinical neuropsychological consulting fees from the National Hockey League, Major League Soccer and NDS (<10% of total income).

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