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Concussion Guidelines in National and International Professional and Elite Sports

The Berlin statement on sport-related concussion was published in 2017 using evidence-based recommendations. We aimed to examine (1) the implementation of, distribution and education based on the Berlin recommendations, and the development of sport-specific protocols/guidelines among professional and elite sports, (2) the implementation of guidelines at the community level, (3) translation of guidelines into different languages, and (4) research activities. Senior medical advisers and chief medical officers from Australian Football League, All Japan Judo Federation, British Horseracing Authority, Cricket Australia, Fédération Equestre Internationale, Football Association, Gaelic Athletic Association, International Boxing Association, Irish Horseracing Regulatory Board, Major League Baseball, National Football League, National Hockey League, National Rugby League, and World Rugby completed a questionnaire. The results demonstrated that all 14 sporting organizations have published concussion protocols/guidelines based on the Berlin recommendations, including *Recognize, Removal from play, Re-evaluation, Rest, Recovery, and Return to play*. There is variable inclusion of *Prolonged symptoms, Prevention and Risk reduction and Long-term effects* are addressed in the guidelines, rules and regulations, and/or sport-specific research. There is variability in education programs, monitoring compliance with guidelines, and publication in other languages. All sporting bodies are actively involved in concussion research. We conclude that the Berlin recommendations have been included in concussion protocols/guidelines by all the sporting bodies, with consistency in the essential components of the recommendations, whilst also allowing for sport- and regional-specific variations. Education at the elite, community, and junior levels remains an ongoing challenge, and future iterations of guidelines may consider multiple language versions, and community- and junior-level guidelines.

KEY WORDS: Concussion, Guidelines, Sport

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The Concussion in Sport Group (CISG) was formed as part of the first International Conference on Concussion in Sport in Vienna in 2001, and produced a summary and agreement statement.¹ An updated statement was produced following each subsequent meeting of the CISG: Prague in 2004,² Zurich (2008 and 2012),^{3,4} and Berlin (2016).⁵

The goals of these statements included both summarizing the extant scientific knowledge in the field and providing useful information to healthcare providers for the management of sport-related concussion (SRC).

According to the Berlin statement,⁵ “The consensus statement is not intended as a clinical practice guideline or legal standard of care,

ABBREVIATIONS: AFL, Australian Football League; AIBA, International Boxing Association; AJFF, All Japan Judo Federation; BHA, British Horseracing Authority; CA, Cricket Australia; CISG, Concussion in Sport Group; FA, Football Association; FEI, Fédération Equestre Internationale; FIFA, Fédération Internationale de Football Association; GAA, Gaelic Athletic Association; IHRB, Irish Horseracing Regulatory Board; MLB, Major League Baseball; NBA, National Basketball Association; NFL, National Football League; NFLPA, National Football League Players Association; NHL, National Hockey League; NRL, National Rugby League; RTP, Return to play; SRC, sport-related concussion; WBC, World Boxing Council; WR, World Rugby

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and should not be interpreted as such. This document is only a guide, and is of a general nature, consistent with the reasonable practice of a healthcare professional. Individual treatment will depend on the facts and circumstances specific to each individual case.”

In 2017, following publication of the Berlin statement, 11 national and international sporting bodies met in Dublin, Ireland, and the purpose of the meeting was “to harmonize interpretation of the Berlin Concussion in Sport Group Consensus Statement recommendations, discuss impediments to implementation, exchange information on current practice and identify areas for collaboration among team collision sports.”⁶

Whilst these meetings and publications aimed to provide evidence-based recommendations for the management of SRC, it was acknowledged that there remained many knowledge gaps in the management of SRC and that there are many sport-specific variables that must be taken into consideration. The aims of this study were to examine (1) the implementation of, distribution and education based on the Berlin recommendations, and the development of sport-specific protocols/guidelines among professional and elite sports, (2) the implementation of guidelines at the community level, (3) translation of guidelines into different languages, and (4) exploration of internal data analytics related to program evaluation and research activities of professional and elite sports in SRC.

METHODS

Senior medical advisers and chief medical officers from major national and international sporting codes, including the Australian Football League (AFL), All Japan Judo Federation (AJJF), British Horseracing Authority (BHA), Cricket Australia (CA), Fédération Equestre Internationale (FEI), Fédération Internationale de Football Association (FIFA), Football Association (FA), Gaelic Athletic Association (GAA), International Boxing Association (AIBA), the Irish Horseracing Regulatory Board (IHRB, formerly the Irish Turf Club), Major League Baseball (MLB), National Basketball Association (NBA), National Football League (NFL), National Hockey League (NHL), National Rugby League (NRL), Para Sports, World Boxing Council (WBC), and World Rugby (WR) were purposively sampled and invited to participate in this study.

A questionnaire (**Text, Supplemental Digital Content 1**) was developed and sent to study participants, which addressed the following elements:

(Continued from previous page)

⁵National Rugby League, Sydney, Australia; ⁶The Football Association, St George's Park, Needwood, England; ⁷National Hockey League, New York, New York; ⁸World Rugby, Dublin, Ireland; ⁹Centre for Urgent and Emergency Care Research, School of Health and Related Research, University of Sheffield, Sheffield, United Kingdom; ¹⁰Major League Baseball, New York, New York; ¹¹British Horseracing Authority, London, United Kingdom; ¹²Gaelic Athletic Association, Dublin, Ireland; ¹³Institute Sport Exercise & Health, Division of Surgery & Interventional Science, Faculty of Medical Sciences, University College London, London, United Kingdom; ¹⁴Concussion in Sport Group, Zurich, Switzerland; ¹⁵The Irish Horseracing Regulatory Body, The Curragh, Ireland; ¹⁶All Japan Judo Federation, Tokyo, Japan; ¹⁷School of Public Health, University of Sydney, NSW, Australia; ¹⁸National Football League, New York, New York

- Adoption and implementation of Berlin recommendations into guidelines at the elite and professional level
- Compliance with organizational protocols/guidelines
- Education mechanisms
- Community implementation
- Languages other than English
- Data analytics, program evaluation, and research activities

Within each of these domains, the responses were analyzed to provide quantitative and qualitative information, and to identify those domains with unanimity in approach, and those with sport- or geographic-specific approaches.

RESULTS

Completed questionnaires were received from representatives of 14 sporting bodies (AFL, AJJF, AIBA, BHA, CA, FA, FEI, GAA, IHRB, MLB, NFL, NHL, NRL, and WR), which were included in the analysis.

Adoption and Implementation of Berlin Recommendations Into Guidelines at the Elite and Professional Level

All 14 sporting organizations sampled have published concussion guidelines or protocols based on the Berlin recommendations. Following the convention adopted by the CISG, the findings will be presented using the 11 “R’s” enumerated in the Berlin statement:

- Recognize;
- Remove;
- Re-evaluate;
- Rest;
- Rehabilitation;
- Refer;
- Recover;
- Return to sport;
- Reconsider;
- Residual effects and sequelae; and
- Risk reduction.

Once aggregated across participants, the results of the survey indicate the following:

- *Recognize, Removal from play, Re-evaluation, Rest, Recovery, and Return to play* have been incorporated into the guidelines for all sporting organizations.
- *Rehabilitation* is included in most guidelines (except AJJF).
- *Recovery - Prolonged symptoms* are included in guidelines by AFL, BHA, GAA, IHRB, MLB, NHL, NRL, and WR but not AIBA, AJJF, CA, FA, FEI, and NFL.
- *Risk reduction and Prevention* are addressed in the guidelines by AIBA, AJJF, BHA, CA, GAA, and NRL. Whilst not specifically in the guidelines in AFL, FA, FEI, IHRB, MLB, NFL, NHL, NRL, and WR, prevention and risk reduction strategies are covered in rules and regulations

TABLE 1. Other Components of Concussion Guidelines and Protocols

| Sporting organization | Other components |
|-----------------------|---|
| AFL | Purpose of guidelines, definition of concussion, baseline testing and player education, role of investigations, video assessment, network of neurology experts for support of team doctors, mandatory use of a digital platform for enhanced compliance and research purposes. |
| FA | Football-specific GRTP. |
| GAA | GAA Concussion Management Guidelines for Gaelic Games were published in September 2018, https://learning.gaa.ie/sites/default/files/Concussion%20Management%20Guidelines%20for%20Gaelic%20Games%20November%202018_0.pdf |
| IHRB | http://www.ihrb.ie/6-medical |
| MLB | The concussion protocol is included in the Collective Bargaining Agreement, https://d39ba378-ae47-4003-86d3-147e4fa6e51b.filesusr.com/ugd/b0a4c2_95883690627349e0a5203f61b93715b5.pdf |
| NFL | NFL Concussion guidelines were peer reviewed and published in the British Journal of Sports Medicine, 2018;52:894-902. Added "postural instability of neurologic origin" as an additional No Go sign in 2018 after publication of the protocol. iPad version of SCAT5 is used in NFL via C3Logix system. |
| NHL | Baseline testing, enhanced identification of possible head injuries via spotters and video review, mandatory use of a digital platform (NHL modified SCAT5) for improved standardization, compliance, and data collection. |
| NRL | Identification of possible head injuries via video spotters at a central bunker, mandatory use of an online digital platform for improved compliance and research purposes, concussion consultant availability for second opinions for club doctors. |

TABLE 2. Guidelines and Protocols With Variations From Berlin Statement

| Sporting organization | Variations from Berlin statement |
|-----------------------|--|
| BHA | Racing version of Maddocks questions, individualized testing, and RTP protocols based on objective testing rather than simply time scales. |
| CA | Have not nominated a specific minimum stand-down period (although it is debatable whether Berlin clearly does); mandate Cogsport® testing on day of injury for all significant head impacts (as well as SCAT 5). Maddocks question has been changed to be cricket specific. |
| IHRB | Added in GAD 7/PHQ 9 as anxiety/depression much higher in jockeys. |
| AIBA | A third concussion within a 12-mo period results in a 12-mo suspension from boxing training and competing. |
| MLB | Players are evaluated on the field and then between innings throughout the game if there is any suspicion of injury. |
| NHL | Hockey-specific Maddocks questions, developed an iPad app for the administration of the SCAT5 that includes mandatory use of the 10-word list for memory assessment, detailed evaluation, and management protocol including mandatory baseline and post-injury evaluations conducted by a neuropsychologist. |
| NRL | Possibly RTP - elite level advanced care pathways including RTP management, but do recommend that the Berlin guidelines be followed with regards to RTP timeframes. Defined removal from play criteria: category 1—immediate and permanent removal, category 2—immediate removal for off-field assessment with temporary free interchange. |
| WR | Expanded and structured removal from play criteria: criteria 1—immediate and permanent removal, criteria 2—off-field assessment with temporary substitution. Structured mandatory follow-up of all head injuries. Game wide operational definition to drive consistency. |

RTP, Return to play.

of the game, by medical committees and sport-specific research.

- *Residual effects and sequelae*—The issue of possible *Long-term effects* of concussion is included in the guidelines of AIBA, BHA, NRL, and WR, and other sports (AFL, FA, NFL, NHL, NRL) address this issue in sport-specific education and/or research programs, or license applications (IHRB).

Other components of guidelines are included in Table 1.

The use of video technology to assess head knocks/hits to the head associated with potential concussion and the video signs of concussion have been addressed specifically in a related consensus publication.⁷

Variations of Berlin Recommendations

Variations of the Berlin recommendations are included in the guidelines/protocols of AIBA, BHA, CA, IHRB, MLB, NHL, NRL, and WR as listed in Table 2, principally to make sport-specific modifications.

TABLE 3. Concussion Education Programs for Each Sport

| Sporting organization | Education program |
|------------------------------|--|
| AFL | Annual professional development sessions, peer-review auditing, incorporated into mandatory medical team emergency medicine training, follow-up of difficult cases, distribution of education materials for doctors, physiotherapists, and sports trainers. |
| AJFF | Enlightenment courses each year and creation of safety manual book each 4 yr are carried out by AJFF. |
| BHA | Annual reminder when updated Maddocks Questions are sent out. |
| CA | (1) Concussion and head impact policy at https://www.cricketaustralia.com.au/cricket/rules-and-regulations ; (2) annual player, team physiotherapists and doctor education; (3) discussed at doctor meetings every 3 to 4 mo and at an annual conference for all medical staff (doctors and physios). |
| FEI | Currently: website has instructions for medical colleagues and a “doctors pack” of documents which organizers are advised to supply to their medical personnel—middle term: a course will be developed for our FEI Campus online learning platform. |
| FA | ATMMiF (Advanced Trauma Medical Management in Field) emergency pitchside care course, validated by Faculty of Prehospital Care is a minimum requirement for pitchside team leaders in all professional matches. The concussion guidelines are taught as part of this course. There is also an online e-learning module and a concussion education video for education of players and coaches. Management of any concussion via the “Enhanced Care Pathway” of our guidelines mandates the presence of a concussion education program within the club. |
| GAA | In addition to our comprehensive Concussion Management Guidelines available and we have an annual education meeting for doctors. We also have a Medical, Scientific and Welfare committee which meets 6 to 8 times per year deals with ad hoc queries as they arise. |
| IHRB | Triennial training days for all racecourse doctors are mandatory and all have been sent out CRT5. |
| AIBA | To become a ringside doctor, you have to pass a ringside doctors course. |
| MLB | Concussion protocol is reviewed each year at the annual winter meetings of physicians and athletic trainers and an updated memo is distributed to all clubs. In addition, all clubs review signs and symptoms of concussion with their respective teams each year. |
| NFL | All members of club medical staff have been provided with written copies of the guidelines agreed upon by the NFL and NFLPA and have been given access to the published version of the protocol in BJSM. In-person training sessions have been held bi-annually with concussion protocol reviews and updates. Medical personnel included: Head Club Physician (Internal/Sports Medicine), Head Club Athletic Trainer, Consulting Club Neuropsychologist, Booth Spotter Certified Athletic Trainers, Unaffiliated Neurotrauma Consultants, Independent Neurological Consultants. |
| NHL | A Medical Handbook containing the written Concussion Protocol is issued to all medical personnel. Mandatory yearly education sessions with Head Coaches, Physicians (Head Team Physician/Medical Director and any other physician responsible for concussion evaluations), Head and Assistant athletic Trainers/Therapists, Club Neuropsychologists and players. Concussion educational video shown to all players, Club general managers, assistant general managers, players, and coaches no later than the first day of training camp each season. Educational video on the Visible Signs of Concussion shown to coaches, medical personnel, General Managers and assistant General Managers annually at training camp. Educational brochure given to players upon diagnosis of concussion (multi-language versions resident on the NHLPA website), and mandatory Concussion Education poster in all dressing rooms (home and visitor). |
| NRL | The guidelines/policy/rules are published in the yearly NRL Operations manual. The changes are also directly communicated by the NRL CMO to the club doctors via email and preseason meetings in association with annual professional development video review sessions. A yearly online Elite NRL concussion module is also mandatory for all Club Doctors and trainers and this also contains the current rules for the upcoming season. |
| WR | Identified in legally binding Player Welfare Standards Required to complete online education (MDD, concussion, video interpretation) in order to access the field of play. Accreditation and re-accreditation process in place. HIA Review Process assesses compliance. |

NFLPA, National Football League Players Association; BJSM, British Journal of Sports Medicine; HIA, Head injury assessment.

Compliance With Protocols/Guidelines

Compliance with the guidelines is monitored by nine of the sporting organizations (AFL, BHA, CA, IHRB, MLB, NFL, NHL, NRL, and WR). Breaches of compliance may be sanctioned with punitive actions by five sporting organizations (AFL, NFL, NHL, NRL, and WR). Sanctions may include disciplinary action for individuals and/or monetary fines for clubs/teams.

Education Mechanisms

Education of team medical staff relevant to concussion evaluation and management varies across sporting organizations, with education programs including mandatory courses (AFL, FA, IHRB, AIBA, NHL, NRL, and WR), annual professional development programs (AFL, AJFF, CA, GAA, MLB, NFL, NHL, and NRL), online courses (FEI, FA, NRL, and WR), and other approaches (BHA, NFL, and NHL) (Table 3).

TABLE 4. URLs for Online Elite Level and Community Level Concussion Guidelines and Protocols

| Sporting organization | Elite level guidelines | Community guidelines |
|-----------------------|--|--|
| AFL | Not published online | www.afl.com.au/afleducation/concussion and https://www.headcheck.com.au/ |
| AJFF | www.judo.or.jp | www.judo.or.jp |
| BHA | Not published online | |
| CA | https://www.cricketaustralia.com.au/cricket/rules-and-regulations https://www.cricketaustralia.com.au/cricket/-/media/7C7879E835F54101B20B641FB803C66F.ashx | www.communitycricket.com.au/clubs/running-your-club/~/-/media/communitycricketcomau/Files/Clubs/Insurance%20and%20Policies/Community%20Cricket%20Concussion%20%20Head%20Trauma%20Guidelines%20Aug%202017 |
| FEI | https://inside.fei.org/fei/your-role/medical-officer/doctor-pack | |
| FA | www.thefa.com/learning/coaching/the-fas-concussion-guidelines | www.thefa.com/learning/coaching/the-fas-concussion-guidelines |
| GAA | https://learning.gaa.ie/Concussion | https://learning.gaa.ie/Concussion |
| IHRB | http://www.ihrb.ie/6-medical | http://www.ihrb.ie/6-medical |
| AIBA | Not published online | |
| MLB | https://d39ba378-ae47-4003-86d3-147e4fa6e51b.filesusr.com/ugd/b0a4c2_95883690627349e0a5203f61b93715b5.pdf | www.usabaseball.com/news/concussions-in-baseball/c-246181494?tid=216639934 |
| NFL | https://bjsm.bmj.com/content/52/14/894 | |
| NHL | https://nhl.bamcontent.com/images/assets/binary/312066734/binary-file/file.pdf | General public educational video: https://www.nhl.com/news/2019-nhl-nhlpa-concussion-fact-sheet/c-308505740 |
| NRL | Not published online | www.playrugbyleague.com/trainer/concussion/ |
| WR | https://playerwelfare.worldrugby.org/concussion | https://playerwelfare.worldrugby.org/concussion |

Community Implementation

Guidelines and/or education for community or lower levels of sports participants are published by 10 of the sporting organizations (AFL, AJFF, CA, FA, GAA, IHRB, MLB, NHL, NRL, and WR), with dissemination of these guidelines via electronic media and publications as detailed in Table 4.

Languages Other Than English

All sporting bodies except AJFF (Japanese) publish the guidelines in English. Guidelines with translations into other languages are published by MLB (Spanish), NHL (French, Russian, German, Czech, Swedish, Slovak, and Finnish), and WR (French, Spanish, Italian, Japanese, and Russian).

Research Activities/Program Evaluation

All of the sporting organizations are actively involved in concussion program evaluation/research, with areas under investigation including protective equipment, functional imaging, biomarkers, computer applications, neuropsychological assessment, audit, video technology, and biomechanics (see Table 5). A selection of some of the sports' research publications is listed in **Text, Supplemental Digital Content 2**.

Other

The sporting organizations were invited to provide other details relevant to their current concussion programs. The results are included in Table 6.

DISCUSSION

The 14 respondent sporting bodies represent a diverse range of sports that are played across the Americas, Europe, Asia, Africa, and Australasia, and each of these national and international sporting bodies has developed concussion protocols and guidelines based upon the Berlin recommendations.⁵ As the Berlin statement acknowledges, individual modifications are required to accommodate different circumstances across the geographical and sporting landscapes. Yet, despite the significant differences among the sports, a comparison of the concussion guidelines reveals more similarities than differences.

Implementation of the Berlin statement differs across the sports, with factors impacting the methods of implementation including professional/amateur status, availability of time-out, substitution rules, sideline medical personnel, and video spotters. Sports played in countries with limited resources must implement guidelines that are suitable to that playing environment, which may be quite different from sports played in countries with generous medical resources available. Even within countries that may be rich in resources, differences are apparent across levels of play, with elite levels enjoying greater resources than recreational or youth sports. Yet, despite these differences, all sporting bodies have sought to implement the Berlin recommendations into their protocols and guidelines.

Compliance with the protocols/guidelines is encouraged by all the sporting bodies, but monitoring compliance differs across the

TABLE 5. Concussion Research Activities for Each Sporting Organisation

| Sporting organization | Research activities |
|------------------------------|---|
| AFL | Concussion audits (male and female), mechanism analysis, past player assessments, sensors (mouthguard and neck), headgear utility and regulation, mental health, advanced imaging (fMRI and PET), genetics, biomarkers, eye-tracking, community surveillance, management and education, independent spotter trials (elite and community). |
| AJFF | Several research projects including prevention of concussion or severe head and neck injuries are supported by AJFF. International Judo Medical Symposium held 1 d prior to International Judo Championship in Tokyo. Some of the research subjects in program have been supported by AJFF. |
| BHA | Collaborative research includes in ear device to measure biological parameters (EEG, ECG, RR, HR), balance post fall, and in due course forces during fall using accelerometer; falls analysis and relationship between helmet damage and concussion; injury rates postconcussion; vestibular rehab; falls training and impact on injury rates; longitudinal analysis of 15 yr of CogSport Data. International multisport study assessing long-term sequelae of concussive episodes in sport undertaken by https://www.ichirf.org/ |
| CA | Introduced a Concussion and Head Trauma Policy in 2014 which outlined a systematic approach to assessing and recording all head impacts, including assessment with the Sports Concussion Assessment Tool (SCAT) and CogSport computerized neurocognitive test, and completion of a head trauma report form and clinical records. These data were supplemented with match video footage where available. Retrospective analysis of 5 seasons of data from Australian and state cricket players who sustained a head impact during a match or cricket training was completed to provide insight into concussion specific to cricket. Multiple studies have been recently undertaken (awaiting publication) comparing SCAT5 and CogSport for same-day diagnosis of concussion; whether CogSport is affected by fatigue and the utility of video signs for diagnosing concussion in cricket. |
| FEI | Support research through the CISG. |
| FA | Recently published FIELD study on dementia in former professional footballers (FPF). Two live cohort studies into neurocognition in FPF. Involvement in FIFPro longitudinal study of player health. Further call for research into dementia risk in FPF planned for 2020. |
| GAA | 1. Partnership with UPMC in Pittsburgh. 2. UCD National Injury Surveillance Database. 3. The Medical, Scientific and Welfare committee also receives research requests on ad hoc basis, and these are assessed and support given to successful requests. |
| IHRB | Have 3 research fellows and one is currently doing research on the cognitive effects of racing. CMO is a trustee of I.C.H.I.R.F. |
| AIBA | Researching the effects of head guards on observable signs of concussion. |
| MLB | Published manuscripts on demographics of TBI in professional baseball players, catchers' perceptions and experiences with different types of face masks, and ability of a simple rule change to lower rates of concussion significantly. Additional projects are in progress, including batting performance after return to play from a concussion, and epidemiology of concussions caused by foul tips to catchers' masks. |
| NFL | Standardized helmet testing is performed annually by independent biomechanical engineers with results provided to NFL players/staff and published online; 14 peer-reviewed publications over the past 2 yr related to concussion protocol, biomechanical analyses of mechanism of injury, results of independent spotter and unaffiliated neurotrauma consultant sideline assessment programs, and sensitivity/specificity of visible signs of concussion; IRB-approved pilot studies of mouthguard-based head impact data and sideline assessment technologies are in progress. |
| NHL | 16 peer-review publications in the last 8 yr covering topics that include epidemiology, mechanisms of injury, video analysis, visible signs, cognitive change, neuropsychological assessment, cultural variability in cognitive test data, and psychometric test properties. |
| NRL | Past player assessment and brain health research including multimodal imaging, biomarkers, and genetics; impact sensors (mouthguards); SCAT—normative data and interpretation (including racial differences); mental health; concussion risk prediction/mechanism of injury; community (junior) incidence/compliance; spotter studies. |
| WR | Current research includes concussion audits, diagnostic accuracy off-field screening tool, new modes for off-field screen, factors impacting on accurate baseline SCAT, normative SCAT5 data, concussion prevention using laws and sanctions, discrete choice experiment investigating value of off-field concussion screening. |

ECG, electrocardiogram; EEG, electroencephalograph; fMRI, functional magnetic resonance imaging; HR, heart rate; IRB, Institutional Review Board; PET, positron emission tomography; RR, respiratory rate; TBI, traumatic brain injury.

See Supplementary Table 2 for a list of some research publications.

various sporting bodies, largely because some sporting bodies are responsible for both the rules of the game and the management of the competition, whilst other sporting bodies are only responsible for the rules of the game, with local organizations managing

the competition. Monitoring compliance is important to ensure ongoing player welfare, yet given the variability across sports and levels of play a uniform approach to compliance has not been established. Ultimately, the most important goal is to establish

TABLE 6. Other Components of Concussion Programs

| Sporting organization | Other components |
|-----------------------|--|
| AFL | Developing a digital (smartphone app) tool for community level adult competition to be used by sports trainers; work co-operatively with other sporting codes both domestic and international on the translation of the Berlin Consensus into sport-specific circumstances; large number of rule changes to protect the head. |
| AJFF | CMO stated that "I believe that prevention program for concussion can also prevent the catastrophic head injuries such as acute subdural hematomas in Judo as well as other contact sports." |
| BHA | Extensive baseline testing includes Cogsport, SCAT5, neuropsychology (repeated 2 yearly). Post fall—additional physio for vestibular assessment/rehab, Buffalo testing, Consultant Neurologist assessment. Concussed jockeys surrender their helmet for analysis and receive an £80 voucher for a new helmet. Jockeys can claim income replacement insurance during stand-down. |
| CA | Have made rule change to include a substitute for concussion (as cricket does not have injury or tactical substitutes) |
| FA | Work in collaboration with leagues and players' union (PFA) including concussion education video being shown to league managers ahead of new season. Video review of concussion by tunnel doctor at Premier League matches. |
| GAA | Although our sport is predominately played in Ireland, our medical team would attend international conferences and our guidelines are in line with international best practice and scrutiny. The GAA were represented in Berlin at the International Consensus Conference on Concussion in November 2016. |
| MLB | Both MLB Commissioner's office and MLB Players' Association must agree before a player is approved to return to play. A 7-d injured list only for concussions was created to allow players time to fully recover from their injuries without tying up a roster spot while they were inactive. A Spanish version of the SCAT 5 was created, albeit with limitations due to the numerous dialects spoken in the Caribbean and South America. |
| NFL | The NFL Head, Neck and Spine Committee, in conjunction with the NFLPA, reviews the concussion protocol annually and makes evidence-based changes as warranted. |
| NHL | Has an active Concussion Subcommittee jointly with the NHL Players' Association that meets in person 5 times per year to review data, enhance education, and make changes to the concussion protocol. |
| NRL | Latest development is a spotter program (injury surveillance bunker, ISB) that has 2 spotters in a central bunker for all elite NRL games assisting in the identification (real time) of possible head injuries which is then relayed to the club doctors at the ground for their review (via the sideline injury surveillance video system [with all camera angles available in HD]) and assessment. Yearly review and modification of concussion policy as required. |
| WR | Concussion prevention strategies—new sanction framework, tackle technique warning system |

an environment that encourages compliance with concussion protocols/guidelines and provides timely feedback and education for any practices that deviate from expectations.

Education programs differ across the sports, ranging from provision of protocols/guidelines (printed or online), to online courses, to mandatory courses for team personnel. A universal education program has not been clearly established, and perhaps not warranted given the diversity of sport-specific and level of play considerations. The process of knowledge translation remains an immense challenge for all concussion programs.⁸ Whilst some of the sports bodies are only responsible for the elite competition, others are responsible for all levels of competition, including community and junior sports participants. Nine of the respondents provide community guidelines for non-elite athletes, and these tend to be disseminated through organizational networks or online portals. Moreover, it would be useful to formally assess the efficacy of education programs/interventions with regard to knowledge transfer and any corresponding alterations in behavior of the target group.

A further consideration in knowledge translation is that sporting organizations may need to publish concussion guide-

lines in multiple languages. The Berlin statement was published in English, and whilst some sports have been able to translate and publish concussion guidelines in multiple languages, it is apparent that future iterations of guidelines would benefit from translation into multiple languages.

The mechanism of concussive injury differs among the various sports, including missile injury (MLB, CA), tackling injury (most football codes), deliberate head contact (AJFF, AIBA), high velocity falls (BHA, FEI, IHRB), and high velocity contact (NHL). The mechanism of injury directly impacts how some elements of concussion guidelines have been constructed, such as *Recognize and remove*, and *Prevention and Risk reduction*. As such, it is expected that organizations will generate sport-specific modifications when implementing sections of the Berlin statement as appropriate.

Prevention and Risk Reduction are included in the guidelines for AIBA, AJFF, BHA, CA, GAA, and NRL. Other sports address prevention through modifications in rules/regulations of the game and enforcement of those rules, by medical committees and sport-specific research/data analyses. As has been noted above, the differences among sports and levels of play make it difficult

to establish a “one-size-fits-all” approach to prevention and risk reduction. Nonetheless, injury prevention and risk reduction are important considerations for all sporting codes.

Whilst not a specific component of guidelines per se, the role of elite and professional sporting bodies in active program evaluation and development as well as generalizable concussion research is very important, not only because of the ability to improve concussion scientific development but also as an educational forum for athletes and the community. The participation in program enhancement and scientific development by all 14 sporting organizations in active concussion research is to be applauded, and further collaborative projects/research are encouraged.

CONCLUSION

The Berlin recommendations have been included in the implementation of concussion protocols/guidelines by elite and professional sporting bodies nationally and internationally, with consistency in the essential components of the recommendations, whilst also allowing for sport- and region-specific variations. Education at the elite, community, and junior levels remains an ongoing challenge for all organizations, and future iterations of concussion guidelines may consider distribution of multiple language versions, in addition to community and junior-level guidelines.

Disclosures

Dr Echemendia is cochair of the NHL/NHLPA Concussion Subcommittee and receives remuneration as a consultant to the NHL, Major League Soccer, and Princeton University. He is a Co-PI on grant-funded research from the NFL and Boston Children's Hospital. Dr Fuller has received travel expenses from World Rugby to attend scientific meetings. Dr Solomon is a paid consultant to the National Football League. Dr Valadka is a paid consultant to Major League Baseball. Dr Davis is an honorary member of the AFL Concussion Working Group Scientific Committee and has attended meetings organized by sporting organizations including the NFL, NRL, IIHF, and FIFA; however, he has not received any payment, research funding, or other monies from these groups other than for travel costs. Dr McCrory is a coinvestigator on competitive grants relating to mild TBI funded by several governmental and other organizations. He is funded under a Fellowship awarded by the National Health & Medical Research Council of Australia and is employed at the Florey Institute of Neuroscience and Mental Health. He has a clinical consulting practice in neurology, including medicolegal work. He has been reimbursed by the government, professional sci-

tific bodies, and commercial organizations for discussing or presenting research relating to MTBI and sport-related concussion at meetings, scientific conferences, and symposiums. He does not hold any individual shares in or receive monies from any company related to concussion or brain injury assessment or technology. He acknowledges unrestricted philanthropic support from CogState Inc (2001-2016). He is the chair of the scientific committees of the International Concussion and Head Injury Research Foundation in London and the Sports Surgery Clinic in Dublin. Dr Sills is an employee of the National Football League. Dr Orchard is Chief Medical Officer of Cricket Australia. The other authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

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